Al-Azhar International Medical Journal

Volume 4 | Issue 11 Article 40

2023
Section: Orthopedics

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Ibrahim Hussien
Department of Orthopedic Surgery, Faculty of Medicine for boys, Al-Azhar University, Cairo, Egypt

Mohamed Gamal Kamel Abdelkader
Department of Orthopedic Surgery, Faculty of Medicine for boys, Al-Azhar University, Cairo, Egypt

Abdelrahman Mostafa Tawfik
Department of Orthopedic Surgery, Faculty of Medicine for boys, Al-Azhar University, Cairo, Egypt,
Doc.abdelrahman2016@gmail.com

How to Cite This Article

Hussien, Ibrahim; Abdelkader, Mohamed Gamal Kamel; and Tawfik, Abdelrahman Mostafa (2023) "Platelet rich plasma (PRP) Injection in the Treatment of Supraspinatus Partial Tear," *Al-Azhar International Medical Journal*: Vol. 4: Iss. 11, Article 40.
DOI: https://doi.org/10.58675/2682-339X.2069

ORIGINAL ARTICLE

Platelet-rich Plasma Injection in the Treatment of Supraspinatus Partial Tear

Ibrahim Hussien, Mohamed Gamal Kamel Abdelkader, Abdelrahman Mostafa Tawfik*

Department of Orthopedic Surgery, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Abstract

Background: **Many people around the world suffer from rotator cuff (RC) lesions. RC tears are also an extremely common complaint, and their incidence rises with age. Both bursal-sided and articular-sided tears can occur as partial-thickness tears.**

Aim: **We aimed to determine the role of therapeutic shoulder injection with platelet-rich plasma (PRP) in the management of supraspinatus partial tears.**

Patients and methods: **This prospective research was performed on 20 patients at Al-Azhar University Hospitals (El Hussein Hospital and Sayed Galal Hospital) from September 2021 to November 2022. We included 20 patients suffering from a partial-thickness tendon tear. We measured patient satisfaction after injection with PRP in the shoulder surgery.**

Results: **Their average age was 51 years, with a range of from 42 to 65 years. The most impacted age group was between 50 and 60 years. The right side was significantly affected higher than the left side at a percentage of 80 %. Fourteen (66.6 %) patients complained of a moderate degree of shoulder pain. There were 85 % of the participants, who were very satisfied, 10 % who were moderately satisfied, and one patient who was not satisfied.**

Conclusion: **Subacromial injection of PRP is an effective minimally invasive therapy for supraspinatus partial tears. It is an accurate and safe technique that showed effective outcomes in tendon healing without significant risks or side effects.**

Keywords: Partial-thickness tears, Platelet-rich plasma, Supraspinatus partial tears

1. Introduction

The shoulder joint is the most movable with a wide range of motion of all the joints of the human body.[1] Structural anomalies in the subacromial space are thought to be the cause of 44–80 % of all shoulder complaints. The rotator cuff (RC) muscle tendons are present in this space.[2] The tendinous portion of the RC muscles becomes impacted under the anteroinferior aspect of the acromion and the coracoacromial arc in the painful condition known as subacromial impingement syndrome, leading to loss of function and restricted movement.[3]

The main course of treatment for RC tendinopathy without complete ruptures is conservative nonoperative care. Rest, exercise, physical therapy, NSAIDs, and activity modification are all parts of the treatment.[4] When conservative treatment has failed for 6 weeks, surgical intervention has been used as an alternative option for management.[5] The success rate of surgical treatment was variable with unfavorable rates of complication and different periods of recovery. Less invasive techniques for the management of long-term tendon injuries have been evaluated and proved to be beneficial in reducing morbidity and decrease the period of recovery.[6]

When other conservative treatments have been attempted, therapeutic subacromial injection should be evaluated.[7] To achieve the best clinical results and minimize local complications, the subacromial

