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Original Article

Combined effects of tranexamic acid and platelet-rich plasma in the arthroscopic treatment of femoroacetabular impingement

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Abstract: Objective: To evaluate the combined effects of tranexamic acid (TXA) and platelet-rich plasma (PRP) in the arthroscopic treatment of femoroacetabular impingement (FAI). Methods: A total of 78 FAI patients were included. In the PRP group (n=36), PRP monotherapy was administered, while the TXA + PRP group (n=42) received both TXA and PRP. We performed comparative analyses on clinical outcomes, surgical metrics, coagulation tests, computed tomography (CT) measurements, Visual Analogue Scale (VAS) pain severity scores, hip joint functionality, serum inflammatory biomarkers, and quality of life. Results: The combination of TXA and PRP demonstrated superior outcomes compared to PRP alone, with higher overall efficacy, improved arthroscopic visual clarity, reduced intraoperative and total blood loss, and shorter hospital stays (all $P<0.05$). Additionally, the TXA + PRP group showed a significant reduction in α and center-edge angles at the 12-months postoperative follow-up compared to both baseline and the PRP group (all $P<0.05$). Furthermore, significant improvements were observed in coagulation function, pain relief, hip joint function, quality of life, and a more effective reduction in serum inflammation (all $P<0.05$). Conclusion: Co-administration of TXA and PRP is highly effective in the management of FAI through hip arthroscopy.

Keywords: Hip arthroscopy, tranexamic acid, platelet-rich plasma, femoroacetabular impingement, clinical efficacy, hip joint function

Introduction

Femoroacetabular impingement (FAI) occurs when the proximal femur impinges on the acetabulum during motion, resulting in damage to the acetabular labrum, the labrum-cartilage junction, and the articular cartilage. Over time, this mechanical conflict exacerbates degenerative changes and promotes the development of osteoarthritis (OA) [1, 2]. Patients commonly experience gradual groin pain, which progresses to persistent hip discomfort with diffuse radiation. These symptoms impair daily activitiesand manual work, and lead to a decline in hip joint mobility [3, 4]. In clinical practice, hip arthroscopy is frequently used to treat FAI syndrome, as it outperforms physiotherapy in alleviating hip pain, improving joint function, and enhancing quality-of-life over a 12-month postoperative period [5]. However, due to the impracticality of using a tourniquet for hemorrhage control during the procedure, antifibrinolytic agents or other hemostatic drugs are essential adjuncts [6]. Tranexamic acid (TXA) is a lysine-derived synthetic amino acid that works by inhibiting lysine-dependent plasminogen activation, delaying clot dissolution, and enhancing hemostasis [7]. In knee and shoulder arthroscopy, TXA has been shown to significantly improve early recovery and prevent complications from hemarthrosis [8]. Samborski et al. [9] have confirmed that TXA is a safe adjunct in hip arthroscopy, as it does not increase complications or elevate the risk of venous thromboembolism when administered preoperatively. Platelet-rich plasma (PRP) is an autologous bio-

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logical agent rich in platelets and growth factors. It offers various benefits, including cartilage repair, metabolic regulation, anti-inflammatory effects, pain relief, and reduction of joint discomfort [10, 11]. In the management of hip osteoarthritis, PRP demonstrates outcomes in pain relief and functional improvement comparable to hyaluronic acid [12]. Mannava et al. [13] highlighted that PRP exploits the biological properties of platelet-derived alpha (α) granules during hip arthroscopy, promoting a regenerative environment and aiding in postoperative hemostasis.

The clinical benefits of combined intra-articular TXA and PRP injections in the arthroscopic management of FAI have yet to be fully explored. This study aims to fill this research gap and contribute to evidence-based optimization of FAI arthroscopy.

Materials and methods

General data

A retrospective review of 78 cases of FAI was conducted using records from Shanghai Tenth People's Hospital, Tongji University, spanning from February 2021 to February 2024. Of these, 35 patients were treated with PRP monotherapy (PRP group), while 43 patients received a combination of PRP and TXA (TXA + PRP group). All procedures adhered to the ethical guidelines set by the ethics committee of Shanghai Tenth People's Hospital.

Participant enrollment criteria

Inclusion criteria: (1) confirmed FAI diagnosis [14]; (2) unilateral involvement; (3) normal preoperative platelet count and coagulation profile; (4) positive Flexion, Adduction, Internal Rotation (FADIR) test with restricted hip mobility; (5) femoral head-neck cam-type deformity (e.g., α angle >50°) or acetabular overgrowth (e.g., lateral center-edge angle [CEA] >40°) on X-ray or CT; (6) surgical candidates consenting to hip arthroscopy; (7) medication tolerance; (8) no psychiatric history; and complete clinical data.

