ORIGINAL ARTICLE

Acta Orthop Traumatol Turc 2016;50(2):191–197
doi: 10.3944/AOTT.2015.15.0113

The effect of platelet-rich plasma on arthroscopic double-row rotator cuff repair: a clinical study with 12-month follow-up

Zhenxiang ZHANG[1], Yong WANG[2], Junying SUN[2]

[1]*The Affiliated Taizhou People's Hospital of Nantong University, Department of Orthoapedics and Traumatology, Taizhou, China*
[2]*The First Affiliated Hospital of Soochow University, Department of Orthopaedics and Traumatology, Suzhou, China*

Objective: The aim of the study was to assess the effect of platelet-rich plasma on arthroscopic double-row rotator cuff repair.

Methods: The study included 60 patients with arthroscopic rotator cuff repair. Thirthy patients (mean age: 57.2±7.4; 16 males and 14 females) underwent arthroscopic double-row repair alone (Group 1), another 30 (mean age: 56.9±6.0; 15 males and 15 females) had an injection of platelet-rich plasma (PRP) (Group 2). The groups were compared with DASH as a primary outcome score and Constant-Murley score, visual analog scale, measurement of active forward flexion, and external and internal rotation as secondary outcome measures. Magnetic resonance imaging was used to assess the integrity of the repair at 12 months postoperatively.

Results: Primary and secondary outcome measures statistically improved in both groups postoperatively ($p<0.05$). Overall mean primary and secondary postoperative outcome measures were not significantly different between the 2 groups. A retear was seen in 9 subjects (30%) in Group 1 and 4 subjects (14%) in Group 2 ($p<0.05$).

Conclusion: The local injection of PRP into a primary arthroscopic double-row cuff repair resulted in lower recurrence rates than repairs without the novel biological augmentation material.

Keywords: Double-row; platelet-rich plasma; rotator cuff tear.

Level of Evidence: Level I, Therapeutic study.

Arthroscopic double-row repair of rotator cuff tears can theoretically increase the initial coverage of rotator cuff tendon-to-bone insertion for healing. It has been reported that a larger contact area between the bone and tendon allows more fibers to take part in the healing process of the rotator cuff.[1–4] The clinical superiority of double-row rotator cuff repairs has yet to be demonstrated.[5,6] Nevertheless, a series of prospective clinical trails indicated a lack of difference in clinical outcomes between single- and double-row rotator cuff repairs.[7,8] Particularly, high rates of recurrence after double-row repair have been reported for full-thickness tears, fluctuating between 10% and 44%.[5,7,8]

Platelet-rich plasma (PRP) is theorized to play an essential role in healing by stimulating growth factors in the area of repair.[9] Animal studies have reported

Correspondence: Zhenxiang Zhang, MD. The Affiliated Taizhou People's Hospital of Nantong University, Orthopedic Department, Taizhou, Jiangsu 225300, People's Republic of China.
Tel: +86 – 21 – 86532798 e-mail: kafeimao1982@126.com

Submitted: February 26, 2015 **Accepted:** September 29, 2015

Available online at
www.aott.org.tr
doi: 10.3944/AOTT.2015.15.0113
QR (Quick Response) Code

increased tendon healing in both patellar and achilles tendon reconstructions.[10] A variety of studies have displayed evidence of stimulated tendon healing following PRP injection.[11,12] However, its efficacy in rotator cuff repair remains an ongoing controversy, with little data to support an improvement in clinical outcome, despite its documented bioactivity.

This study was conducted to investigate the efficacy of PRP application in double-row repairs of rotator cuff tears. It was hypothesized that a local injection of activated PRP into a primary rotator cuff repair would result in improved tendon healing and better clinical outcomes.

Patients and methods

Subjects were assessed for the presence of a full-thickness rotator cuff tear on the basis of history, clinical examination, standard anteroposterior and scapular Y-view radiographs of the shoulder, as well as gadolinium-enhanced magnetic resonance arthrography in a 1.5-Tesla scanner. Inclusion criteria were 1) a full-thickness tear measuring more than 1 cm in diameter, 2) patient's willingness to be randomized to double-row repair with or without PRP, and 3) adequate resources for magnetic resonance imaging (MRI) examination. Exclusion criteria were 1) tear size less than 1 cm (small tear), 2) cuff tear arthropathy, 3) extension of the tear to the subscapularis tendon or an isolated subscapularis tear, 4) degenerative arthritis of the glenohumeral joint, 5) irreparable tear, and 6) previous surgery on the same shoulder.