Accepted 17 July 2023.
Available online 22 February 2024

* Corresponding author at: Department of Orthopedic Surgery, Faculty of Medicine for Boys, Al-Azhar University, 1 ElMokhayam El Daem St., Nasr City, Cairo, 11884, Egypt.
E-mail address: doc.abdelrahman2016@gmail.com (A.M. Tawfik).

https://doi.org/10.58675/2682-339X.2069

subdeltoid bursa must be precisely injected as the key component of the injection procedure.[8] The use of blind injection in clinical practice is common.[9] Studies have shown that image guidance, most often ultrasonography (US), improves the accuracy of needle placement. The US provides precise targeting of the target structure while minimizing injury to significant anatomical structures (nerves, vessels, etc.).[10] Only a few medications, such as steroids and anesthetics were used until a few years ago due to limited availability and inadequate understanding of pharmacological effects.[11] In recent years, the introduction and discovery of new medications [platelet-rich plasma (PRP) and hyaluronic acid], as well as developments in diagnostic tools and data of joint illnesses have facilitated the progress of a modern discipline that combines technology and knowledge for the management of joint diseases.[12–15]

We aimed to determine the role of therapeutic shoulder injection with PRP in the management of supraspinatus partial tears.

2. Patients and methods

This was a prospective cohort study on 20 patients, 14 males and six females performed at the Al-Azhar University Hospitals (El Hussein Hospital and Sayed Galal Hospital), Egypt. The study period was from September 2021 to November 2022.

2.1. Inclusion criteria

Male or female patients diagnosed with partial thickness tendon tear on the basis of clinical, laboratory data, and radiological investigations, failed conservative treatment and were able to complete follow-up periods at 4 and 12 weeks.

2.2. Exclusion criteria

Previous shoulder surgery, full-thickness RC tear, the patient who received corticosteroid or other shoulder injections during the last 6 months before the study, patients on anticoagulant therapy, or with coagulation disorders. Patients with chronic shoulder disorders (e.g., rheumatoid arthritis and seronegative arthropathy), application of physiotherapy of the injured limb, and patients receiving or likely to need systemic corticosteroids during the following 12 months, for any reason.

2.3. Patient counseling and consenting

The entire process, including the steps, results, and any complications, was thoroughly explained to the patients. Then, following the ethics committee's guidelines, written consent was obtained from each patient.

2.4. Patient evaluation

Each participant in our study underwent a clinical evaluation that involved full history taking, physical examination, and radiological evaluation.

2.5. Clinical history

Demographic data recording age, sex, and occupation. Full history taking including pain (site, onset, course, duration, and interference with normal daily activity) and review of the previous imaging studies. Laboratory investigation: complete blood count, liver function test, kidney function test, prothrombin time, partial thromboplastin time, and international normalized ratio. Clinical examination: positive empty can test. Clinical scoring: visual analog scale (VAS): a VAS scoring system used to assess the degree of pain for all studied patients initially at baseline and also during the two follow-up periods. Patients were asked to express the degree of pain at the time of evaluation by giving a degree from 0 to 10 (0 = no pain and 10 = the most severe pain).

2.6. Radiological evaluation

Cases were evaluated using an MRI study and US measurement of supraspinatus tendon thickness. All patients show partial thickness tears.

2.7. Shoulder injection procedure

Conventional subacromial injection of 3–5 ml of PRP and repeated for 3 successive months. (a) Pre-procedure instructions: patients who have an injection scheduled must stop using any anti-inflammatory drugs for 1–2 weeks before the injection. (b) Tools of procedure: centrifuge machine to obtain PRP, 5 ml syringes, 10 cm test tubes that should be sterile, lidocaine 2 % (local anesthetic), and citrate dextrose as anticoagulant under antiseptic conditions. (c) Preparation of PRP: PRP was generated using conventional techniques. With tubes made of acid-citrate and dextrose, the patient's blood was drawn under aseptic conditions. A measure of 10 ml of antecubital blood draw will yield 2–3 ml of PRP depending on the baseline platelet count of an individual. This blood was spun at 900 revolutions per minute in a centrifuge for 7–10 min (soft spin). Three layers of the entire blood were created. The buffy coat and the plasma