Exclusion criteria: (1) spinal/vertebral involvement; (2) prior traumatic hip injury; (3) preexisting hip pathologies (Perthes, slipped capital femoral epiphysis, developmental dysplasia, avascular necrosis of femoral head); (4) recent use of anticoagulants/TXA-interacting drugs; (5) current pregnancy or breastfeeding; (6) rheumatic disorders; (7) ankylosing spondylitis, lumbar disorders, or sacroiliac joint abnormalities; (8) malignant neoplasms.

Treatment methods

In the PRP group, PRP treatment was administered following preoperative fasting and water deprivation under general anesthesia. The patient was positioned supine on a traction table with adducted and internally rotated hips, and traction was applied to both lower extremities. X-rays ensured accurate joint spacing. Fluoroscopy-assisted lateral portal placement was followed by anterior portal creation using the outside-in method under direct arthroscopic view. The joint capsule was accessed with radiofrequency ablation, followed by a diagnostic assessment to identify the impingement type and location. Osteoplasty was then performed. Postoperative outcomes were assessed through hip joint mobility evaluation. The PRP preparation protocol involved: 1) collecting 10 mL venous blood, 2) primary centrifugation (2,000 rpm, 10 minutes) to obtain the platelet-rich intermediate layer, 3) secondary centrifugation to obtain 2 mL of concentrated platelets and leukocytes, 4) calcium chloride activation, and 5) intra-articular injection of the activated solution followed by wound dressing.

In the TXA + PRP group, a 15 mg/kg TXA solution (0.5 g per 5 mL) was administered intravenously 10 minutes before the surgical incision. Blood pressure management was maintained by the anesthesia team throughout the procedure. All other steps, including PRP preparation and injection, followed the same procedures as the PRP group. Postoperative care for all patients included a 24-hour water exposure restriction, with ice packs or analgesics for symptom relief.

Endpoints

Clinical efficacy: Based on Harris Hip Score (HHS) changes, efficacy was classified as: Cure = improvement rate ≥90%; marked effectiveness =70% ≤ improvement rate <90%; effectiveness =30% ≤ improvement rate <70%; ineffectiveness = improvement rate <30%. Improvement rate = [(post-treatment HHS score - pre-treatment HHS score)/pre-treatment HHS score] × 100%.

Clinical data: Both groups were evaluated for intraoperative/total bleeding volumes, arthroscopic visual clarity (assessed using a 3-tier Arthroscopic Visibility Grading Scale [15]: 1= active bleeding/poor visibility; 2= sporadic bleeding/partial visibility with mild interference; 3= negligible bleeding/clear visibility), and hospitalization duration.

Coagulation function: Venous blood specimens (5 mL) were collected pre- and post-treatment. Prothrombin time (PT) and activated partial thromboplastin time (APTT) were measured using a fully automated hematology analyzer.

CT-related indices: Preoperative and 12-month postoperative CT measurements of the α angle and carcinoembryonic antigen (CEA) were performed. Raw data underwent 3D reconstruction, and measurements were conducted on standardized 2D reformatted planes. The α angle was measured using radial sequence reconstruction. Oblique-sagittal images along the femoral neck's long axis were generated based on the coronal plane. The femoral neck center was identified, and the α angle was measured between the line connecting Point A (where the anterosuperior contour deviates from a spherical shape) and the femoral head center (Point O), and the femoral neck's central axis. An α angle >55° indicated cam-type FAI.

For CEA, the angle between a vertical line through the femoral head center (Point O) and a line to the lateral edge of the acetabulum was measured. A CEA <25° was considered diagnostic of acetabular dysplasia.

Postoperative pain: Pain levels were recorded pre-surgery and on postoperative days 3 and 7 using the Visual Analogue Scale (VAS). Scores were categorized as: 0 (pain-free), 1-3 (mild, tolerable discomfort), 4-6 (moderate, sleep-interfering pain), and 7-10 (severe, sleep-depriving pain requiring intervention) [16].