From May 2009 to May 2013, all subjects who met the inclusion criteria were enrolled in the present study on an intent-to-treat basis. The study was approved by the medical ethics committee of our hospital, and all subjects signed an informed consent form before participating in the present study.

All surgical interventions were performed with the subjects under general anesthesia (Figure 1). Posterior, anterior, and 3 to 4 lateral portals were established for each subject. The posterior portal was used as the viewing portal, while the anterior and lateral portals were used as working portals. Two NO_2 double-loaded suture anchors were located close to the articular cartilage to form the medial row. Different colored wires were passed through the cuff with a suture passer, and wires of one color were tied together with a simple knot and an outside-in knot. One wire of another color was retrieved from each anchor, placed into a push lock, and fixed to the anterolateral part of the greater tuberosity. The same procedure was repeated with the last 2 wires, which were fixed with a push lock to the posterolateral aspect of the greater tuberosity. Only 1 strand of the suture was passed through the tendon each time, so as to avoid creating large holes through the cuff.

Fifty-four milliliters of blood were collected from subjects in Group 2 (Figure 2). The blood was transferred to a specially designed disposable tube (GPS II-Plasmax-Platelet Concentration System, Biomet Biologics, Warsaw, IN, USA). The platelet-poor plasma at the top of the tube was centrifuged for 2 minutes at 2000 RPM. The concentrated platelets were resuspended to form PRP. An additional 20 ml of blood was collected from the subjects into tubes without an anticoagulant. Two vacuum tubes were filled and gently shaken to ensure blood coagulation. After centrifugation for 2 minutes at 3200 RPM, the serum was aspirated. A ratio of 1:5 of 10% calcium chloride solution was added to the serum to counteract the citrate-based anticoagulant when the autologous serum was mixed with PRP.

After PRP repair, the arthroscope was inserted into the lateral portal to provide optimal visualization of the

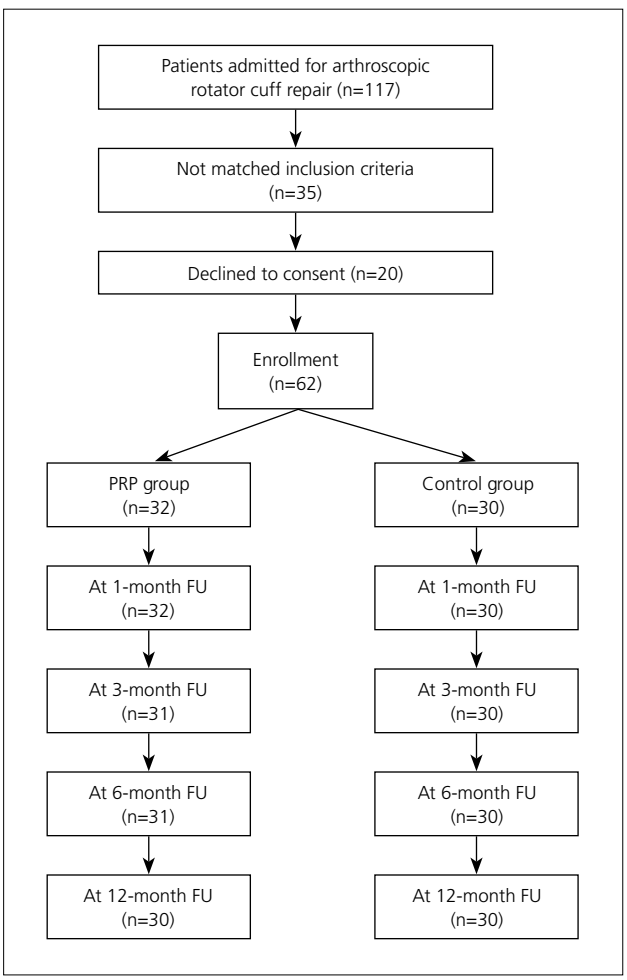

Fig. 1. Consort flow diagram.

Fig. 2. Arthroscopic view during double-row rotator cuff repair. **(a)** Passing the medial-row sutures with suture passer from bursal to articular side. **(b)** Suture passer again retrieving sutures to bursal side. **(c)** All medial-row sutures have now been passed. **(d)** Lateral-row anchors placed. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

repair site. A spinal needle was inserted approximately 1.5 cm anterior to the lateral portal at an approximately 15° angle to allow penetration into the repair site. The spinal needle was placed under the rotator cuff tendon and inserted below the repair site until the humerus was abutted. Once the needle tip was against the humeral bony surface, it was withdrawn a few millimeters, and the PRP was injected using a syringe attached to the needle. Once the PRP was injected, no more arthroscopic fluid was used (Figure 3).