supernatant layer were separated, and they underwent centrifugation at a speed of 2000 revolutions per minute for 10 min. The lower third of the tube, which was PRP augmented with a superficial buffy coat, was injected, while the upper part of the tube, which contained platelet-poor plasma, was disposed of technique. Patient position: the patient was seated with his hands on his knees. Disinfection: the procedure was done under complete aseptic conditions, using sterile surgical gloves, and betadine to sterilize the injection site. Anesthesia: cutaneous and tract anesthesia was achieved with 1 ml of local anesthetic (lidocaine at the site of the injection subcutaneously). Injection technique: using the posterior approach, a sterile needle and 5-ml syringe were inserted percutaneously. A measure of 4 ml of PRP was injected in the subacromial space. Postinjection protocol: the patient was observed for 10 min and then discharged after being informed of the postinjection instructions. The use of local analgesics as NSAIDs in the form of topical gel and ice packs if needed for pain control and modify activity as tolerated. There is no use of NSAIDs throughout our 3-month follow-up period due to their antiplatelet and anticoagulant effects, which could diminish the effectiveness of PRP. The patients were instructed to avoid strenuous activity including the injected region for at least the first 48 h. Gradual return to activity is allowed. The patient was instructed to contact us immediately if he felt any of the following symptoms: prolonged redness, swelling, fever, or chills.

2.8. Evaluation and follow-up protocol

The patients underwent follow-up with the second and third injections at weeks 4 and 8, as measured by the VAS scoring for pain and range of motion of the affected shoulder, and the patients were evaluated by shoulder MRI or the US after 6 months.

2.9. Statistical analysis

The Statistical Package for the Social Sciences (SSPS) software was used to conduct statistical analysis. All data were statistically analyzed using SPSS 22.0 software (SPSS Co. Ltd., USA). The mean ± SD was used to convey patient data, and the number of cases and percentage were used to represent categorical variables. To compare the two study groups, the Student *t*-test was used for typically quantitative variables. *P* values less than 0.05 were considered significant. Appropriate descriptive and inferential statistical tests were used. Friedman's test [was used in testing the significant variance between periods using the post-hoc test (Dunn's)]. The *F*:*F* test (analysis of variance) with repeated measures [was used in the comparison between periods using the post-hoc test (Bonferroni)]. *P*: *P* value for comparing among the studied periods. *P*1: *P* value for comparing baseline and 4 weeks. *P*2: *P* value for comparing baseline and 12 weeks. *P*3: *P* value for comparing among 4 weeks and 12 weeks. *U*: Mann–Whitney test and Student *t*-test were used.

Table 1. Demographics including age and sex.

Age (years)	Sex [*n* (%)]		Total [*n* (%)]
	Males	Females	
<50	2 (14.3)	1 (16.66)	3 (15)
50–<60	8 (57.14)	4 (66.66)	12 (60)
>60	4 (28.6)	1 (16.66)	5 (25)
Total	14 (100)	6 (100)	20 (100)
Minimum–maximum			42.0–65.0
Mean ± SD			53.5 ± 7.25
Median			53.5

3. Results

The present study included 20 patients: 14 males and six females. Their ages ranged from 42 to 65 years with a mean age of 51 years. The most affected age group was between 50 and 60 years. The least affected age group was below 50 years (Table 1, Fig. 1).

Table 2 shows that the right side was significantly affected more than the left side as a percentage of 80 % (Fig. 2).

Table 3 shows that the patients were classified according to the degree of pain (VAS score) as mild (score 1–3), moderate (4–6), and severe (7–10).