Hip function: Preoperative and 6-week postoperative hip function was assessed using the HHS (0-100 points) and Non-Arthritic Hip Score (NAHS) (0-100 points). Improved scores indicate enhanced joint functionality. For HHS, the Pain subscale (max 44 points) assesses pain intensity, and the Mobility subscale (max 47 points) evaluates daily activities and gait. The Deformity subscale (max 4 points) reflects joint deformities, and the Motion subscale (max 5 points) measures hip movements [17].

Serum inflammatory biomarkers: Pre-treatment and postoperative (4-week) serum samples were analyzed for matrix metalloproteinase (MMP)-13 and interleukin (IL)-1β using enzyme-linked immunosorbent assay.

Quality of life: The 36-Item Short Form Health Survey (SF-36) evaluated quality of life pre-treatment and 6 weeks post-intervention across various domains (role-physical, bodily pain, social functioning, role-emotional, and mental health), with total scores positively correlating with improvement in quality of life [18].

Statistical methods

Continuous variables (coagulation function indices, hip function assessments, inflammatory biomarkers) were presented as mean ± SD. Independent t-tests were used to analyze between-group differences, while paired t-tests assessed pre-post intervention changes. Categorical data (e.g., patient sex, impingement type, clinical outcomes) were expressed as counts and percentages, with group differences analyzed using chi-square tests. Statistical analyses were performed using SPSS version 22.0, with a significance level set at $P<0.05$.

Results

Comparison of baseline characteristics

The analysis revealed comparable distributions for age, gender, impingement type, comorbidities (diabetes/hypertension), and familial disease history, with none reaching significance (all $P>0.05$). See **Table 1**.

Comparison of clinical effectiveness

The TXA + PRP group demonstrated significantly superior overall effectiveness compared to the PRP group ($P=0.005$). See **Table 2**.

Comparative evaluation of clinical data

Patients treated with TXA + PRP exhibited significantly less bleeding (both intraoperative and total), better arthroscopic visual clarity, and shorter hospitalization duration than those in the PRP group (all $P<0.05$). See **Table 3**.

Table 1. Comparison of baseline characteristics

Data	PRP group (n=36)	TXA + PRP group (n=42)	χ^2/t	P
Age (years)	32.67±6.99	32.86±7.86	0.112	0.911
Sex			0.359	0.549
Male	19 (52.78)	25 (59.52)		
Female	17 (47.22)	17 (40.48)		
Impingement type			0.257	0.879
Cam-type	25 (69.44)	27 (64.29)		
Pincer-type	4 (11.11)	5 (11.90)		
Mixed-type	7 (19.44)	10 (23.81)		
Comorbidities				
Diabetes	11 (30.56)	14 (33.33)	0.069	0.793
Hypertension	13 (36.11)	18 (42.86)	0.368	0.544
Family medical history			0.115	0.735
No	31 (86.11)	35 (83.33)		
Yes	5 (13.89)	7 (16.67)		

Note: TXA, tranexamic acid; PRP, platelet-rich plasma.

Table 2. Comparison therapeutic efficacy

Therapeutic effectiveness	PRP group (n=36)	TXA + PRP group (n=42)	χ^2	P
Cure	2 (5.56)	4 (9.52)		
Effectiveness	4 (11.11)	11 (26.19)		
Marked effectiveness	19 (52.78)	24 (57.14)		
Ineffectiveness	11 (30.56)	3 (7.14)		
Overall effectiveness	25 (69.44)	39 (92.86)	7.215	0.007

Note: PRP, platelet-rich plasma; TXA, tranexamic acid.

Table 3. Comparison of clinical parameters

Indicator	PRP group (n=36)	TXA + PRP group (n=42)	t	P
Intraoperative bleeding volume (mL)	54.22±15.20	44.74±11.35	3.147	0.002
Total bleeding volume (mL)	344.17±49.51	297.67±31.62	5.012	<0.001
Arthroscopic visual clarity (level)	1.92±0.60	2.26±0.59	2.517	0.014
Hospitalization duration (d)	3.61±1.81	4.76±1.78	2.823	0.006

Note: PRP, platelet-rich plasma; TXA, tranexamic acid.

Comparison of coagulation function

Coagulation function assessment (**Figure 1**) revealed significantly lower PT and APTT in the TXA + PRP group compared to the PRP group (both P<0.01).

Comparison of CT-related indices

Baseline measurements of the α angle and CEA were comparable between groups (both P>0.05). After treatment, both groups showed significant decreases in these angles, with the TXA + PRP group exhibiting more favorable changes (lower α angle and CEA) compared to the PRP group (both P<0.05). See **Table 4**.