Preoperatively and 1, 3, 6, and 12 months postoperatively, several outcome measures were assessed. The primary outcome measure was the Disabilities of the Arm, Shoulder and Hand (DASH) score. Secondary outcome measures included Constant-Murley score, active forward flexion, external and internal rotation at the back, and visual analog scale (VAS). Fatty degeneration of rotator cuff muscles was documented on MRI and classified according to Fuchs et al.[21] Twelve months postoperatively, MRI was performed to investigate the integrity of the repaired tendons. Subjects completed the DASH and VAS questionnaires independently without assistance from the examiner. Due to the obvious incision pattern, the examiner could not be blinded. Cuff integrity was evaluated with established criteria described by Owen et al.[13]

A power analysis was performed based on the effects of PRP treatment on shoulder function. The primary outcome measure was the mean DASH score. The alternative hypothesis was that DASH score would be 7 points lower in Group 2 in comparison to Group 1. Standard deviation of Constant-Murley score was estimated at 8 points. With these parameters, 52 participants were needed to detect a difference of 7 points in Constant-Murley score. These numbers were calculated from a power (1-β) of 0.80 and a significance level of 5% (2-sided). Due to the potential for patient dropout, a total of 62 patients were included.

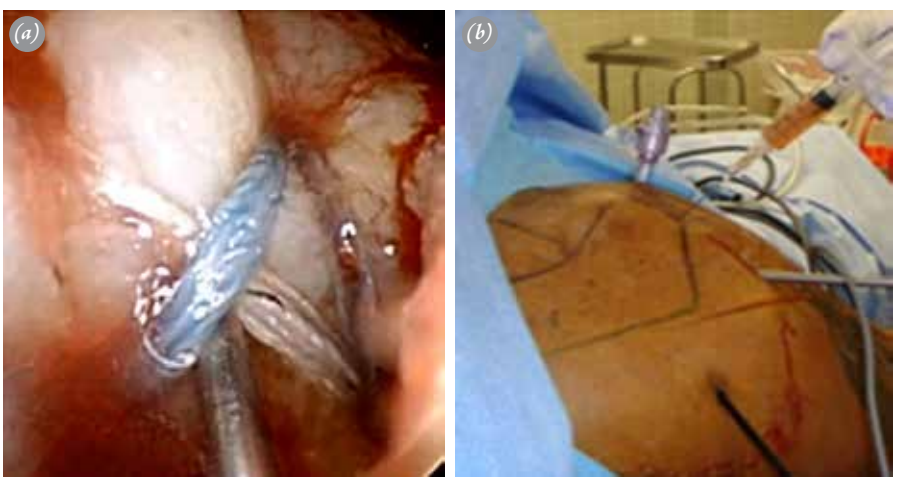

Fig. 3. Methods of PRP injection. **(a)** Injecting PRP under a rotator cuff repair needle under arthroscopic visualization. **(b)** Insertion of syringe with PRP into rotator cuff repair under visualization. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

Table 1. Comparison of patient characteristics.

	Group 1	Group 2	p
No. of shoulder	30	30	–
Age (y)			
Mean±SD	57.2±7.4	56.9±6.0	>0.05
Range	35–70	37–71	–
Gender (male/female)	16/14	15/15	>0.05
Side (right/left)	15/15	16/14	>0.05
Duration of symptoms (mo)			
Mean±SD	12.1±3.4	11.7±2.7	>0.05
Range	1–27	2–25	–
Tear size (cm)			
Mean±SD	3.1±0.3	3.2±0.4	>0.05
Range	1.5–5.3	1.6–5.5	–
Cigarette use			
Nonsmoker	17	16	>0.05
Current smoker	5	6	>0.05
Ex-cigarette smoker	8	8	>0.05
Fatty degeneration			
Grade 1	9	8	>0.05
Grade 2	10	11	>0.05
Grade 3	10	11	>0.05
Grade 4	1	1	>0.05

SD: Standard deviation.

Paired t-test was used to compare the differences between preoperative and postoperative DASH scores, Constant-Murley scores, VAS, and flexion/external rotation. A chi-square test was used to compare the final tendon healing rates between the 2 groups. All analyses were conducted using SPSS software (version 16.0, SPSS Inc., Chicago, IL, USA). Significance was set at $p<0.05$.

