RESEARCH ARTICLE

MRI Findings after Injection of Single and Double Centrifuged Platelet-Rich Plasma and Placebo (Normal Saline) in Patients with Knee Osteoarthritis: A Randomized Double-Blind Clinical Trial with Six-Month Follow-Up

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Received: 9 December 2024 *Accepted: 12 February 2025*

Abstract

Objectives: This research aimed to compare the changes in knee MRI findings after the injection of platelet-rich plasma with those after the injection of a placebo (normal saline) in patients with knee osteoarthritis.

Methods: This randomized clinical trial study was conducted on 63 patients with grade 2 and 3 knee osteoarthritis. Patients were randomly assigned to one of three injection groups: double-centrifuged PRP, single-centrifuged PRP, or placebo (normal saline). Patients were evaluated with MRI, VAS (visual analog scale), WOMAC (Western Ontario and McMaster Universities Arthritis Index), knee ROM (range of motion), and functional tests before and six months after the intervention. The investigated MRI characteristics included cartilage thickness of the medial tibia and patella, WORMS score of osteophyte and subchondral cyst, as well as severity of subchondral sclerosis.

Results: In the comparison between the three groups six months after the intervention, the VAS, ROM, functional tests, WOMAC scores, sclerosis severity, and the thickness of the medial tibial and patellar cartilage in the two groups, single centrifuged and double centrifuged, were significantly better than the placebo group. However, the mean overall WORMS score for osteophyte ($p = 0.480$) and subarticular cyst ($p = 0.559$) was not significant between the groups, and the PRP groups did not show a significant difference in reducing osteophyte and subarticular cysts compared to the placebo group.

Conclusion: Compared to the control group, PRP was effective in improving pain, range of motion (ROM), functional performance, WOMAC scores, articular cartilage thickness, and the severity of sclerosis. No significant difference was observed between the two groups of PRP in improving these variables.

Level of evidence: II

Keywords: Knee, Magnetic resonance imaging, Osteoarthritis, Platelet-rich plasma

Introduction

Osteoarthritis is the most prevalent disease of synovial joints in humans, leading to chronic pain, muscle weakness, impaired neuromuscular function, severe disability, and a significant decline in social activities and quality of life for patients[1-4] The World Health Organization has recognized this disease as one of the most critical global health challenges, ranking it among the top ten health threats, particularly in developing countries. Knee osteoarthritis is frequently associated with changes in the structure of articular cartilage and subchondral bone, as well as intra-articular inflammation and functional and balance disorders. Neuromuscular dysfunction, including decreased proprioception, strength, and muscle atrophy, increases stress on the joint cartilage. Although osteoarthritis significantly impacts individuals and reduces their quality of life, no definitive treatment has been identified to halt its progression. Non-surgical

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THE ONLINE VERSION OF THIS ARTICLE
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interventions commonly employed in the early stages of osteoarthritis include non-steroidal anti-inflammatory drugs (NSAIDs), physical therapy, exercise therapy, and intra-articular injections such as hyaluronic acid, ozone, corticosteroids, and platelet-rich plasma (PRP) injections. PRP is produced by centrifuging the patient's whole blood, yielding a concentrate of autologous platelets along with their associated growth factors and other bioactive components. This combination has been used in orthopedic and sports medicine for the treatment of ligament, tendon, and bone injuries. Moreover, PRP plays a crucial role in maintaining tissue homeostasis and regulating inflammation and coagulation responses in the body, including inhibition of cartilage cell apoptosis, bone and vascular regeneration, and collagen synthesis. Various growth factors and cytokines are released upon platelet separation, which play a crucial role in accelerating cartilage matrix production, inhibiting inflammation of the synovial membrane, and promoting cartilage healing. Most studies focus on the impact of these treatment methods on subjective patient outcomes, such as clinical symptoms, function, and quality of life. In contrast, fewer studies have examined the objective changes in the articular cartilage of the knee and surrounding tissues. Imaging techniques are valuable for assessing the objective changes induced by PRP therapy. One of the most important imaging modalities for evaluating articular cartilage and surrounding soft tissues is magnetic resonance imaging (MRI). MRI provides a three-dimensional view of the joint structure, allowing for precise and reliable measurement of cartilage volume due to its high soft tissue contrast. Several studies have utilized MRI to assess the effects of intra-articular injections, including viscosupplements, growth factors, and stem cells. However, the impact of PRP on cartilage structure remains a topic of controversy in several studies. Given the effectiveness of PRP in treating knee osteoarthritis and the availability of various methods for preparing PRP, this study aims to investigate the effect of PRP on MRI findings in patients with knee osteoarthritis. Specifically, we compare the outcomes of two preparation methods — single centrifuge and double centrifuge — to identify an optimal method for more effective treatment of patients with this condition. Previous studies have demonstrated that platelet-rich plasma (PRP) can positively reduce symptoms and improve function in patients with osteoarthritis. However, the objective and structural changes in knee cartilage and surrounding tissues following PRP treatment remain poorly understood. Therefore, the results of this study will help determine whether PRP injections, regardless of the preparation method (single or double centrifuge), positively influence MRI findings of articular cartilage and surrounding tissues in patients with knee osteoarthritis, and whether they enhance the overall effectiveness of the treatment. The primary objective of this study is to compare the effects of single-centrifuge and double-centrifuge platelet-rich plasma (PRP) preparation methods on objective magnetic resonance imaging (MRI) changes in patients with knee osteoarthritis.

