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RESEARCH

Efficacy of arthroscopic cartilage transplantation combined with platelet-rich plasma in the treatment of early knee osteoarthritis: a retrospective cohort study

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Abstract

Background Knee osteoarthritis (KOA) is a common degenerative disease that leads to functional decline in the knee joint and a significant reduction in quality of life. Arthroscopic cartilage transplantation combined with platelet-rich plasma (ACT-PRP) has emerged as a novel treatment method and is gradually being applied to patients with early KOA. This study aimed to evaluate the therapeutic efficacy of ACT-PRP compared to conventional conservative treatment.

Methods Patients diagnosed with KOA who were treated in the Department of Orthopedics at the First People's Hospital of Lianyungang from January 2020 to January 2022 were included in the study. Patients were divided into two groups: the ACT-PRP group, receiving arthroscopic cartilage transplantation combined with PRP, and the conservative treatment group, receiving standard conservative treatment. All patients were followed for six months, and knee function and pain relief were assessed using the Lysholm score, IKDC score, KOOS, and VAS.

Results A total of 113 patients were enrolled, with 43 in the ACT-PRP group and 70 in the conservative treatment group. Baseline characteristics showed no significant differences ($P>0.05$). At the final follow-up, the ACT-PRP group showed greater improvements in knee function and pain relief compared to the conservative treatment group, with significantly higher Lysholm score ($P<0.001$), IKDC score ($P<0.001$), and KOOS ($P<0.001$), and lower VAS ($P<0.001$). These findings suggest the ACT-PRP approach is more effective for early knee osteoarthritis.

Conclusions Arthroscopic cartilage transplantation combined with platelet-rich plasma is significantly superior to conventional conservative treatment in improving knee function, alleviating pain, and enhancing patient satisfaction, making it a recommended option for early KOA.

Keywords Knee osteoarthritis · Arthroscopic cartilage transplantation · Platelet-rich plasma · Conservative treatment

Background

Knee osteoarthritis (KOA) is a degenerative joint disease that primarily affects the knee, causing the breakdown of articular cartilage. This leads to pain, swelling, and stiffness, ultimately resulting in a loss of joint function [1, 2]. Due to its high prevalence in the general population and the gradual increase in disability that may result, it places a heavy socioeconomic burden on society [3]. In recent years, there has been increasing evidence that interventional therapy in the early stages of the disease may provide more significant benefits, and that early identification of patients with OA and interventions can effectively promote the repair and reconstruction of mildly damaged cartilage, thereby slowing down or even reversing the progression of osteoarthritis [1, 4, 5].

Traditional conservative treatments, such as physical therapy and non-steroidal anti-inflammatory drugs (NSAIDs), primarily address symptoms but do not halt cartilage degeneration or prevent further progression of the disease [4, 6]. The arthroscopic cartilage transplantation (ACT) technique is now widely used [7]. In this technique, one or more autologous osteochondral grafts are extracted from the minimal weight-bearing area within the joint and transplanted to

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the site of cartilage injury [8]. The main advantage of this procedure is the ability to achieve rapid subchondral graft healing and reconstruction of the original type II hyaline cartilage tissue on the articular surface [9]. In contrast, local injection of platelet-rich plasma (PRP) therapy is a therapeutic approach that has received much attention in recent years [10]. A large body of literature confirms that PRP has positive effects in reducing pain and improving function [11–13].PRP is platelet-rich, and through the release of a variety of growth factors and bioactive proteins, it is able to attract cartilage-derived cells and stimulate chondrogenic proliferation, promote cartilage matrix synthesis, and thus enhance cartilage repair [14]. In addition, PRP can inhibit the inflammatory response of local synovium and soft tissues, providing a favorable microenvironment for articular cartilage repair [15].

This study aims to evaluate the clinical efficacy of ACT-PRP in the treatment of early knee osteoarthritis and compare its outcomes to those of traditional conservative therapies.