Results

Sixty-two subjects were enrolled, 60 of whom were available at the 12-month follow-up. In Group 1, there were 30 patients (16 men and 14 women), with a mean age of 57.2 years (range: 35–70 years). The dominant shoulder was affected in 15 subjects. In Group 2, there were 30 subjects (15 men and 15 women), with a mean age of 56.9 years (range: 37–71 years). The dominant shoulder was affected in 16 subjects. Mean follow-up duration was 13.5 months, and mean time for postoperative MRI was 14.1 months. Patient characteristics were comparable between the 2 groups and are summarized in Table 1. No infection, neurovascular complication, or anchor pullout occurred in the current study.

Postoperative outcome—including Constant-Murley score, active forward flexion, external and internal rotation, and VAS—displayed a significant improvement in comparison with preoperative status in both groups. At the 12-month follow-up, no significant difference was observed between the 2 groups with respect to primary and secondary outcomes (Table 2).

MRI assessment of the integrity of the repair after 12 months revealed retear in 9 subjects (30%) in Group 1 and 4 subjects (14%) in Group 2. Postoperative MRI revealed 0 type I, 2 type II, 4 type III, 3 type IV, and 0 type V in Group I; 0 type I, 1 type II, 2 type III, 1 type IV, and 0 type V were found in Group 2. A statistically significant difference was observed between the groups. Of the 9 subjects with a retear in Group 1, 3 subjects were symptomatic. Of the 4 subjects with a retear in Group 2, 2 patients were symptomatic. Two subjects with a symptomatic retear had revision cuff repair, 1 in Group 1 and 1 in Group 2. Comparison of baseline values between patients with retear and without retear is shown in Table 3.

Discussion

Our present study was conducted to investigate the efficacy of PRP application in arthroscopic double-row repairs of rotator cuff tears. The major finding was that

Table 2. Comparison of intra- and intergroup clinical outcomes.

	Group 1			Group 2			Postop		
	Preop	Postop	p	Preop	Postop	p	Group 1	Group 2	p
	Mean±SD	Mean±SD		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
DASH	92.1±8.7	70.2±7.3	<0.05	91.6±9.2	71.5±6.1	<0.05	70.2±7.3	71.5±6.1	>0.05
Constant	41.6±3.9	80.3±6.7	<0.05	40.1±4.0	81.5±7.7	<0.05	80.3±6.7	81.5±7.7	>0.05
Pain	6.7±0.9	3.2±0.2	>0.05	6.6±.04	3.1±0.1	>0.05	3.2±0.2	3.1±0.1	>0.05
Impairment	6.8±0.3	3.5±0.3	>0.05	6.7±0.5	3.6±0.2	>0.05	3.5±0.3	3.6±0.2	>0.05
FF	110.1±9.3	176.0±8.4	<0.05	108.1±7.0	175.0±9.4	<0.05	176.0±8.4	175.0	>0.05
ER	43.2±4.1	78.1±8.2	<0.05	42.2±4.9	77.8±6.0	<0.05	78.1±8.2	77.8±6.0	>0.05
IR	17.2±2.1	12.2±1.4	<0.05	16.1±2.2	11.9±2.1	<0.05	12.2±1.4	11.9±2.1	>0.05

SD: Standard deviation; FF: Forward şexion; ER: External rotation; IR: Internal rotation at spine level.

Table 3. Comparisons of baseline between patients with retear and without retear.

	Retear group	Intact group	p
No. of shoulder	13	47	–
Age (y)			
Mean±SD	56.6±6.6	57.4±7.1	>0.05
Range	37–71	35–68	–
Gender (male/female)	16/14	15/15	>0.05
Side (right/left)	7/6	24/23	>0.05
Duration of symptoms (mo)			
Mean±SD	11.3±2.1	12.0±2.5	>0.05
Range	2–27	1–26	–
Tear size (cm)			
Mean±SD	3.2±0.4	3.1±0.1	>0.05
Range	1.7–5.5	1.5–5.4	–
Cigarette use			
Nonsmoker	7	26	>0.05
Current smoker	2	9	<0.05
Ex-cigarette smoker	4	12	>0.05
Fatty degeneration			
Grade 1	3	14	>0.05
Grade 2	5	16	>0.05
Grade 3	5	16	>0.05
Grade 4	0	1	<0.05

SD: Standard deviation.

the double-row technique combined with local injection of PRP had a significantly lower retear rate of tendon than did the technique without PRP.