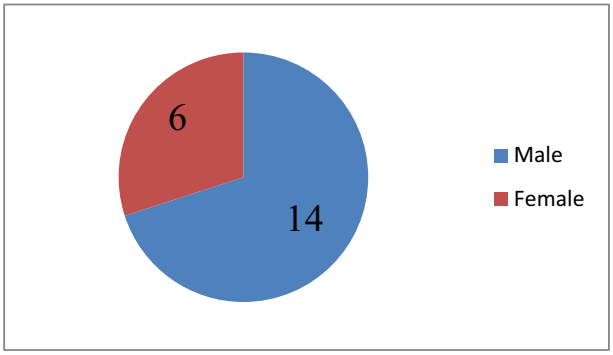

Fig. 1. Pie chart displaying the percentage of each sex included in the study group (n = 20).

Table 2. Distribution of the studied patients according to the affected side (N = 20).

Affected sides	*n* (%)
Right	16 (80)
Left	4 (20)

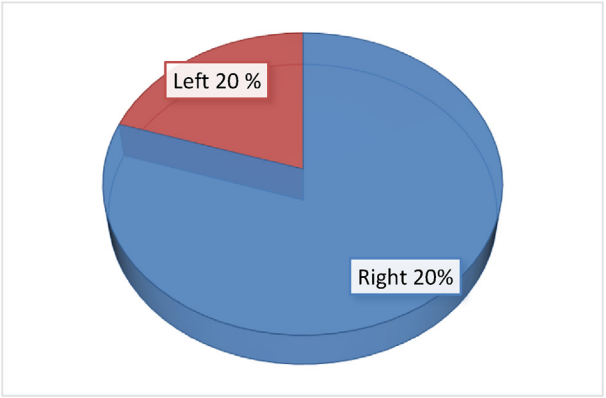

Fig. 2. Pie chart displaying the percentage of the affected side among the studied cases (n = 20).

Table 3. Distribution of the studied patients according to baseline visual analog scale score (N = 20).

Baseline pain (VAS) scores	*n* (%)
Mild (1–3)	3 (16.7)
Moderate (4–6)	14 (66.6)
Severe (7–10)	3 (16.7)
Minimum–maximum	2.0–9.0 (28.2)
Median (IQR)	5.0 (5.0–6.0) (5.9)
Mean ± SD	4.98 ± 1.57 (7.1)

IQR, interquartile range; VAS, visual analog scale.

Table 4. Distribution of the studied cases according to tear site (N = 20).

Tear sites	*n* (%)
Interstitial	5 (25.0)
Articular surface	10 (50.0)
Bursal surface	5 (25.0)

Table 5. Satisfaction of the included patients.

Variables	Studied patients (*N* = 20) [*n* (%)]
Very satisfied	17 (85)
Moderately satisfied	2 (10)
Not satisfied	1 (5)

Table 4 shows that the patients diagnosed with partial thickness tendon tears were classified according to the site of the tear, whether interstitial, articular, or bursal surface (Fig. 3).

Table 5 shows that regarding the satisfaction of the included patients, we found that 85 % of the patients were very satisfied, 10 % were moderately satisfied, and only one patient was not satisfied.

4. Discussion

According to the Parada et al.[16] study, it has been shown that the traditional choice for treating these cases had risks like infection, injury to nearby blood vessels and nerves, delayed healing, and a recovery time of up to 6 months, depending on the degree of the injury and shoulder's stiffness. Randelli et al.[17] observed that these risks have a high prevalence, ranging from 6 to 11 %. This study included 20 patients complaining of varying degrees of shoulder pain and limited range of movements and diagnosed with supraspinatus partial tears not responding to other lines of conservative treatment. Our main objective was to evaluate the role of therapeutic PRP subacromial injection in patients with supraspinatus partial tears. In our study, the age group most