Materials and Methods

This study was a double-blind randomized clinical trial on 63 patients with knee osteoarthritis. Patients randomly assigned in the three groups of 21 people. Two patients were withdrawn from the evaluation at later stages, so the final analysis included 61 patients (47 women and 14 men) [Chart 1].

If both knees of a patient were affected by osteoarthritis, the knee with the greater pain was selected for study and treatment. The inclusion criteria for participant selection were as follows: primary knee osteoarthritis grades 2 and 3 according to the Kellgren and Lawrence scale; age between 50 and 75 years; persistent knee pain for at least six months with a severity of at least four based on the Visual Analog Scale (VAS) during activities; ability to walk independently for at least 30 meters; and a body mass index (BMI) ≤35. The exclusion criteria included patients with recent intra-articular injections in the knee, prior knee or lower limb surgery, injury or fractures in the past year, acute traumatic injuries in other knee structures, contraindications for MRI, neuromuscular diseases, bone implants, use of anti-thrombotic medications, or participation in exercise therapy or physiotherapy in the last three months. This research was conducted with the approval of the Research Ethics Committee at the Iran University of Medical Sciences, under the code IR.IUMS.FMD.REC.1400.236, and registered with the Iran Clinical Trial Registration Center (IRCT) under the code IRCT20211016052782N. Before the study began, a summary of the research protocol was provided to each participant, and written informed consent was obtained. Participants were randomly assigned to one of three intervention groups: single-centrifuge PRP, double-centrifuge PRP, or normal saline (placebo). Patients were instructed to discontinue the use of NSAIDs and aspirin one week before receiving a PRP injection. The PRP solution was prepared using kits (Arya Mabna Tashkhis Corporation, RN: 312569, Rooyagen Kit) containing sterile materials. For each patient, 35 cc of venous blood was drawn, mixed with 5 cc of anticoagulant, and distributed into four tubes for centrifugation. In the single centrifuge PRP group, the tubes were rotated at 1600 RPM for 10 minutes, and the upper half of the plasma was separated from all four tubes. For the injection, only 5 cc of the lower half of the plasma was used. In the double centrifuge group, the plasma separated during the first centrifugation was transferred into two additional tubes and centrifuged at 3500 RPM for 6 minutes. After removing the upper plasma, 3 cc from the ends of both tubes was used for injection. At each stage, 0.5 cc of the solution was sent to the laboratory for analysis. In the third group, after blood collection, 5 cc of normal saline was injected as a placebo. The injection was administered into the knee from either the inferomedial or inferolateral area using a 21G needle, with the patient lying down. After a 30-minute rest, patients were allowed to leave the clinic. Patients were instructed to take only acetaminophen for pain relief after the injection and were advised against using NSAIDs or aspirin for 7 days. They were also instructed to avoid weight-bearing activities for 48 hours and to refrain from undergoing corticosteroid treatments or other intra-articular injections during the six-month follow-up period. Before the interventions, participants' demographic information, including age, gender, body mass index, and osteoarthritis grade, was recorded. For each patient, pain levels were assessed using the Visual Analog Scale (VAS), and the WOMAC questionnaire was completed. Functional tests, including the Timed Up and Go (TUG) test, stair climbing, and the six-minute walk test, were conducted. The active range of motion (ROM) of the knee was measured, and a knee MRI was requested. Knee MRI images were obtained using a 1.5 Tesla MR system (Philips, Ingenia, Netherlands) in coronal, sagittal, and axial fat-suppressed PD, T1, and T2 sequences with a knee coil, both before and 6 months after the intervention. Two expert radiologists, who were blinded to the intervention groups, reviewed all the images and recorded the MRI findings.