Randelli et al.[14] conducted a clinical trial in 53 subjects with 24-month follow-up. The treatment group consisted of those who received an intraoperative application of PRP, and the control group consisted of those who did not receive the treatment. No significant differences were observed in functional outcomes. In addition to Randelli et al., Ruiz-Moneo[15] found no difference between the group given PRP and the control group in terms of functional outcomes. With regard to functional outcomes, our results are consistent with these 2 reports.

Double-row techniques can achieve high initial fixation strength, minimize gap formation, and maintain mechanical stability until healing occurs by increasing fixation strength and by restoring the rotator cuff footprint compared with single-row techniques.[5,6] Cadaveric models have shown an ability to withstand an increased load before failure with double-row repair compared with single-row repair. Cadaveric and arthroscopic studies have shown double-row repair leads to 100% restoration of the footprint, whereas only approximately 50% of the footprint is restored with single-row repair.[16] Clinical studies have shown that double-row rotator cuff repair techniques have a significantly lower retear rate compared with single-row techniques, especially in those rotator cuff tears >30 mm in size.[5,6,17]

Variable results have been reported from investigations on the incidence of retears after rotator cuff augmentation with PRP. In a prospective randomized study, Jo et al.[18] reported that the application of PRP significantly improved structural outcomes. In contrast, in a meta-analysis by Zhang et al.,[19] PRP augmentation was found to have no benefit in terms of either functional results or rerupture. A prospective randomized double-blinded study by Rodeo et al.[20] found that PRP application inhibited tendon recovery, and when applied in the 12th week following double-row transosseous repair, it produced less successful results compared with the control group. Moreover, experimental studies have shown that PRP application after repair impairs recovery of the tendon.[21] Our results are consistent with those reported by Jo et al; however, no significant difference was detected regarding the functional outcomes between the PRP and non-PRP groups. A longer follow-up period may be required to differentiate between functional outcomes because many subjects with incompletely healed cuff tendons have an initial positive outcome before a significant deterioration in symptoms.

Compared with the solid PRP constructs, the number of platelets in liquid form required for a clinically

significant effect has not been determined. A system that provides a higher number of platelets may not necessarily be better, especially if the platelets have completely dissipated within hours of activation. Furthermore, the presence of leukocytes in the liquid form may be disadvantageous due to the deleterious effects associated with neutrophils containing matrix metalloproteinases. Barber et al.[22] used a solid form of PRP that did not possess thrombin activation or contain leukocytes. This globular fibrin matrix product is more technically demanding to use, as it must be sutured into the repair instead of being injected into the area of cuff repair. With this technique, the release of growth factors into the healing milieu lasts for several days rather than hours.

Based on the literature, preoperative factors that have been suggested to be predictive of higher retear rates include age greater than 65 years, smoking, large tear sizes, preoperative duration of symptoms, and preoperative stage of fatty degeneration.[23] During the design of the present study, these factors predictive of higher retear rates were compared preoperatively, and no significant difference was seen (Table 1). In our review, despite a limited sample size, PRP demonstrated a beneficial effect on healing rates.

Some potential limitations must be acknowledged: only single-dose PRP applications were used in a comparatively low number of patients who were not studied for an extended period. The patients will remain under follow-up to assess long-term results.

Conclusion

Our study indicates the repair of rotator cuff using arthroscopic double-row technique combined with the injection of PRP has a significantly higher rate of tendon healing than does the technique without PRP. However, the improvement in healing rate has not been universally shown to translate into improved overall functional outcomes. Further studies should be conducted in order to present recommendations for the use of autologous blood-derived perioperative PRP augmentation.

Acknowledgments

This work was supported by the Natural Science Foundation of China 81401770.

Conflicts of Interest: No conflicts declared.

