Platelet-rich Plasma Combined with Arthroscopic Microfracture for the Treatment of Knee Cartilage Injury

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Abstract

Background: Knee articular cartilage injury is a prevalent clinical condition characterized by limited intrinsic repair capacity. Arthroscopic microfracture is the most commonly performed surgical intervention for this injury; however, its long-term repair outcomes remain suboptimal. Platelet-rich plasma (PRP), a biological product enriched with multiple growth factors, has been shown to promote cartilage regeneration and repair. This study aimed to evaluate the clinical efficacy and safety of PRP combined with arthroscopic microfracture in the treatment of knee cartilage injury. Methods: A total of 80 patients diagnosed with knee cartilage injury who were admitted to our hospital between January 2022 and December 2023 were randomly assigned to either the control group (n=40) or the observation group (n=40). Patients in the control group underwent arthroscopic microfracture alone, while those in the observation group received PRP combined with arthroscopic microfracture. Intraoperative and postoperative outcomes, including operation time, hospital stay, Lysholm knee score, International Knee Documentation Committee (IKDC) score, Visual Analog Scale (VAS) pain score, 36-Item Short Form Health Survey (SF-36) score, and incidence of complications, were compared between the two groups. Results: There were no statistically significant differences in operation time or hospital stay between the two groups ($p>0.05$). At 3 and 6 months postoperatively, the Lysholm score, IKDC score, and SF-36 score in the observation group were significantly higher than those in the control group, whereas the VAS score was significantly lower (all $p<0.05$). The complication rate was 5.00% (2/40) in the observation group and 20.00% (8/40) in the control group, with a statistically significant difference between the two groups ($p<0.05$). Conclusion: The combination of PRP and arthroscopic microfracture can significantly improve knee joint function, alleviate pain, and enhance the quality of life in patients with knee cartilage injury, with a favorable safety profile. This combined approach is therefore worthy of clinical promotion and application.

Keywords

Platelet-rich plasma, Arthroscopy, Microfracture, Knee cartilage injury, Knee joint function

Introduction

Knee articular cartilage injury, primarily caused by trauma or age-related degeneration, often results in persistent pain, joint swelling, and impaired motor function, severely affecting patients' quality of life. Due to the avascular nature of articular cartilage, its self-repair ability is extremely limited once damaged. Arthroscopic microfracture is a widely used minimally invasive surgical technique that induces the migration of bone marrow mesenchymal stem cells (BMSCs) to the injury site, thereby promoting cartilage repair [1]. However, the tissue regenerated via this method is mostly fibrocartilage, which has inferior mechanical properties and durability compared to native hyaline cartilage, leading to unsatisfactory long-term therapeutic effects [2,3].

Platelet-rich plasma (PRP) is derived from autologous whole blood through centrifugation, which concentrates platelets to a level significantly higher than that in peripheral blood. Platelets within PRP can release a variety of growth factors, such as transforming growth factor-β (TGF-β), vascular endothelial growth factor (VEGF), and insulin-like growth factor (IGF), which play crucial roles in promoting cell proliferation, migration, and cartilage matrix synthesis. In recent years, PRP has been increasingly applied in the field of orthopedic tissue repair, but high-quality clinical

evidence supporting its combination with arthroscopic microfracture for knee cartilage injury remains scarce. Therefore, this study was designed to compare the clinical outcomes of PRP combined with arthroscopic microfracture versus arthroscopic microfracture alone, aiming to provide a reliable reference for clinical treatment decision-making [4-6].

Materials and methods

Subjects

Eighty patients with knee cartilage injury who met the inclusion criteria were enrolled in this study. The inclusion criteria were as follows: (1) Diagnosis of knee cartilage injury confirmed by preoperative physical examination and magnetic resonance imaging (MRI). (2) Cartilage injury graded as Outerbridge III-IV. (3) Age ranging from 18 to 65 years old. (4) Completing clinical and follow-up data. (5) Voluntary participation in the study and signed informed consent. The exclusion criteria included: (1) Complicated with intra-articular fracture, ligament tear, or meniscal injury requiring surgical repair. (2) Presence of severe systemic diseases (e.g., severe heart, liver, or kidney disease). (3) Coagulation disorders or history of bleeding tendency. (4) Previous knee joint surgery. (5) Allergic to PRP components.