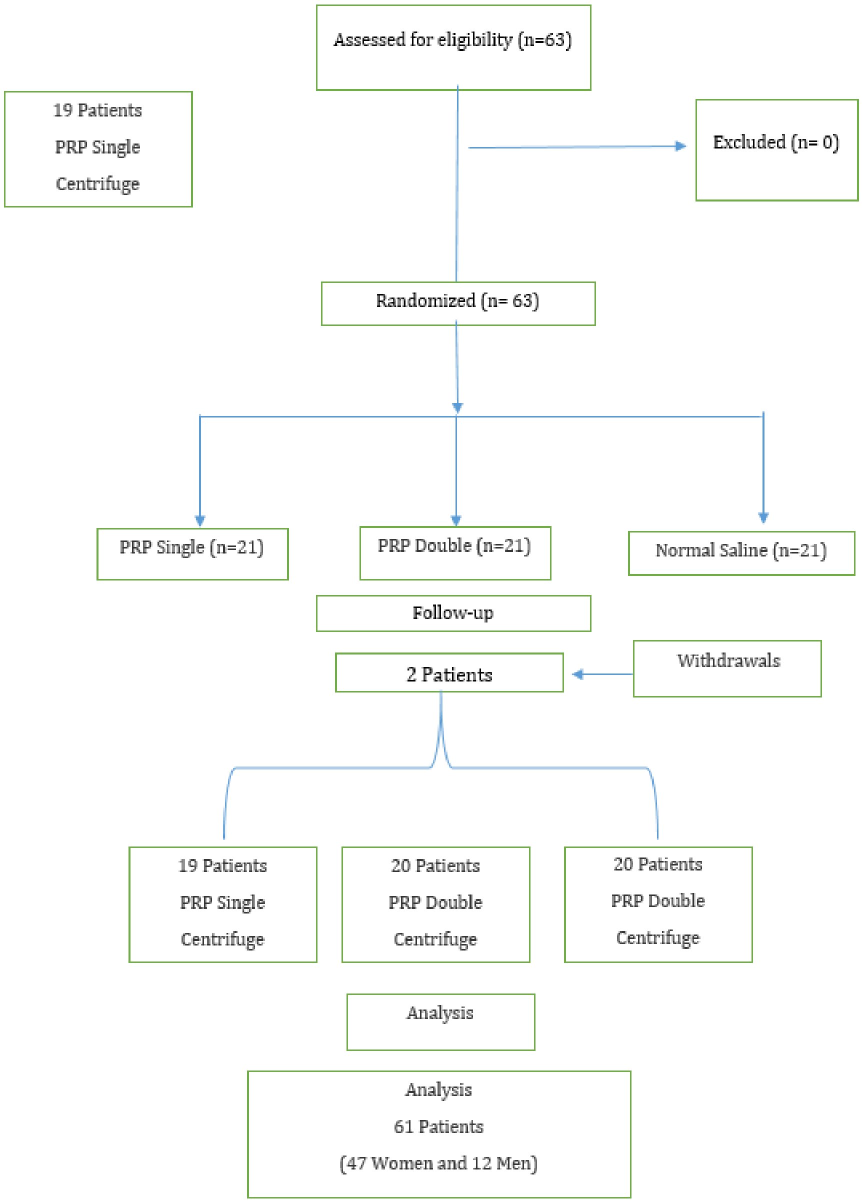

Chart 1. Flowchart of the study protocol

The evaluated MRI characteristics were:

1) Cartilage thickness:

The thickness of the medial tibial cartilage was measured by dividing the compartment into two parts using a line across the tibial plateau in the sagittal plane. The midpoint was identified, and the anterior (center of the anterior part) and posterior (center of the posterior part) points were also marked. Cartilage thickness was measured at these three points, and the average was calculated to determine the overall thickness [Figure 1].

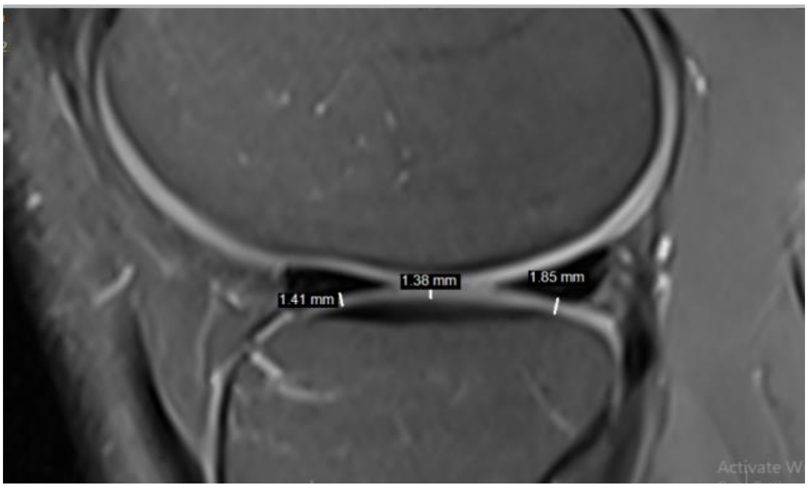

Figure 1. How to measure the thickness of medial tibial cartilage

The thickness of the patellar cartilage was measured using the axial view, where it was thickest. The lowest point of the patella was considered the center point, with the medial and lateral points marked at the center of each respective part. The average thickness of these three points was used to determine the overall cartilage thickness [Figure 2].