Methods

Study design

This is a single-center, retrospective cohort study to evaluate the efficacy of arthroscopic cartilage transplantation combined with platelet-rich plasma (ACT-PRP) in the treatment of early knee osteoarthritis and to compare the outcomes with those of conservative treatments. The study population consisted of knee osteoarthritis patients who received treatment from January 2020 to January 2022 in the Department of Orthopedics of the First People's Hospital of Lianyungang. All patients were divided into two groups according to the treatment protocol: the ACT-PRP group and the conservative treatment group. All patients were followed up for 6 months after treatment, and knee function and pain relief were assessed by the Lysholm score, the International Knee Documentation Committee (IKDC) score, the Knee Injury and Osteoarthritis Outcome Score (KOOS), and the visual analogue score (VAS).

Diagnosis of early knee osteoarthritis

Three classes of criteria were agreed: (1) Pain, symptoms/signs, self-reported function, and quality of life using tools such as KOOS: scoring≤85% in at least 2 out of these 4 categories; (2) Clinical examination: at least 1 present out of joint line tenderness or crepitus; (3) Knee radiographs: Kellgren & Lawrence grade of 0 or 1.

Inclusion criteria

The inclusion criteria will be as follows: (1)Patients who meet the diagnostic criteria for knee osteoarthritis (KOA) according to the Chinese Guidelines for the Diagnosis and Treatment of Osteoarthritis (2021 Edition).(2)Patients with complete imaging data, including X-rays, CT, and MRI.(3) Patients without contraindications to surgery and with clear surgical indications.(4)Patients with a postoperative follow-up period of more than 6 months.

Exclusion criteria

The exclusion criteria will be as follows: (1)Patients who have undergone open joint surgery. (2)Patients with rheumatic diseases, infectious arthritis, reactive arthritis, Kashin-Beck disease, gout, intra-articular tumors, or other specific joint diseases. (3)Patients with severe knee deformities. (4)Patients undergoing anticoagulant therapy during the perioperative period. (5)Patients with severe liver or kidney dysfunction, coagulation disorders, or mental disorders. (6)Patients with incomplete clinical data or those lost to follow-up during the study period.

Data collection

This study retrospectively collected clinical data on patients with early knee osteoarthritis who were treated from January 2020 to January 2022 in the Department of Orthopedics at the First People's Hospital of Lianyungang. Basic patient information, imaging data and follow-up visits were collected through the hospital's medical record system and image archiving and communication system (PACS).

PRP preparation

Whole blood (8 mL) was drawn from the antecubital vein via a 21G butterfly needle into a citrate-anticoagulated RegenTHT vacuum tube. After immediate gentle inversion to prevent coagulation, the tube underwent centrifugation at 1,500 g for 9 min in a pre-balanced fixed-angle centrifuge. Post-centrifugation stratification revealed three layers: erythrocytes, buffy coat, and platelet-poor plasma. For PRP extraction, the buffy layer and upper PPP were resuspended by gentle tube inversion, generating 4 mL PRP. Strict aseptic protocols were observed, including single-use sterile components and immediate administration (<2 h post-preparation).

Surgical methods

After successful anesthesia, routine disinfection and laying of sterile sheets, the affected limb was elevated and a pneumatic tourniquet was applied with a hemostatic time control of up to 90 min and a pressure setting of 50 kPa.The procedure was performed through the anterior inferior and medial-lateral entrances of the right knee, with each incision measuring approximately 0.5 cm in length.The articular cavity was accessed with a blunt cotter, and the arthroscope was inserted through the lateral entrance to fully expand the joint cavity. A probe is inserted through the medial portal to sequentially examine the suprapatellar bursa, medial intertrochanteric groove, medial articular space, intercondylar fossa, lateral articular space, and lateral intertrochanteric groove. After completing the examination, the cartilage region of the medial femoral condyle was trimmed and a bone groove was drilled at the weight-bearing center using a circular saw. Next, an autogenous bone column with cartilage was obtained from the center of the medial femoral trochanter in the non-weight-bearing region, and the column was immersed in platelet-rich plasma for 5 min, after which PRP was injected into the region of the bone groove and the bone column was pressed into it. The implantation of the bone column was confirmed to be secure during the procedure. Postoperatively, the joint cavity was flushed and the remaining PRP was injected into the knee joint cavity. At the end of the procedure, the affected knee could reach 5° hyperextension and 135° flexion without tissue obstruction. The entire procedure was completed successfully without significant bleeding. The tourniquet was released for 15 min at 60-minute intervals. At the end of the surgery, the affected limb was immobilized in a brace and returned to the ward. PRP injections were performed weekly for 3 consecutive weeks after the operation, along with functional knee rehabilitation exercises.