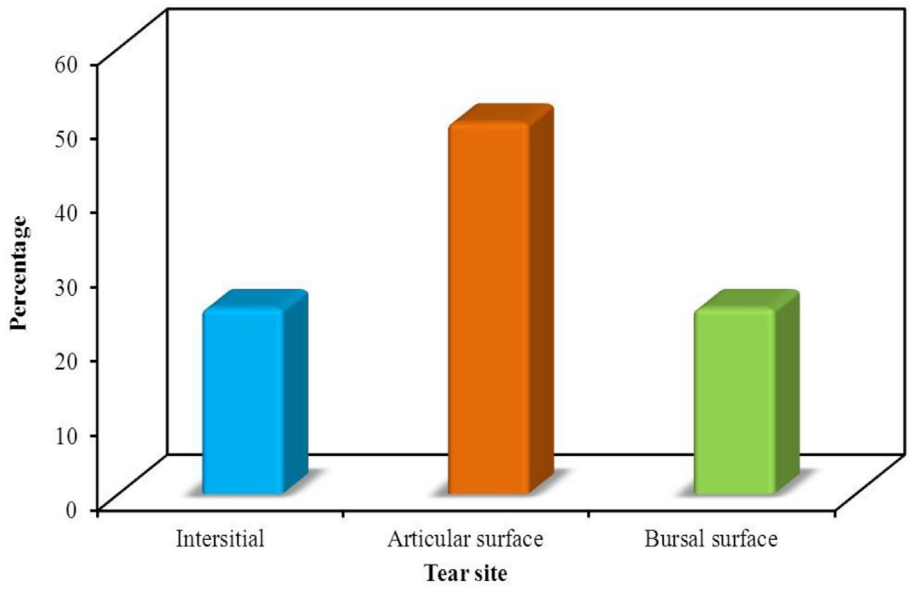

Fig. 3. Graph displays the distribution of the studied cases according to tear site (n = 20).

affected was between 50 and 60, followed by those over 60 years, with a mean age of 53.5 ± 7.25.

Similar disease prevalence was suggested by the study by George et al.,[18] which also noted that the mean age group was 58–60 years and that the prevalence increases with age. We observed that the right shoulder was affected more than the left one. This result matches with Ibrahim et al.[19] and Shams et al.,[20] who highlighted that this happens as a result of the dominant shoulder being overused, which makes it more vulnerable to inflammation and damage.

In this study, we used PRP injection in 20 patients. All the studied patients were successfully injected with the posterior approach. We evaluated the capacity to get into the subacromial bursa and inject the substance in the peritendinous region as a technical success in our study, as described by Niazi and Habib.[21] We used the anterior approach for subacromial injection as adopted by Hashiuchi et al.,[9] while Cole et al.[22] used the lateral approach. We used the same method as several studies[21,23–25] regarding mixing the local anesthetic with corticosteroid preparation. According to other findings, corticosteroid producers advise against this mixture due to the possibility of steroid crystal clumping and precipitation. However, most rheumatologists and physiotherapists believe that this mixture produces transient analgesia, ensures medicine administration to the appropriate target, and dilutes the crystalline solution so that it is better diffused throughout the injected area. All patients were diagnosed with partial-thickness supraspinatus tendon tears.

The outcome measures collected at pretreatment and posttreatment visits were VAS scores for pain, MRI, and US supraspinatus tendon thickness. Follow-up was done at 4, 8, and 12 weeks postinjection to evaluate the patient's clinical and radiological response. The mean VAS score for our patients decreased from 4.98 as a baseline score to 3.07 after 4 weeks till reached 1.98 at the end of the third month postinjection. This finding denoted clinical improvement. This is consistent with the Niazi and Habib[21] study, which found a mean value of 2.5 points pain reduction; however, that study extended follow-up for 6 months postinjection. Pasin et al.[26] also reported that the mean VAS score significantly reduced from week 3 to week 8 postinjection. Levendoğlu and Halim Yõlmaz[27] had similar results, showing a statistically significant VAS score improvement at rest and in movement on day 15 and at 1 and 3 months postinjection. Our included patients, diagnosed with supraspinatus tendon partial thickness tears, were injected with PRP. We found that there was no significant difference after 4 weeks and that the mean reduction in the size of the tear was noted only in the 12-week postinjection follow-up.