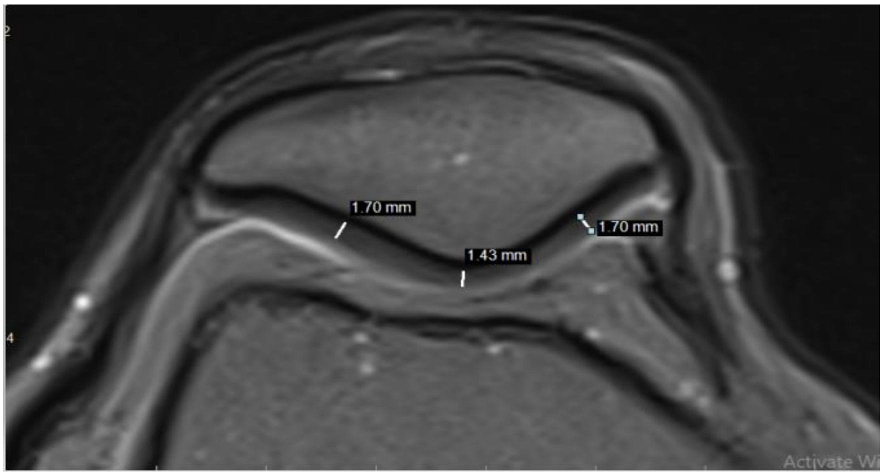

Figure 2. How to measure the thickness of patellar cartilage

2) Subchondral cysts based on the WORMS score:

Subchondral cysts are identified as areas of significant signal increase in the sub-articular bone, with well-defined, round margins in fat-suppressed T2-weighted images. Subchondral cysts in each region were graded from 0 to 3 based on the extent of involvement: Grade 0 = none; Grade 1 = <25% of the region; Grade 2 = 25% to 50% of the region; Grade 3 = >50% of the region. The maximum possible score for the entire knee is 45 [Figure 3].

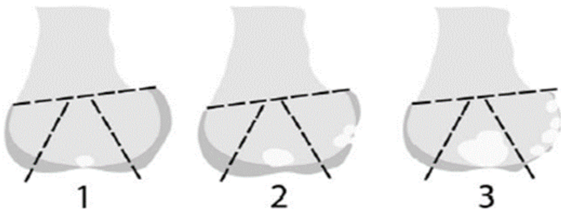

Figure 3. Grading of subchondral cysts in the WORMS criterion

3) Osteophytes based on the WORMS score:

Osteophytes are also graded in all regions except subspinous using the following scale from 0 to 7: 0=any osteophyte/1 = equivocal/2 = small/3 = small-medium/4 = medium/5 = medium-large/6 = large /7=very large.

The maximum score for the whole knee is 98 [Figure 4].

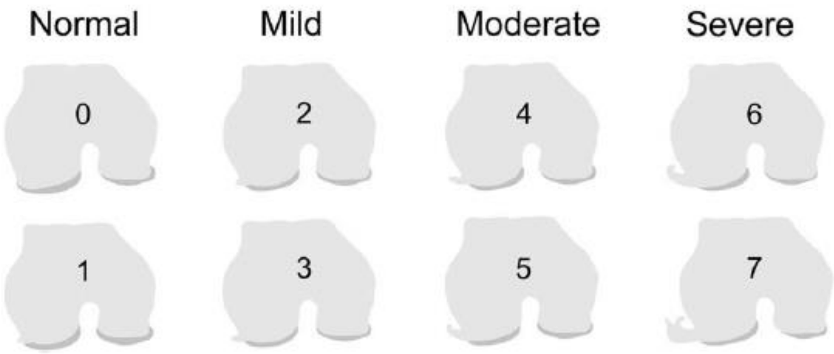

Figure 4. Grading of osteophytes in the WORMS criterion

4) Subchondral sclerosis:

Subchondral sclerosis on MRI is characterized by ill-defined areas in direct contact with the subchondral bone, exhibiting low signal intensity across all fast spin-echo (FSE) pulse sequences. The severity of sclerosis in the medial tibial plateau is graded from 0 to 3 based on the extent of involvement: Grade 0 = none; Grade 1 = <25% of the area; Grade 2 = 25% to 50% of the area; Grade 3 = >50% of the area [Figure 5].