Data collection timeline

Data were collected at three time points: (1)Baseline: Prior to treatment, patient demographics, clinical history, and imaging data were collected. Outcome measures were assessed using the Lysholm score, IKDC score, KOOS, and VAS. (2)Interim: Follow-up assessments were conducted at 3 months post-treatment to monitor progress and assess initial improvements in knee function and pain relief. (3)Follow-up: At the 6-month follow-up, final evaluations were conducted to assess the long-term effects of ACT-PRP or conservative treatment on knee function.

Conservative treatment methods

Patients in the conservative treatment group received non-surgical management of knee osteoarthritis as per the standard care protocol. The conservative treatment included: (1)Pharmacological treatment: Non-steroidal anti-inflammatory drugs, analgesics, and chondroprotective agents to manage pain and inflammation.(2)Physical therapy: Targeted exercises to improve knee joint flexibility and strength, with an emphasis on low-impact activities. The frequency and intensity of physical therapy varied based on the patient's needs but typically involved sessions 2–3 times per week for the duration of the study. (3)Lifestyle modifications: Weight management through dietary guidance and physical activity promotion, as well as education on joint protection strategies.

Patients in the conservative treatment group followed this regimen for 6 months, with regular follow-ups to monitor their progress.

Statistical analysis

Statistical analyses were performed using SPSS software (version 27.0). Continuous variables were tested for normality using the Shapiro-Wilk test. Since many variables did not follow a normal distribution, nonparametric methods were applied, including the Mann-Whitney U test for continuous variables and the chi-square or Fisher's exact test for categorical variables. Clinical outcomes, such as Lysholm scores, IKDC scores, KOOS, and VAS, were assessed between groups at 6 months of follow-up using the Mann-Whitney U test. The U value represents the rank-based sum of differences between the two groups, which is appropriate for non-normally distributed data. Data were expressed as mean ± standard deviation for continuous variables and frequency for categorical variables. $p < 0.05$ was considered statistically significant.

Results

Comparison of patient general information

A total of 113 patients were enrolled in the study, including 43 in the ACT-PRP group and 70 in the conservative treatment group (Fig. 1). The demographic and clinical characteristics of the two groups are shown in Table 1. At baseline, the demographic and clinical characteristics of the two groups were comparable. Statistical analyses confirmed no significant differences between the groups regarding age, gender distribution, symptom duration, and other relevant characteristics ($p > 0.05$).