Comparison of postoperative pain

No intergroup difference was observed in preoperative pain scores (P>0.05). Both groups showed a progressive reduction in pain scores at the subsequent evaluations (P<0.05). Notably, the TXA + PRP group had significantly lower pain scores at both postoperative intervals compared to the PRP group (P<0.05). See **Figure 2**.

Comparison of hip joint function

As shown in **Table 5**, hip function was evaluated using the HHS and NAHS. Baseline values were

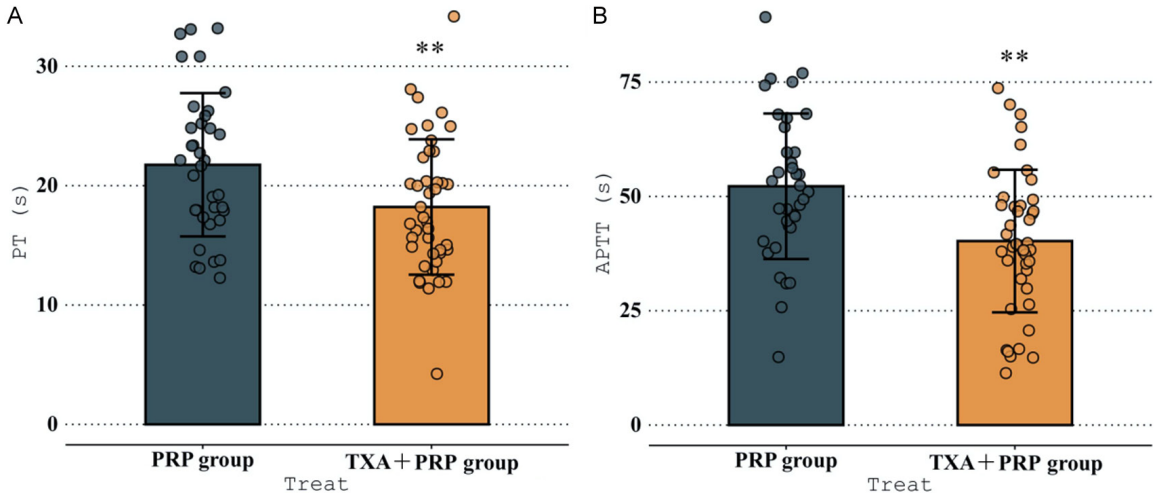

Figure 1. Comparison coagulation function. A: PT level comparison (PRP vs. TXA groups). B: APTT measurment comparison (PRP vs. TXA groups). Note: PT, prothrombin time; PRP, platelet-rich plasma; TXA, tranexamic acid; APTT, activated partial thromboplastin time; **P<0.01 vs. PRP group.

Table 4. Comparison of CT-associated indices

Indicator	PRP group (n=36)	TXA + PRP group (n=42)	t	P
α angle				
Before	60.61±6.15	60.38±6.98	0.153	0.879
After	54.08±5.12*	49.90±4.41**	3.874	<0.001
Center-edge angle				
Before	45.08±5.74	45.93±6.50	0.607	0.545
After	35.06±3.67*	31.05±3.82**	4.706	<0.001

Note: PRP, platelet-rich plasma; TXA, tranexamic acid; CT, computed tomography; *P<0.05; **P<0.01.

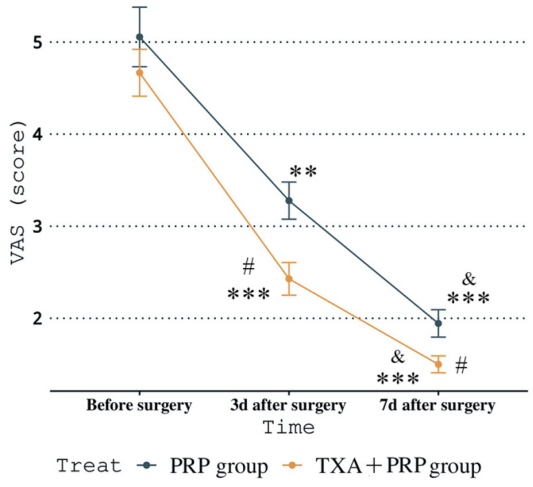

Figure 2. Comparison postoperative pain. Note: PRP, platelet-rich plasma; TXA, tranexamic acid; VAS, Visual Analogue Scale; **P<0.01, ***P<0.001 (within-group comparison vs. preoperative); #P<0.05 (same timepoint vs. PRP group); &P<0.05 (within-group comparison vs. postoperative 3 d).

comparable between the groups (both P> 0.05). Post-treatment, both groups showed significant improvements, with the TXA + PRP group achieving superior outcomes on both scales (both P<0.05).