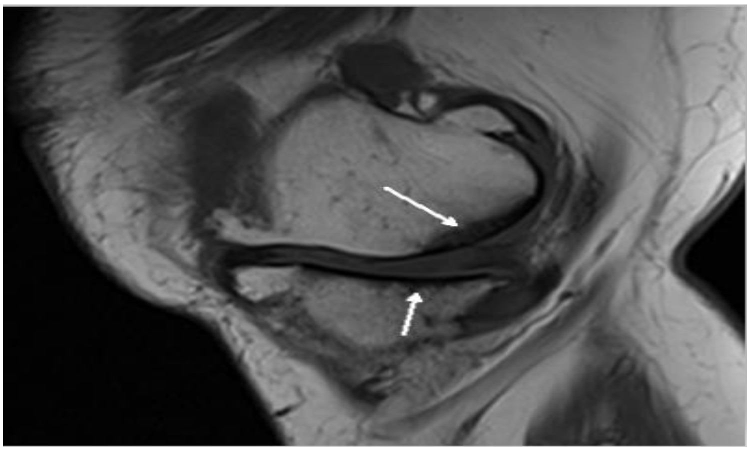

Figure 5. Subchondral sclerosis

Data were analyzed using SPSS version 26 software. The Shapiro-Wilk test was employed to assess the assumption of normality for demographic and clinical factors at the beginning of the study, as well as for the distribution of the investigated outcomes. The homogeneity of variances was tested using Levene's test. For normally distributed variables, the mean and standard deviation were reported, while for non-normally distributed variables, the median and interquartile range were reported. A paired t-test was used to analyze intra-group results, and the Wilcoxon test was applied for non-normally distributed variables. To compare between groups, a one-way ANOVA was used for normally distributed variables, and the Kruskal-Wallis test was used for non-normally distributed variables. If a significant difference was found between the three groups, Tukey's and Dunn's post hoc tests were applied to identify the superior group. Frequency and percentage were used to report qualitative data. The significance level in this study was set at less than 0.05.

Results

The average age of the participants was 61.16 ± 6.56 years, and the average body mass index (BMI) was 28.3 ± 3.07 kg/m^2. The platelet concentration in the single and double centrifugation groups was equivalent to 2 and 3 times the baseline level, respectively.

The results of this study showed that, in the intra-group comparison, the placebo group only demonstrated a slight improvement in VAS during the follow-up. At the same time, stair climbing, ROM, and the overall WORMS score for osteophytes did not improve [Table 1]. However, in both the single and double centrifugation groups, all variables significantly enhanced compared to the pre-intervention state [Table 1].

The severity of sclerosis worsened after the intervention in the placebo group, while it improved in the PRP groups [Table 2].

In the comparison between the three groups, six months after the intervention, the mean VAS, TUG, and WOMAC scores in the two PRP groups were significantly lower than those in the placebo group. Additionally, the mean values for the six-minute walk test, stair climbing, ROM, and the thickness of the medial tibial and patellar cartilage were significantly higher in the PRP groups compared to the placebo group [Table 1].

Furthermore, after the intervention, the severity of sclerosis was significantly lower in both PRP groups than in the placebo group [Table 2].

However, the mean overall WORMS scores for osteophytes and subchondral cysts did not differ significantly between the groups. The PRP groups did not show a significant difference in reducing the rate of osteophytes and subchondral cysts compared to the placebo group [Table 1].

Table 1. Efficacy of Single and Double Centrifuged Platelet-Rich Plasma on Pain and Function in Knee Osteoarthritis Patients: Pre- and Post-Intervention Outcomes