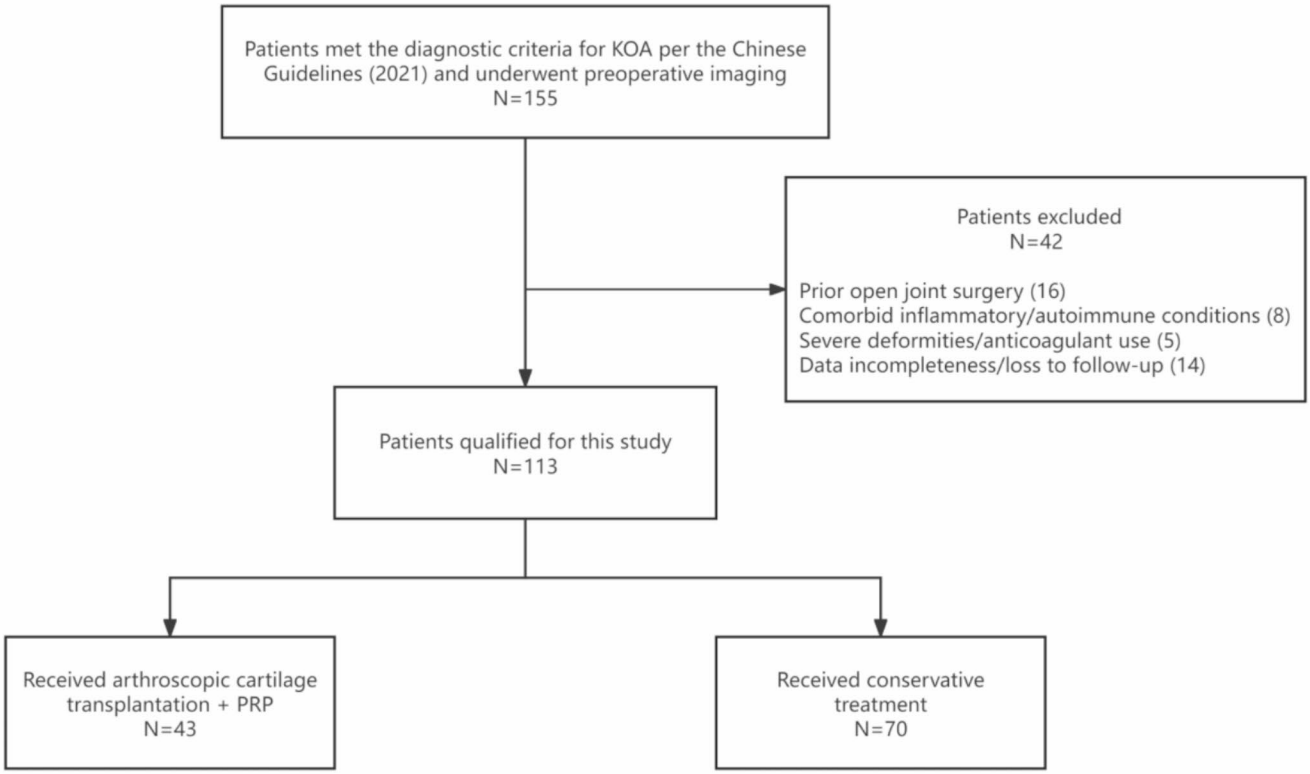

Fig. 1 Flowchart

Table 1 Baseline demographic and clinical characteristics of patients in the ACT-PRP and Conservative treatment groups

Group	Number of cases	Gender		Age (year)	Symptom duration	Follow-up duration(year)
		Male	Female			
ACT-PRP	43	20	23	44.12±5.97	12.19±2.61	12.00±2.469
conservative treatment	70	38	32	44.91±6.14	12.60±2.48	12.79±2.570
U/X^2		0.644		1700	1703	1769.5
p		0.422		0.248	0.237	0.114

Table 2 Comparison of clinical outcome scores between ACT-PRP and Conservative treatment groups

Group	Number of cases	Lysholm Score		IKDC Score		KOOS		VAS	
		Initial Lysholm Score	Final Lysholm Score	Initial IKDC Score	Final IKDC Score	Initial KOOS	Final KOOS	Initial VAS Score	Final VAS Score
ACT-PRP	43	53.53±3.541	56.30±3.686	56.30±5.374	89.05±4.169	81.12±2.084	89.51±4.169	6.02±0.740	1.33±0.993
Conservative treatment	70	53.29±3.754	70.00±3.514	53.97±5.888	75.54±4.671	80.39±2.330	85.06±4.173	6.34±0.899	3.54±1.510
U		1449.5	1.5	1189	46	1201.5	555	1739.5	2652.5
p		0.742	0.000	0.061	0.000	0.070	0.000	1.21	0.000