This agrees with the study by Cai et al.,[28] which determined the healing degree by calculating the difference in tear size using MRI concluding a good therapeutic effect of PRP. Many studies[29–31] have documented the beneficial effects of individual growth factors of PRP on tendon healing. Application of PRP was shown to promote tendon cell proliferation, collagen synthesis, and vascularization *in vitro* and *in vivo* as emphasized by the study made by de Mos et al.[32]

Nguyen et al.[33] recommended that PRP be used as a nonoperative option to treat RC partial tears. Furthermore, additional studies[33–36] investigated the use of intraoperative PRP injection in augmentation of arthroscopic RC repair and found a considerably decreased retear rate. Saltzman et al.[37] also said that there is less discomfort and a shorter rehabilitation period.

However, Chahal et al.[38] and Kesikburun et al.[4] found no significant beneficial effect of using PRP in chronic RC tendinopathy. , According to Matthewson et al.[39] while PRP is widely available, several alternative techniques of extraction, concentration, distribution, and timing protocols may limit the use of this method. Regarding the side effects of our procedure, the only noted adverse effect was postinjection pain. Sixteen (70 %) patients have experienced mild transient shoulder pain which started in the early hours following injection and spontaneously resolved within 2–3 days. In our study to reduce the postinjection pain, we used immediate postinjection local ice fomentation. It was a successful method as these patients did not complain of postinjection pain. This was the same technique used by Haque et al.,[40] who recommended that the area should be immediately iced following the injection.

There were only a few limitations to this study. The first is that there was no placebo control group, hence it was not a randomized study. Next is the relatively small sample size, and a short follow-up period. We also did not conduct a comparative analysis of injection results under US guidance against the blind technique. We recommended that the clinical value of PRP injection for RC diseases might be evaluated in a larger randomized controlled trial compared with the current conventional therapy.

4.1. Conclusion

Finally, we concluded that subacromial injection of PRP provides a good minimally invasive method for the treatment of supraspinatus partial tears by

adding great value to its diagnostic role. It is an accurate and safe technique that showed effective outcomes in tendon healing without significant risks and side effects. We recommended that PRP injection should be performed as the next step after the failure of other conservative treatment lines.

Conflicts of interest

There are no conflicts of interest.