	Group	Pre-intervention	Post-intervention	p-value
VAS	Single centrifuged PRP	7.0 (6.0, 8.0)	3.10 ± 1.29	<0.001
	Double-centrifuged PRP	7.0 (6.0, 8.0)	2.71 ± 2.03	<0.001
	Placebo	7.0 (7.0, 8.0)	6.20 ± 2.04	0.019
			<0.001	
6 MWT	Single centrifuged PRP	448.14 ± 117.17	493.60 ± 133.80	0.038
	Double-centrifuged PRP	449.76 ± 106.96	501.19 ± 78.92	<0.001
	Placebo	412.10 ± 107.65	398.60 ± 103.28	0.273
			0.005	
TUG	Single centrifuged PRP	12.0 (11.0, 12.0)	9.45 ± 2.01	0.046
	Double-centrifuged PRP	12.0 (8.0, 13.0)	9.81 ± 2.04	0.001
	Placebo	13.0 (10.0, 15.0)	11.80 ± 2.65	0.831
			0.003	
Stair Up Test	Single centrifuged PRP	20.33 ± 5.56	23.50 ± 9.27	0.006
	Double-centrifuged PRP	21.48 ± 6.99	26.05 ± 8.72	<0.001
	Placebo	17.33 ± 4.03	14.60 ± 3.73	<0.001
			<0.001	
ROM	Single centrifuged PRP	115.0 (100.0,125.0)	130.0 (122.5,132.5)	<0.001
	Double-centrifuged PRP	110.0 (100.0,115.0)	130.0 (125.0,130.0)	<0.001
	Placebo	105.0 (100.0,110.0)	100.0 (95.0,107.5)	0.039
			<0.001	
WOMAC Total	Single centrifuged PRP	48.38 ± 10.28	21.60 ± 11.73	<0.001
	Double-centrifuged PRP	52.05 ± 18.76	21.47 ± 20.54	<0.001
	Placebo	54.57 ± 14.64	52.45 ± 18.32	0.768
			<0.001	
WOMAC pain	Single centrifuged PRP	11.0 (10.0, 14.0)	5.0 (3.0, 5.0)	0.263
	Double-centrifuged PRP	10.0 (7.0, 15.0)	2.0 (1.0, 7.0)	<0.001
	Placebo	12.0 (9.0, 14.0)	11.0 (6.5, 14.5)	<0.001
			<0.001	
WOMAC function	Single centrifuged PRP	31.0 (27.0, 39.0)	17.0 (8.0, 18.0)	<0.001
	Double-centrifuged PRP	34.0 (25.0, 49.0)	17.0 (3.0, 20.0)	<0.001
	Placebo	40.0 (31.0, 51.0)	39.0 (26.0, 50.0)	0.931
			<0.001	
WOMAC Stiffness	Single centrifuged PRP	4.0 (4.0, 5.0)	2.0 (1.5, 2.0)	0.001
	Double-centrifuged PRP	4.0 (2.0, 6.0)	2.0 (0.0, 3.0)	<0.001
	Placebo	6.0 (4.0, 6.0)	5.0 (3.0, 6.0)	0.109
			<0.001	

Table 1. Continued

Medial tibial cartilage thickness	Single centrifuged PRP	2.0 (1.0, 2.0)	2.3 (2.0, 3.0)	0.001
	Double-centrifuged PRP	2.0 (1.0, 2.3)	3.0 (2.0, 3.0)	<0.001
	Placebo	1.5 (0.0, 2.0)	1.5 (0.0, 2.3)	0.066
		0.009		
Patella cartilage thickness	Single centrifuged PRP	2.0 (1.0, 2.0)	2.3 (2.0, 3.0)	0.002
	Double-centrifuged PRP	2.0 (1.0, 2.3)	3.0 (2.0, 3.0)	<0.001
	Placebo	1.0 (0.0, 1.5)	1.5 (0.0, 2.3)	0.785
		0.020		
WORMS score of osteophyte	Single centrifuged PRP	12.0 (7.0, 20.0)	9.0 (5.0, 24.0)	0.017
	Double-centrifuged PRP	11.0 (6.0, 22.0)	10.0 (2.0, 18.0)	0.001
	Placebo	10.0 (5.0, 35.0)	12.0 (7.0, 20.0)	0.011
		0.480		
WORMS score subchondral cyst	Single centrifuged PRP	3(0.0, 10.0)	2(0.0, 7.5)	0.004
	Double-centrifuged PRP	8.0 (4.0, 10.0)	4(1.0, 5.0)	0.001
	Placebo	4.0 (0.0, 15.0)	5.0 (0.0, 14.0)	0.221
		0.559		

Note: P-value <0.05 was considered significant

Table 2. Distribution of Sclerosis Severity in Knee Osteoarthritis Patients: Comparison of Single and Double Centrifuged Platelet-Rich Plasma and Placebo Pre- and Post-Intervention

Sclerosis		**Group**			**Total**	**P-value**
		Placebo	**Single centrifuge PRP**	**Double centrifuge PRP**		
Pre intervention	*None*	1	3	0	4	0.398
		4.80%	14.30%	0.00%	6.30%	
	Mild	3	5	7	15	
		14.30%	23.80%	33.30%	23.80%	
	Moderate	10	10	10	30	
		47.60%	47.60%	47.60%	47.60%	
	Severe	7	3	4	14	
		33.30%	14.30%	19.00%	22.20%	
Post intervention	*None*	1	3	0	4	<0.001
		5.00%	15.00%	0.00%	6.60%	
	Mild	3	7	16	26	
		15.00%	35.00%	76.20%	42.60%	
	Moderate	9	9	3	21	
		45.00%	45.00%	14.30%	34.40%	
	Severe	7	1	2	10	
		35.00%	5.00%	9.50%	16.40%	