Comparison of knee joint function and clinical efficacy

Table 2 presents a comparison of the clinical outcome scores, including Lysholm, IKDC, KOOS, and VAS scores, between the two groups at baseline and follow-up. The results indicate that the ACT-PRP group showed significant improvements in knee function, pain relief, and quality of life compared to the conservative treatment group. Specifically, the ACT-PRP group demonstrated a significant increase in Lysholm, IKDC, and KOOS scores, as well as a notable reduction in VAS scores, reflecting better knee function and less pain. In contrast, the conservative treatment group showed less marked improvements in these outcomes.

Postoperative adverse events

The safety profile of ACT-PRP was favorable, with no reported cases of postoperative complications, including wound infection, joint adhesion, nerve injury, or adverse events such as pain, limping, or restricted range of motion in the donor site. Additionally, no patients required total knee arthroplasty during the study follow-up period. This supports the low-risk nature of ACT-PRP and highlights its safety as a treatment for early knee osteoarthritis.

Discussion

This study retrospectively analyzed the clinical effects of arthroscopic cartilage transplantation combined with PRP in the treatment of early knee osteoarthritis, and the results showed that the ACT-PRP treatment group was superior to the traditional conservative treatment group in terms of improvement of knee joint function, relief of pain, and improvement of the patients' quality of life, which confirmed the significant efficacy of the ACT-PRP treatment in patients with early KOA.

Knee osteoarthritis is a highly prevalent disease and a leading cause of disability worldwide, and its burden is expected to continue to increase in the coming decades [3]. The increasing number of total knee replacements performed each year reveals both the heavy burden borne by healthcare and the lack of available treatments in preventing disease progression [16]. The biological function of articular cartilage is critical to maintaining joint function, as it not only lubricates the joint, but also maximizes stress absorption and relief. Due to the lack of vasculature within cartilage, which receives its nutrition mainly through diffusion from perichondrial blood vessels, it has a very limited capacity for self-repair and is difficult to regenerate once damaged.

Previous studies have shown that ACT surgery has proven to be an effective treatment for cartilage defects in the knee [8, 17]. ACT surgery aims to repair damage and promote the restoration of joint function by grafting the patient's own healthy osteochondral cartilage onto the damaged articular surface. An analysis of reoperation rates after knee cartilage repair found that patients who underwent ACT had a lower incidence of reoperation compared to autologous chondrocyte implantation (ACI) [18]. Long-term follow-up studies have shown that most patients are able to maintain good joint function and quality of life after undergoing ACT [8, 9, 19]. Despite the significant progress that has been made in ACT surgery, extensive research efforts are still underway aimed at further refining this therapeutic technique. This includes the search for better quality material sources, optimization of surgical approaches, and the development of innovative biomaterials and techniques to facilitate effective cartilage repair and reconstruction [8, 20].

Platelet-rich plasma, an autologous blood product, is increasingly used for the treatment of musculoskeletal disorders, including chronic sports injuries and degenerative joint diseases, due to its high concentration of platelets in a small volume of plasma [12].The anabolic growth factors and anti-inflammatory cytokines enriched in PRP promote cell proliferation, migration, differentiation, angiogenesis, and biosynthesis of cartilage, thereby enhance cartilage anabolic processes and promote healing [14].The mechanism of action of PRP in the treatment of OA is thought to be through the modulation of key pro-inflammatory mediators and catabolic enzymes as well as the maintenance of joint stability [15]. Inflammation triggered by cartilage damage as well as inflammatory components play a key role in the development of OA. It has been shown that PRP promotes cartilage formation and inhibits the inflammatory response in cartilage tissue [21]. Several recent meta-analyses have demonstrated significant improvement of PRP in the treatment of OA [22–24]. Chen et al. further demonstrated that PRP effectively inhibited adipogenesis and inflammatory activation of adipocytes in the infrapatellar fat pad (IFP), suggesting that the IFP and its adipocytes may participate in the pathological process of OA by releasing pro-inflammatory adipokines that promote chondrocyte dedifferentiation and inflammation [25].