Grouping and intervention

Using a random number table, the enrolled patients were divided into the control group and the observation group, with 40 patients in each group. Both groups underwent arthroscopic surgery under spinal anesthesia. For the control group: After arthroscopic exploration to confirm the location and extent of cartilage injury, a microfracture awl was used to create multiple small holes (diameter: 3-4 mm, spacing: 3-4 mm) perpendicular to the cartilage defect surface, penetrating the subchondral bone plate until bone marrow blood oozed out. The joint cavity was rinsed thoroughly, and the incision was sutured.

For the observation group: Arthroscopic microfracture was performed using the same method as the control group. Prior to surgery, 20 mL of autologous venous blood was collected from the patient and placed in an anticoagulant tube. PRP was prepared using a secondary centrifugation method: First centrifugation at 1,500 r/min for 10 min to separate red blood cells from plasma; the upper plasma layer was transferred to another centrifuge tube for secondary centrifugation at 3,000 r/min for 15 min [7]. After centrifugation, the upper platelet-poor plasma was discarded, and the remaining 2-3 mL of PRP was collected. Immediately after microfracture, the prepared PRP was evenly sprayed onto the cartilage defect area using a syringe, and the joint cavity was closed after 5 min of static adsorption. Postoperative management was identical for both groups: Antibiotics were administered for 24 h to prevent infection, and patients were guided to perform progressive knee joint functional exercises under the supervision of physical therapists.

Outcome measures

(1) Intraoperative and hospitalization indicators: operation time (from skin incision to suture completion) and hospital stay (from admission to discharge).

(2) Knee joint function scores: Lysholm score and IKDC score were evaluated preoperatively and at 3, 6 months postoperatively [8]. The Lysholm score assesses knee function based on pain, swelling, instability, and activity level, with a maximum score of 100 (higher scores indicate better function). The IKDC score evaluates knee joint morphology and function, with a maximum score of 100 (higher scores indicate better function).

(3) Pain assessment: VAS score was used to evaluate pain intensity preoperatively and at 3, 6 months postoperatively. The VAS score ranges from 0 to 10, with 0 indicating no pain and 10 indicating severe pain (lower scores indicate less pain).

(4) Quality of life: SF-36 score was evaluated preoperatively and at 6 months postoperatively. The SF-36 score includes 8 dimensions (physical function, role physical, bodily pain, general health, vitality, social function, role emotional, mental health), with a total score of 100 (higher scores indicate better quality of life).

(5) Complications: Incidence of postoperative complications such as joint effusion, infection, and nerve injury was recorded.

Statistical analysis

All statistical analyses were performed using SPSS 25.0 statistical software. Measurement data were expressed as mean ± standard deviation (x±s), and comparisons between groups were conducted using independent samples t-test. Repeated measures analysis of variance (ANOVA) was used to compare the changes in scores at different time points within groups, followed by Bonferroni post-hoc test. Enumeration data were

expressed as n (%), and comparisons between groups were performed using χ^2 test. $p<0.05$ was considered statistically significant.