Note: P-value <0.05 was considered significant

Discussion

The treatment of knee osteoarthritis aims to control pain, improve function, and reduce disability. Non-surgical methods, including intra-articular injections of platelet-rich plasma (PRP), corticosteroids, and hyaluronic acid, are particularly popular among younger patients and those with lower grades of osteoarthritis. Studies suggest that PRP injections are more effective than other methods in reducing pain and improving function in patients.[5-7] Most studies focus on the impact of these treatments on patients' subjective experiences, including clinical symptoms, function, and quality of life. At the same time, only a few have addressed the objective changes in knee articular cartilage and surrounding tissues. Various imaging techniques can be used to assess these objective changes following PRP treatment. One of the most important imaging modalities for examining articular cartilage and other soft tissues around the joint is MRI.[8,9] The findings of the present study indicated that, in intra-group comparisons, only the VAS variable showed slight improvement in the placebo group six months after the intervention. At the same time, stair climbing, range of motion, overall WORMS score, osteophyte scores, and severity of sclerosis worsened. In contrast, both the single and double centrifugation groups showed significant improvements in all variables compared to baseline measurements. These results suggest that the interventions in both PRP groups were effective in reducing pain, increasing knee range of motion, improving patient functionality, and enhancing articular cartilage, with a more significant overall improvement observed in the PRP injection groups compared to the placebo group. In our study, the thickness of the medial tibial cartilage and patellar cartilage after the intervention was significantly greater in the single and double centrifugation groups compared to the placebo group. Additionally, the severity of sclerosis after the intervention was significantly lower in these groups than in the placebo group. However, the mean overall WORMS score for osteophytes and subchondral cysts showed no significant differences among the studied groups, and the PRP groups did not show a statistically significant difference from the placebo group in reducing the levels of osteophytes and subchondral cysts. In a study by Halpern et al,[10] the effects of a single platelet-rich plasma (PRP) injection on clinical symptoms and MRI findings in the knees of 15 patients with osteoarthritis were examined. It was found that after 6 and 12 months, 12 out of 15 knees (80%) showed no changes in the severity of patellofemoral osteoarthritis on MRI. Additionally, no radiological changes were observed in the lateral tibiofemoral joint of 12 knees (80%) over one year. Similarly, no changes in the internal tibiofemoral joint involvement were reported in 73.3% of cases, although one knee showed radiological improvement after one year. The authors noted that some studies have reported an annual reduction of 4 to 6 percent in cartilage volume in osteoarthritic compartments. While this study did not demonstrate any increase in cartilage thickness, it also did not show any cartilage loss. The most likely significant reason for the differences in results between our study and the mentioned research is the type of study; Halpern's study was a pilot, limited case series with a small sample size. Hart et al[11] investigated the effect of PRP injection in the knees of 50 patients with grades 2 and 3 chondromalacia in 2013. Each participant received a total of 9 PRP injections, starting with the first injection 6 weeks after the initial arthroscopy, followed by five weekly injections and then three additional injections at 3-month intervals. MRI assessments were conducted before and one year after the study to evaluate cartilage thickness and regeneration in the tibiofemoral joint. The results showed that after one year, cartilage thickness increased in 3 cases (6%), remained unchanged in 47 cases (94%), and did not decrease in any case, with the increase in thickness being less than 1 mm in those three instances. MRI did not reveal any significant improvements in cartilage status, which was inconsistent with our findings. Possible reasons for this discrepancy include differences in the PRP preparation kit used, methods of PRP preparation and centrifugation, as well as the absence of a placebo group. Additionally, the methods for measuring cartilage thickness were not clearly described in the published article. In a study conducted by Samara et al,[12] it was found that the use of autologous platelet lysate significantly improved cartilage thickness on MRI after one year of follow-up. These results align with our findings.