Comparison of serum inflammatory biomarkers

No intergroup differences were observed at baseline for MMP-13 or IL-1β (both P>0.05). Post-treatment, both biomarkers significantly decreased in all patients, with TXA + PRP administration showing more pronounced suppression of these inflammatory mediators compared to PRP monotherapy (both P<0.05). See **Figure 3**.

Comparison of quality of life

No baseline disparities were noted between groups (all P>0.05). After treatment, marked

Table 5. Comparison of hip joint function

Indicator	PRP group (n=36)	TXA + PRP group (n=42)	t	P
HHS (points)				
Before	65.00±6.39	65.31±7.26	0.199	0.843
After	80.39±6.25*	84.81±6.35**	3.087	0.003
NAHS (points)				
Before	62.50±6.88	61.10±6.34	0.935	0.353
After	70.42±6.94*	77.38±8.07**	4.048	<0.001

Note: PRP, platelet-rich plasma; TXA, tranexamic acid; HHS, Harris Hip Score; NAHS, Non-Arthritic Hip Score. *P<0.05; **P<0.01.

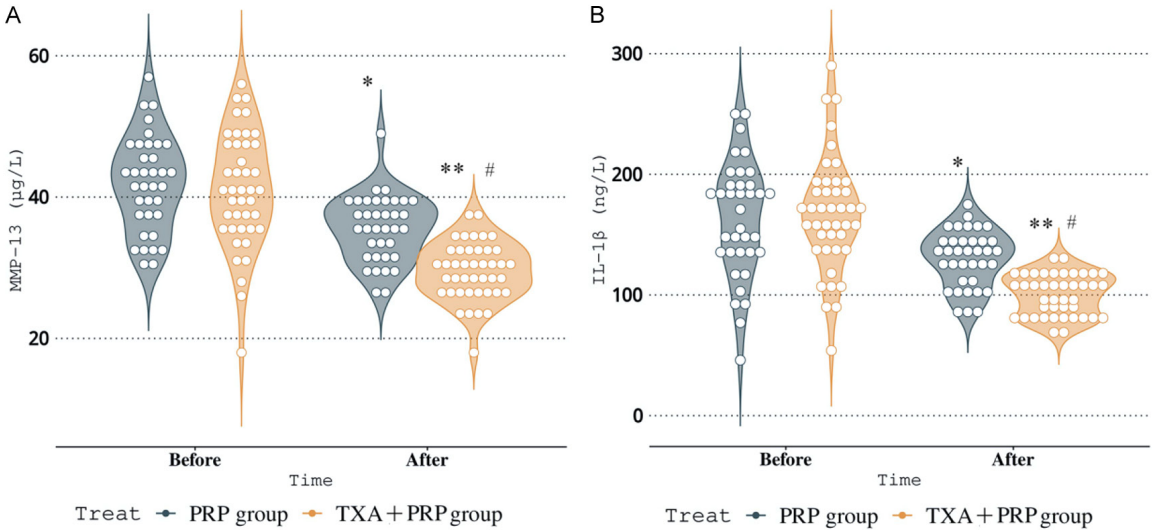

Figure 3. Comparison of serum inflammatory biomarkers. A. Pre- vs. post-treatment MMP-13 level differences. B. Pre- vs. post-treatment IL-1β level differences. Note: PRP, platelet-rich plasma; TXA, tranexamic acid; MMP-13, matrix metalloproteinase; IL-1β, interleukin-1β; *P<0.05, **P<0.01 (intragroup comparison vs. baseline); #P<0.05 (intergroup comparison at the same time point).

improvements were observed in all dimensions for both groups, with the TXA + PRP group showing significantly greater improvements in role-physical, bodily pain, social functioning, role-emotional, and mental health domains (all P<0.05). See **Table 6**.