Results

Baseline data

Baseline clinical data including gender composition, patient age, disease duration, cartilage defect area and Outerbridge lesion grading were collected and statistically compared between the control group and observation group, with 40 subjects enrolled in each group. Count data such as gender distribution and Outerbridge classification grade were analyzed by the chi-square test, while measurement data conforming to normal distribution including age, course of disease and defect areas were expressed as mean ± standard deviation (x±s) and compared via independent-samples t test. The statistical results showed that the t values for gender and Outerbridge classification were 0.200 and 0.267, with corresponding p-value of 0.655 and 0.605 respectively; the t-values of age, course of disease and defect area were 0.386, 0.602 and 0.645, and their p-values were 0.701, 0.549 and 0.520 in sequence. All the above p-values were greater than the significance level of 0.05, which meant there existed no statistically intergroup differences in all baseline indicators mentioned above. It could be concluded that the demographic and disease-related baseline characteristics of patients in the two groups were well balanced and homogeneous, eliminating the confounding interference from basic clinical factors on subsequent efficacy evaluation, so the two groups possessed good comparability for further observation and statistical analysis (see Table 1).

Table 1. Comparison of baseline data between the two groups (x±s).

Indicator	Control group (n=40)	Observation group (n=40)	t value	p value
Gender (male/female)	22/18	24/16	0.200	0.655
Age (years old)	42.3±8.5	43.1±7.9	0.386	0.701
Course of disease (months)	6.8±2.3	7.1±2.1	0.602	0.549
Defect area (cm^2)	2.8±0.7	2.9±0.6	0.645	0.520
Outerbridge classification (III/IV)	25/15	23/17	0.267	0.605

Operation indicators

We recorded and compared two key intraoperative and perioperative indexes between groups. The operation time of the control group was 60.7±7.9 min, and that of the observation group was 62.3±8.5 min; the hospital stay of the control group was 5.0±1.0 d, and that of the observation group was 5.2±1.1 d. Independent-samples t test revealed there were no significant differences in operation time or hospital stay between the two groups (both $p>0.05$) (see Table 2).

Table 2. Comparison of operation time and hospital stay between the two groups (x±s).

Indicator	Control group (n=40)	Observation group (n=40)	t value	p value
Operation time (min)	60.7±7.9	62.3±8.5	0.789	0.432
Hospital stay (d)	5.0±1.0	5.2±1.1	0.756	0.451

Knee function and pain

We evaluated knee joint function and pain severity using Lysholm, IKDC and VAS scales. Preoperatively, there were no significant differences in Lysholm score, IKDC score, or VAS score between the two groups (all $p>0.05$). At 3 and 6 months postoperatively, the Lysholm score and IKDC score in both groups were significantly higher than those preoperatively, and the VAS score was significantly lower than that preoperatively (all $p<0.05$). Moreover, the Lysholm score and IKDC score in the observation group were significantly higher than those in the control group, and the VAS score was significantly lower than that in the control group at the same time points (all $p<0.05$) (see Table 3).

Table 3. Comparison of Lysholm, IKDC and VAS scores between the two groups at different time points (x±s).

Indicator	Group	Preoperation	3 months postoperation	6 months postoperation
Lysholm score	Control group	58.3±6.2	72.5±5.8△	78.6±5.3△
	Observation group	57.9±6.5	79.3±5.5△#	86.2±4.9△#

Indicator	Group	Preoperation	3 months postoperation	6 months postoperation
IKDC score	Control group	56.7±5.9	70.2±5.4△	76.5±4.8△
	Observation group	56.3±6.1	77.5±5.1△#	84.1±4.5△#
VAS score	Control group	7.2±1.3	4.1±1.1△	3.2±0.9△
	Observation group	7.3±1.2	2.8±0.8△#	1.9±0.7△#

Note: △p<0.05 compared with preoperation; #p<0.05 compared with control group at the same time point.

Quality of life

We adopted the SF-36 scale to evaluate patients' overall quality of life. Preoperatively, there was no significant difference in SF-36 score between the two groups (p>0.05). At 6 months postoperatively, the SF-36 score in both groups was significantly increased compared with that preoperatively (p<0.05), and the SF-36 score in the observation group (82.3±6.5) was significantly higher than that in the control group (73.5±5.8) (p<0.05) (see Table 4).

Table 4. Comparison of SF-36 scores between the two groups preoperatively and at 6 months postoperatively.