In contrast, the study by Buendía-López et al.[13] showed no increase in cartilage thickness in the femoral and tibial regions when comparing double-centrifuged PRP, hyaluronic acid, and NSAIDs. The difference in results between these two studies may be attributed to variations in the methodology used to measure cartilage and its location. Samara et al. studied the effects of autologous platelet lysate on cartilage using MRI, finding a significant improvement in cartilage thickness on both sides of the tibiofemoral joint after one year, which aligns with our findings. However, Buendía-López and colleagues observed no increase in cartilage thickness in the femoral and tibial regions when comparing double-centrifuged PRP, hyaluronic acid, and NSAIDs. The differences in results may be due to the measurement methods and cartilage locations; our study measured thickness only in the medial tibia and patella, while Buendía-López assessed 16 sites in the femur and 24 in the tibia, reporting averages. Additionally, Raeissadat et al. noted the significant effects of PRP on radiological characteristics, such as patellofemoral cartilage volume and synovitis, which corroborates our findings. The study by Bennell et al.[14] showed that intra-articular injection of PRP did not result in a significant difference in the volume of the internal tibial cartilage compared to placebo (normal saline) after 12 months, which is not consistent with our findings. One of the main reasons for this discrepancy is the method of PRP preparation in the Bennell study. The PRP used in their research resembled plasma, with low white and red blood cell counts, as the platelet concentration was reported to be 1.2 times the baseline. In contrast, in our study, this value was 2 times for the single centrifugation group and 3 times for the double centrifugation group. Due to the low dose of platelets, the PRP used in the Bennell study likely did not reach the therapeutic threshold. In a randomized controlled trial (RCT) conducted by Tshopp et al., 120 patients with mild to moderate knee osteoarthritis were divided into 4 groups, each receiving one of the following injections: PRP, HA, glucocorticoid, and placebo (contrast agent). Results showed that platelet-rich plasma injection had a positive effect on the thickness of the medial femoral condyle cartilage compared with glucocorticoid group and medial tibial plateau compared with the placebo group. Glucocorticoid, PRP, or hyaluronic acid injection did not show a better effect on the rate of osteophytes and subchondral cysts compared with placebo in the short or long term.[15]

Fatima and colleagues conducted a study on the effects of PRP on knee cartilage in patients with osteoarthritis. They found that intra-articular PRP injection for knee osteoarthritis had a positive effect on VAS and WOMAC, but no significant changes in articular cartilage were observed by MRI. The small sample size (33 cases) and the lack of a control group could be the reasons for the differences in the results of our study.[16]

A study by Gozel et al., conducted on athletes with knee cartilage injuries, showed that PRP resulted in a greater reduction in VAS and a greater improvement in KOOS scores compared to HA. Examination of articular cartilage using MRI showed that PRP treatment was significantly better at restoring cartilage, especially in the patella and medial femoral condyle regions.[17]

In addition to pain, reduced range of motion in the knee is another common complication of osteoarthritis. The results showed that the PRP groups had a significant improvement compared to the control group after six months, while the control group did not demonstrate any positive effect in this regard. In functional tests, the PRP groups also exhibited significant improvement compared to the control group, confirming the positive impact of therapeutic exercise alongside PRP injection. Furthermore, assessments using the WOMAC questionnaire indicated that both PRP groups were effective in improving patient conditions, and overall, both PRP techniques showed better outcomes compared to the placebo group. In conclusion, treatment of knee osteoarthritis using PRP, primarily through two centrifugation methods, can lead to pain reduction, improved range of motion, and enhanced patient performance.

One of the main limitations of this study was the onset of the COVID-19 pandemic, which led to a sudden reduction in the number of available samples. Additionally, some eligible patients declined to participate, despite being informed of the study's benefits. There was also a lack of sufficient referrals from specialists, and the distance of the treatment center from patients' homes, along with transportation issues, posed significant challenges. Increased pain in some patients and requests for repeat injections, particularly in the placebo group, further complicated the situation. The study's findings indicated that both the single and double centrifugation methods for preparing platelet-rich plasma (PRP) had a significant positive impact on reducing pain and improving function and range of motion in patients with knee osteoarthritis, suggesting that various specialists can utilize these methods. Recommendations for future research include more extended follow-up periods (12 months or more), investigating the differences between single and multiple PRP injections, conducting the study in a multicenter format, and assessing cartilage thickness in other knee compartments using MRI.

Conclusion

The study found that both the single and double centrifugation methods were effective in reducing pain, improving range of motion, and increasing cartilage thickness. No significant difference was observed between the two methods; however, a more extended follow-up period may provide further insights.

Acknowledgement

We thank all those who helped us in this way, including the respected radiologist Dr. Hadi Akbarzadeh, as well as the officials of Iran University of Medical Sciences and the MRI imaging department of Rasoul Akram Hospital.

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Declaration of Conflict of Interest: The authors do not have any potential conflicts of interest for this manuscript.

Declaration of Funding: This study project is financially supported by a grant from Iran University of medical sciences

Declaration of Ethical Approval for Study: This research was done with the approval of the ethical committee of the research assistant at the Iran University of Medical Sciences with the code IR.IUMS.FMD.REC.1400.236 and registered in the Iran Clinical Trial Registration Center (IRCT) with the code IRCT20211016052782N.

Declaration of Informed Consent: There is no information (names, initials, hospital identification numbers, or photographs) in the submitted manuscript that can be used to identify patients.

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