References

1. Lambert A, Loffroy R, Guiu B, et al. Rotator cuff tears: value of 3.0 T MRI. *Clin Imag*. 2009 Nov 1;33(6):493–495.
2. Kelly SM, Wrightson PA, Meads CA. Clinical outcomes of exercise in the management of subacromial impingement syndrome: a systematic review. *Clin Rehabil*. 2010 Feb;24(2): 99–109.
3. Say F, Gürler D, Bülbül M. Platelet-rich plasma versus steroid injection for subacromial impingement syndrome. *J Orthop Surg*. 2016 Apr;24(1):62–66.
4. Kesikburun S, Tan AK, Yilmaz B, Yaşar E, Yazicio lu K. Platelet-rich plasma injections in the treatment of chronic rotator cuff tendinopathy: a randomized controlled trial with 1-year follow-up. *Am J Sports Med*. 2013 Nov;41(11):2609–2616.
5. Tallon C, Coleman BD, Khan KM, Maffulli N. Outcome of surgery for chronic Achilles tendinopathy. A critical review. *Am J Sports Med*. 2001;29:315–320.
6. Housner JA, Jacobson JA, Misko R. Sonographically guided percutaneous needle tenotomy for the treatment of chronic tendinosis. *J Ultrasound Med*. 2009;28:1187–1192.
7. Tallia AF, Cardone DA. Diagnostic and therapeutic injection of the shoulder region. *Am Fam Physician*. 2003;67:1271–1278.
8. Huang Z, Du S, Qi Y, Chen G, Yan W. Effectiveness of ultrasound guidance on intraarticular and periarticular joint injections: systematic review and meta-analysis of randomized trials. *Am J Phys Med Rehabil*. 2015;94:775–783.
9. Hashiuchi T, Sakurai G, Sakamoto Y, Takakura Y, Tanaka Y. Comparative survey of pain-alleviating effects between ultrasound-guided injection and blind injection of lidocaine alone in patients with painful shoulder. *Arch Orthop Trauma Surg*. 2010;130:847–852.
10. Barile A, La Marra A, Arrigoni F, et al. Anaesthetics, steroids and platelet-rich plasma (PRP) in ultrasound-guided musculoskeletal procedures. *Br J Radiol*. 2016;89:20150355.
11. Sun Q-B, Liu S-D, Meng Q-J, Qu H-Z, Zhang Z. Single administration of intra-articular bupivacaine in arthroscopic knee surgery: a systematic review and meta-analysis. *BMC Muscoskel Disord*. 2015;16:21.
12. Dhurat R, Sukesh M. Principles and methods of preparation of platelet-rich plasma: a review and author's perspective. *J Cutan Aesthetic Surg*. 2014;7:189.
13. Lai LP, Stitik TP, Foye PM, Georgy JS, Patibanda V, Chen B. Use of platelet-rich plasma in intra-articular knee injections for osteoarthritis: a systematic review. *PM&R*. 2015;7:637–648.
14. Kuijpers T, van der Windt DAWM, Boeke JPA, et al. Clinical prediction rules for the prognosis of shoulder pain in general practice. *Pain*. 2006;120:276–285.
15. Seitz AL, McClure PW, Finucane S, Boardman ND, Michener LA. Mechanisms of rotator cuff tendinopathy: intrinsic, extrinsic, or both? *Clin Biomech*. 2011;26:1–12.
16. Parada SA, Dilisio MF, Kennedy CD. Management of complications after rotator cuff surgery. *Curr Rev Musculoskelet Med*. 2015;8:40–52.
17. Randelli PS, Arrigoni P, Cabitza P, Volpi P, Maffulli N. Autologous platelet rich plasma for arthroscopic rotator cuff repair. A pilot study. *Disabil Rehabil*. 2008;30:1584–1589.
18. George J, Li SC, Jaafar Z, Hamid MSA. Comparative effectiveness of ultrasound-guided intratendinous prolotherapy injection with conventional treatment to treat focal supraspinatus tendinosis. *Scientifica (Cairo)*. 2018;2018:1–7.
19. Ibrahim DH, El-Gazzar NM, El-Saadany HM, El-Khouly RM. Ultrasound-guided injection of platelet rich plasma versus corticosteroid for treatment of rotator cuff tendinopathy: effect on shoulder pain, disability, range of motion and ultrasonographic findings. *Egypt Rheumatol*. 2019 Apr 1;41(2): 157–161.
20. Shams A, El-Sayed M, Gamal O, Ewes W. Subacromial injection of autologous platelet-rich plasma versus corticosteroid for the treatment of symptomatic partial rotator cuff tears. *Eur J Orthop Surg Traumatol*. 2016 Dec;26:837–842.
21. Niazi G, Habib L. The role of ultrasound guided peri-tendinous injection in the treatment of non-calcific tendinopathy. *Egypt J Radiol Nucl Med*. 2015;46:71–78.
22. Cole B, Lam P, Hackett L, Murrell GAC. Ultrasound-guided injections for supraspinatus tendinopathy: corticosteroid versus glucose prolotherapy – a randomized controlled clinical trial. *Shoulder Elbow*. 2018;10:170–178.
23. Chen MJL, Lew HL, Hsu T-C, et al. Ultrasound-guided shoulder injections in the treatment of subacromial bursitis. *Am J Phys Med Rehabil*. 2006;85:31–35.
24. Lee H-J, Lim K-B, Kim D-Y, Lee K-T. Randomized controlled trial for efficacy of intra-articular injection for adhesive capsulitis: ultrasonography-guided versus blind technique. *Arch Phys Med Rehabil*. 2009;90:1997–2002.
25. Ucuncu F, Capkin E, Karkucak M, et al. A comparison of the effectiveness of landmark-guided injections and ultrasonography guided injections for shoulder pain. *Clin J Pain*. 2009;25: 786–789.
26. Molini L, Mariacher S, Bianchi S. US guided corticosteroid injection into the subacromial-subdeltoid bursa: technique and approach. *J Ultrasound*. 2012 Feb 1;15(1):61–68.
27. Levendoğlu F, Halim Yõlmaz HU. Comparison the effectiveness of physical therapy and corticosteroid injection for subacromial impingement syndrome. *J Turk Leag Against Rheum*. 2005;20:1.
28. Cai Y, Sun Z, Liao B, Song Z, Xiao T, Zhu P. Sodium hyaluronate and platelet-rich plasma for partial-thickness rotator cuff tears. *Med Sci Sports Exerc*. 2019;5:227–233.
29. Hansen M, Boesen A, Holm L, Flyvbjerg A, Langberg H, Kjaer M. Local administration of insulin-like growth factor-I (IGF-I) stimulates tendon collagen synthesis in humans. *Scand J Med Sci Sports*. 2013 Oct;23(5):614–619.
30. Ide J, Kikukawa K, Hirose J, et al. The effect of a local application of fibroblast growth factor-2 on tendon-to-bone remodeling in rats with acute injury and repair of the supraspinatus tendon. *J Shoulder Elbow Surg*. 2009 May-Jun; 18(3):391–398.
31. Kaux JF, Janssen L, Drion P, et al. Vascular Endothelial Growth Factor-111 (VEGF-111) and tendon healing: preliminary results in a rat model of tendon injury. *Muscles Ligaments Tendons J*. 2014 Jan;4(1):24–30.
32. de Mos M, van der Windt AE, Jahr H, et al. Can platelet-rich plasma enhance tendon repair? *Am J Sports Med*. 2008;36: 1171–1178.
33. Nguyen RT, Borg-Stein J, McInnis K. *Applications of Platelet-Rich Plasma in Musculoskeletal and Sports Medicine: An Evidence-Based Approach*. PM R; 2011.
34. Noud PH, Esch J. Complications of arthroscopic shoulder surgery. *Sports Med Arthrosc Rev*. 2013 Jun 1;21(2):89–96.