References

1. Ko SH, Shin SM. Single row rotator cuff repair with modified technique. World J Orthop 2012;3:199–203. CrossRef
2. Russo R, Cautiero F, Giudice G, Ciccarelli M, Visconti V. Arthroscopic repair of rotator cuff tears using absorbable anchors with a single-row technique. J Orthop Surg (Hong Kong) 2010;18:332–7.
3. Longo UG, Rizzello G, Berton A, Maltese L, Fumo C, Khan WS, et al. Biological strategies to enhance rotator cuff healing. Curr Stem Cell Res Ther 2013;8:464–70.
4. Tudisco C, Bisicchia S, Savarese E, Fiori R, Bartolucci DA, Masala S, et al. Single-row vs. double-row arthroscopic rotator cuff repair: clinical and 3 Tesla MR arthrography results. BMC Musculoskelet Disord 2013;14:43. CrossRef
5. Huijsmans PE, Pritchard MP, Berghs BM, van Rooyen KS, Wallace AL, de Beer JF. Arthroscopic rotator cuff repair with double-row fixation. J Bone Joint Surg Am 2007;89:1248–57. CrossRef
6. Sheibani-Rad S, Giveans MR, Arnoczky SP, Bedi A. Arthroscopic single-row versus double-row rotator cuff repair: a meta-analysis of the randomized clinical trials. Arthroscopy 2013;29:343–8. CrossRef
7. Sugaya H, Maeda K, Matsuki K, Moriishi J. Repair integrity and functional outcome after arthroscopic double-row rotator cuff repair. A prospective outcome study. J Bone Joint Surg Am 2007;89:953–60. CrossRef
8. Li R, Guo G, Chen B, Zhu L, Lin A. Arthroscopically-assisted reduction and fixation of an old osteochondral fracture of the lateral femoral condyle. Med Sci Monit 2012;18:CS117–20. CrossRef
9. Yuan T, Zhang CQ, Wang JH. Augmenting tendon and ligament repair with platelet-rich plasma (PRP). Muscles Ligaments Tendons J 2013;3:139–49.
10. Abrams GD, Frank RM, Fortier LA, Cole BJ. Platelet-rich plasma for articular cartilage repair. Sports Med Arthrosc 2013;21:213–9. CrossRef
11. Factor D, Dale B. Current concepts of rotator cuff tendinopathy. Int J Sports Phys Ther 2014;9:274–88.
12. Jiang D, Wang JH. Tendinopathy and its treatment with platelet-rich plasma (PRP). Histol Histopathol 2013;28:1537–46.
13. Owen RS, Iannotti JP, Kneeland JB, Dalinka MK, Deren JA, Oleaga L. Shoulder after surgery: MR imaging with surgical validation. Radiology 1993;186:443–7. CrossRef
14. Randelli P, Arrigoni P, Ragone V, Aliprandi A, Cabitza P. Platelet rich plasma in arthroscopic rotator cuff repair: a prospective RCT study, 2-year follow-up. J Shoulder Elbow Surg 2011;20:518–28. CrossRef
15. Ruiz-Moneo P, Molano-Muñoz J, Prieto E, Algorta J. Plasma rich in growth factors in arthroscopic rotator cuff repair: a randomized, double-blind, controlled clinical trial. Arthroscopy 2013;29:2–9. CrossRef
16. Wall LB, Keener JD, Brophy RH. Double-row vs single-row rotator cuff repair: a review of the biomechanical evidence. J Shoulder Elbow Surg 2009;18:933–41. CrossRef
17. Xu C, Zhao J, Li D. Meta-analysis comparing single-row and double-row repair techniques in the arthroscopic

treatment of rotator cuff tears. J Shoulder Elbow Surg 2014;23:182–8. CrossRef
18. Jo CH, Kim JE, Yoon KS, Lee JH, Kang SB, Lee JH, et al. Does platelet-rich plasma accelerate recovery after rotator cuff repair? A prospective cohort study. Am J Sports Med 2011;39:2082–90. CrossRef
19. Zhang Q, Ge H, Zhou J, Cheng B. Are platelet-rich products necessary during the arthroscopic repair of full-thickness rotator cuff tears: a meta-analysis. PLoS One 2013;8:e69731. CrossRef
20. Rodeo SA, Delos D, Williams RJ, Adler RS, Pearle A, Warren RF. The effect of platelet-rich fibrin matrix on rotator cuff tendon healing: a prospective, randomized clinical study. Am J Sports Med 2012;40:1234–41. CrossRef
21. Beck J, Evans D, Tonino PM, Yong S, Callaci JJ. The biomechanical and histologic effects of platelet-rich plasma on rat rotator cuff repairs. Am J Sports Med 2012;40:2037–44. CrossRef
22. Barber FA, Hrnack SA, Snyder SJ, Hapa O. Rotator cuff repair healing influenced by platelet-rich plasma construct augmentation. Arthroscopy 2011;27:1029–35. CrossRef
23. Mall NA, Tanaka MJ, Choi LS, Paletta GA Jr. Factors affecting rotator cuff healing. J Bone Joint Surg Am 2014;96:778–88. CrossRef