Discussion

This study demonstrated that TXA plus PRP co-administration resulted in higher effectiveness in managing FAI patients. Gamea's team [19] documented improved clinical outcomes when PRP was co-administered with TXA for melasma treatment, attributable to their synergistic effects. This pharmacologic rationale may extend to our observed therapeutic benefits in FAI cases, where both agents maintained a favorable safety profile. Additionally, the combined TXA and PRP treatment yielded better outcomes, including less bleeding (both intraoperative and total), clearer operative visibility, and reduced hospitalization. The underlying mechanism may involve significant suppression of prothrombin time (PT) and activated partial thromboplastin time (APTT), enhancing clot stability and preventing intraoperative hemorrhage. Similar results were reported by Li et al. [20], who found that prophylactic TXA use before FAI surgery effectively minimized blood loss, improved operative field visibility, and facilitated better functional outcomes during rehabilitation. Furthermore, the TXA-PRP combination led to better improvements in angular measurements (α angle and CEA) compared to PRP alone. This suggests a synergistic mechanism in which the combined treatment alters femoral head-neck morphology and increases

Table 6. Comparison of quality of life

Indicator	PRP group (n=36)	TXA + PRP group (n=42)	t	P
Role-Physical (points)				
Before	56.53±5.33	54.62±6.59	1.392	0.168
After	73.94±5.69*	78.26±5.11**	3.532	<0.001
Bodily Pain (points)				
Before	52.47±4.47	51.10±5.38	1.211	0.230
After	69.61±5.70*	76.19±5.49**	5.185	<0.001
Social Functioning (points)				
Before	48.97±5.08	49.79±5.20	0.702	0.485
After	62.56±6.09*	76.31±6.61**	9.495	<0.001
Role-Emotional (points)				
Before	49.67±5.87	49.90±5.66	0.176	0.861
After	57.03±5.90*	61.90±8.49**	2.893	0.005
Mental Health (points)				
Before	44.47±4.97	45.81±5.56	1.114	0.269
After	58.19±6.13*	66.79±7.51**	5.481	<0.001

Note: PRP, platelet-rich plasma; TXA, tranexamic acid; *P<0.05, **P<0.01.

acetabular coverage, offering a fundamental resolution to the impingement. An increased α angle is associated with higher risk of contralateral symptoms, likelihood of surgical conversion, and vulnerability to age-related superior/posterosuperior labral tears [21, 22].

In this study, combining TXA with PRP injections in FAI patients resulted in notable pain reduction at 3- and 7-day postoperative intervals, along with marked hip function improvement by the sixth week post-treatment. A study by Zhu et al. [23] also found significant pain reduction when TXA was administered intra-articularly to patients undergoing arthroscopic rotator cuff repair, which aligns with our findings. The TXA-PRP combination translated into superior hip function at 6 weeks post-surgery, likely due to an optimized procedural effect and accelerated recovery. Li et al. [24] further demonstrated that TXA's topical use in knee arthrolysis surgeries improved early functional outcomes, mobility, and recovery metrics, such as pain, blood loss, and inflammation, providing additional evidence for its clinical benefits. Additionally, a marked downregulation of MMP-13 and IL-1β was observed in FAI patients treated with TXA + PRP, surpassing the effects of PRP monotherapy. These results suggest a synergistic anti-inflammatory benefit of combining TXA with PRP injections. Specifically, TXA directly suppresses macrophage-mediated cytokine release, while PRP's plasma constituents regulate macrophage phenotypes [25, 26]. Thus, the two treatments work in concert through different pathways to enhance the anti-inflammatory effect. Similar benefits were observed in total hip replacement surgeries, where TXA helped control systemic inflammation and blood clotting [27]. Moreover, the TXA-PRP combination for FAI patients resulted in superior quality-of-life outcomes compared to PRP alone. This likely stems from the combined treatment's clinical strengths, including improved therapeutic efficacy, enhanced hemostasis, better surgical outcomes, faster recovery, effective pain management, and reduced inflammation.

Several limitations of this study should be addressed in future research. First, the absence of long-term (5-10 year) follow-up data limits the evaluation of the sustained effects of TXA-PRP combination therapy, which could be clarified through extended monitoring. Second, evaluations of negative emotions, sleep quality, and patient comfort are necessary to further demonstrate the clinical advantages of combining TXA with PRP therapy. Third, mechanistic investigations at the molecular level remain unexplored; such analyses would be essential for identifying specific targets.

In conclusion, this study confirmed that TXA-PRP co-administration in FAI patients yields superior clinical effectiveness through multi-

dimensional analysis. Hemostatic efficiency is enhanced, arthroscopic visual clarity is improved, and early postoperative recovery is promoted. Patients also experience significant pain relief, functional improvement, and normalized inflammatory responses, contributing to better overall well-being.

Disclosure of conflict of interest

None.

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