35. Barber FA, Hrnack SA, Snyder SJ, Hapa O. Rotator cuff repair healing influenced by platelet-rich plasma construct augmentation. *J Arthrosc Relat Surg*. 2011 Aug 1;27(8):1029–1035.
36. Castricini R, Longo UG, De Benedetto M, et al. Platelet-rich plasma augmentation for arthroscopic rotator cuff repair. *Am J Sports Med*. 2011;39:258–265.
37. Saltzman BM, Jain A, Campbell KA, et al. Does the use of platelet-rich plasma at the time of surgery improve clinical outcomes in arthroscopic rotator cuff repair when compared with control cohorts? A systematic review of meta-analyses. *Arthrosc J Arthrosc Relat Surg*. 2016;32:906–918.
38. Chahal J, Van Thiel GS, Mall N, et al. The role of platelet-rich plasma in arthroscopic rotator cuff repair: a systematic review with quantitative synthesis. *J Arthrosc Relat Surg*. 2012 Nov; 28(11):1718–1727.
39. Matthewson G, Beach CJ, Nelson AA, et al. Partial thickness rotator cuff tears: current concepts. *Adv Orthop*. 2015;2015: 458786.
40. Haque A, Pal Singh H, Pandey R. Treatment of massive irreparable rotator cuff tears using dermal allograft bridging reconstruction. *J Clin Orthop Trauma*. 2021;22:101593.