Arthroscopic cartilage grafting combined with PRP, the highlight of this treatment is the combined use of the two techniques, which not only improves the success rate of cartilage repair, but also speeds up the recovery process. The use of arthroscopic technology makes the procedure more delicate and minimally invasive, reducing postoperative pain and recovery time for the patient. Meanwhile, the use of PRP enhances the ability of cartilage self-repair and improves the microenvironment of the knee joint, making it a safe and effective treatment for early knee osteoarthritis.

In addition, meticulous evaluation prior to treatment ensures individualization and precision. Through weight-bearing X-rays, MRI and arthroscopy, the surgeon is able to gain a detailed understanding of the structural condition of the knee, including the extent of cartilage damage, the state of the ligaments and the integrity of the meniscus. This evaluation process not only helps determine the most appropriate treatment plan, but also provides a solid foundation for a successful surgery. First, it is important to ensure that the patient's clinical presentation matches the physical examination and diagnostic imaging findings to clarify whether cartilage damage is the direct cause of the patient's symptoms. Second, the preoperative examination should include a full-length radiograph of the lower extremity in

the weight-bearing position to assess the lower extremity biologic lines of force and to avoid pressure overload due to the presence of static or dynamic inversion or eversion of the knee compartment. In patients with tibial inversion deformity greater than 5°, treatment with high tibial osteotomy (HTO) should be considered [26]. In addition, a thorough and meticulous ligament evaluation is essential, including assessment of the cruciate ligament, collateral ligaments, and the patellofemoral joint. Once a ligament injury is detected, ligament reconstruction surgery must be performed prior to or concurrently with the cartilage grafting procedure to avoid failure of the grafted cartilage under excessive stress. Finally, the surgeon needs to carefully evaluate the meniscus lesion by MRI and arthroscopy and ensure that the meniscus is as intact as possible. Particular attention must be paid to the meniscus root, as there is now evidence that missing the intact posterior root of the meniscus leads to greater stress on the knee.

However, there are several limitations to this study. The study's uneven group sizes may stem from clinical preferences, eligibility criteria, or patient decision-making in real-world settings, despite comparable baseline characteristics. While statistical adjustments addressed overt confounders, residual selection bias—driven by unmeasured factors like disease severity perception, socioeconomic barriers, or treatment preferences—could influence outcomes. Retrospective designs inherently limit control over such confounders, and the smaller ACT-PRP group may reduce power to detect nuanced effects. Future research should further validate these findings through multi-center, large-sample, prospective randomized controlled trials. Additionally, the follow-up period in this study was limited to 6 months, which precludes an assessment of long-term outcomes and potential complications. Future studies should extend the follow-up period to better evaluate long-term efficacy.

In summary, treatment with arthroscopic cartilage grafting combined with platelet-rich plasma significantly reduces knee pain and effectively restores knee function, demonstrating its use as a safe and effective technique for the treatment of early knee osteoarthritis. In contrast to previous studies in which ACT or PRP were performed as stand-alone treatments, our study provides evidence that combining these two approaches improves efficacy. However, limitations of this study include a small sample size and a short follow-up period. Therefore, prospective studies are essential to provide stronger evidence and a more comprehensive assessment of long-term outcomes. Additionally, future studies should focus on expanding the sample size and extending the follow-up period to further validate the clinical benefits of this technique.

Author contributions XL and YD was responsible for the conceptualization and design of this study, CY and LJ performed the data analysis, and XL and WH drafted the initial version of the manuscript.JZ managed the publication process, had full access to all the data in the study, and had the final responsibility for the decision to submit for publication. All authors read and approved the final version.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate This protocol is in compliance with the Helsinki Declaration and was approved by the Research Ethics Committee of the First People's Hospital of Lianyungang (NO: JS-20161227001). Written informed consent will be obtained from all study participants.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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