Time point	Control mean	Control SD	Observation mean	Observation SD
Pre-op	70.2	6.1	69.8*	5.9
6 months post-op	73.5	5.8	82.3#	6.5

Note: *p<0.05 compared with preoperation; #p < 0.05 compared with control group at 6 months postoperatively.

Complications

During the follow-up period, 2 cases of joint effusion occurred in the observation group, with a complication rate of 5.00%. In the control group, there were 4 cases of joint effusion, 2 cases of infection, and 2 cases of temporary nerve numbness, with a complication rate of 20.00%.

The complication rate of the observation group was significantly lower than that of the control group (χ^2=4.114, p=0.043) (see Table 5).

Table 5. Comparison of complication rates between the two groups.

Group	Total cases	Complications	Rate	Breakdown
Control	40	8	20.00%	4 joint effusion, 2 infection, 2 nerve numbness
Observation	40	2	5.00%*	2 joint effusion

Note: *p<0.05 compared with control group.

Discussion

Knee cartilage injury is a challenging clinical problem due to its limited self-repair capacity [9]. Arthroscopic microfracture is a classic minimally invasive treatment that promotes cartilage repair by inducing BMSCs migration. However, the regenerated fibrocartilage is prone to degeneration and wear, resulting in poor long-term outcomes [10]. In recent years, the application of biological agents such as PRP has provided new strategies for improving the efficacy of cartilage repair.

PRP contains a variety of growth factors that synergistically promote cartilage repair.

For example, TGF-β can stimulate BMSCs differentiation into chondrocytes and promote the synthesis of type II collagen and proteoglycan; VEGF can promote angiogenesis in the repair area, improving local blood supply and nutrient delivery; IGF can enhance chondrocyte proliferation and inhibit apoptosis.

In this study, the combination of PRP and arthroscopic microfracture significantly improved knee function scores (Lysholm and IKDC) and reduced pain (VAS score) compared with microfracture alone. This may be attributed to the growth factors in PRP enhancing the repair ability of microfracture, promoting the formation of cartilage-like tissue with better biological properties, and thus improving joint function and alleviating pain.

In terms of quality of life, the SF-36 score in the observation group was significantly higher than that in the control group at 6 months postoperatively, indicating that the combined treatment can better improve patients' overall quality of life. In addition, the complication rate of the observation group was significantly lower than that of the control group, suggesting that PRP may have anti-inflammatory and antibacterial effects, reducing the risk

of postoperative joint effusion and infection. This is consistent with previous studies that have shown that PRP can regulate the local inflammatory response and promote tissue healing.

This study has several limitations. First, the follow-up time was relatively short (6 months), and the long-term efficacy and durability of the combined treatment need to be verified by longer-term follow-up. Second, this was a single-center study with a relatively small sample size, which may limit the generalizability of the results. Future studies should include multi-center, large-sample, and long-term follow-up to further confirm the clinical value of PRP combined with arthroscopic microfracture.

Conclusion

Platelet-rich plasma combined with arthroscopic microfracture is a safe and effective regenerative therapy for Outerbridge grade III-IV knee cartilage injury. As hypothesized, autologous PRP plus microfracture achieves better short-term outcomes than microfracture alone. Locally injected PRP, abundant in chondrogenic growth factors, remodels the cartilage repair microenvironment: It raises Lysholm and IKDC knee function scores, reduces VAS pain scores, and improves 6-month SF-36 quality-of-life scores. Moreover, this combined treatment mitigates postoperative inflammatory reactions and lowers risks of complications such as joint effusion and surgical infection. Despite limitations of single-center data and only 6 months of follow-up, our statistical results confirm its strengths in early functional recovery and surgical safety. With easy preparation, autologous biosafety and good compatibility with minimally invasive arthroscopy, PRP-augmented microfracture deserves broader clinical use for moderate to severe knee cartilage lesions. Future multi-center, large-cohort trials with prolonged follow-up are needed to verify its long-term cartilage repair durability.

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Conflicts of Interest

The authors declare no conflict of interest.

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