

PLATELET-RICH PLASMA INJECTIONS UNDER ULTRASOUND GUIDANCE FOR MANAGEMENT OF ROTATOR CUFF TENDINOPATHY: A SYSTEMATIC REVIEW

Naveen Nair¹, Arun Kaliyaperumal¹, Ravi Kumar N², Marie Bernard Arokiaraj², Arunchandar R³, Vimal Raj D⁴

Received : 08/02/2023
Received in revised form : 11/03/2023
Accepted : 03/04/2023

Keywords:

'Shoulder Tendinopathy', 'Rotator Cuff Tendinitis', 'Platelet Rich Plasma', 'Prp Injection', 'Conservative Treatment Of Rotator Cuff Tendinopathy' And 'Ultrasound Guidance'.

Corresponding Author:

Dr. Naveen Nair,

Email: naveentheorthopod@gmail.com

DOI: 10.47009/jamp.2023.5.4.327

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5 (4); 1643-1649



¹Associate Professor, Department of Orthopedics, IGMC & RI, Puducherry, India.

²Assistant Professor, Department of Orthopedics, IGMC & RI, Puducherry, India.

³Senior Resident, Department of Orthopedics, IGMC & RI, Puducherry, India.

⁴Professor & Head, Department of Orthopedics, IGMC & RI, Puducherry, India.

Abstract

Background: Tendinopathy of the rotator cuff commonly causes shoulder pain and disability leading to a poor quality of life. Initial treatment is conservative with exercise and analgesics. More invasive methods are dry needling, local steroids, saline and dextrose prolotherapy and surgery. Platelet rich plasma release growth factors which causes tendon healing. The role of PRP injection in this condition evokes interest and was evaluated by a systematic analysis of randomized controlled trials using this modality. **Materials and Methods:** This study followed the PRISMA guidelines and selected randomized controlled trials after a thorough search on the available library databases using inclusion and exclusion criteria. From these the study design, test and control group numbers, interventions, outcome observed and conclusions were recorded in tabular form. **Result:** A total of 14 RCT were selected and the parameters under study were recorded. Significant improvement in the test groups of PRP injections with respect to symptoms and function against the controls was seen in the nine selected trials. Improvement in both test and control groups with no statistically significant difference between them was observed in two studies. Three studies established that PRP was not superior to the control groups. Though a common disorder, the actual cause of rotator cuff tendinopathy, is not clear. A lack of healing potential and altered loading may be the cause. This may explain the benefits of PRP with its growth factors, cytokines and chemokines in causing healing. Though most of the studies indicated improved healing with PRP injections with reduced pain and improved function, a lack of uniformity in procedures used as controls, variation in doses and preparation of PRP and varying assessment protocols could influence outcomes in the studies. **Conclusion:** This systematic review found that PRP injection, was more effective in reducing pain and improving function in rotator cuff tendinopathy. It was safe and appropriate for long-term use. Though current evidence is promising, more high quality double blind randomised controlled trials with standard controls, PRP preparations, diagnostic and injection techniques and a tendinopathy specific outcome assessment protocol, are needed.

INTRODUCTION

Rotator cuff tendinopathy is the most common cause of shoulder pain and dysfunction, incidence being proportionate to age, accounting for more than 50% of cases by 60 years.^[1] This disorder leads to a poor quality of life. The most common muscle component of the rotator cuff involved in this condition is the supraspinatus though other components may also be involved.^[2] Increased age, professions involving

repetitive lifting or overhead activities and obesity contribute to the problem.^[1]

The ultrasonogram of the shoulder is the corner stone of diagnosis of Rotator Cuff Tendinopathy. The only drawback being the need for expertise and consistent scanning technique.^[3] Treatment options for Rotator cuff tendinopathy range from conservative, such as NSAIDs and a rehabilitation exercise program, to invasive such as dry needling, local injections of corticosteroids, dextrose and saline prolotherapy, and surgery.^[4] Conservative options are used in the early

phase of the disease. These fail when the condition reaches a refractory stage because of reduced vascularity and increased healing time. Biomechanical alterations occur in tendon which never regains initial strength.^[5]

Platelet rich plasma is an autologous whole blood product that after a centrifugation process provides a concentration of platelets higher than in circulating blood. These contain growth factors like transforming growth factor-beta (TGF- β), Platelet-Derived Growth Factor (PDGF), Vascular Endothelial Growth Factor (VEGF), and Epidermal Growth Factor (EGF) that support cell recruitment, development and morphogenesis and local healing.^[6] The aim of this systematic review was to scientifically evaluate studies that are randomised controlled trials using PRP injection as a treatment modality for rotator cuff tendinopathy.

How this treatment affected shoulder pain and function compared to controls along with the side effects was evaluated in this review.

MATERIALS AND METHODS

This study was performed according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines.^[7] An extensive and methodical literature search was performed within the Medline, PubMed, Science Direct, Embase and Cochrane library database and the studies which were randomized controlled trials only, were selected. The selection was done based on certain inclusion and exclusion criteria.

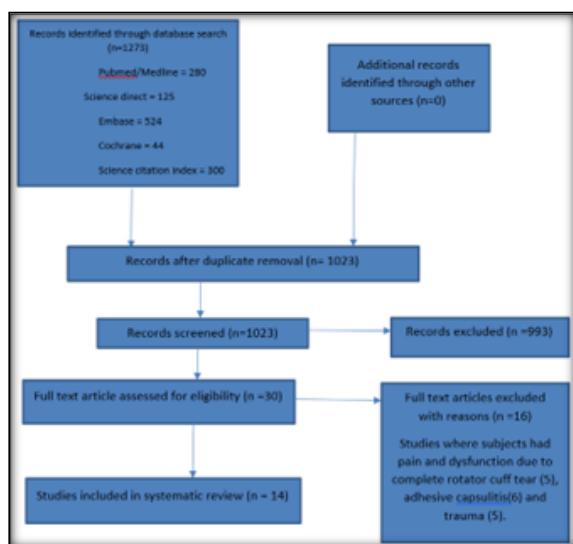


Figure 1: PRISMA flow chart for systematic review

Only randomised controlled trials which included patients having a diagnosis of rotator cuff tendinopathy, having symptoms for more than three months and failing conservative management with medical and physical therapy for a duration of at least four weeks. Studies which used platelet-rich plasma (PRP) group only (on subjects) compared to other methods used (as controls), were included. Control

groups in the studies selected included subjects receiving saline injection, dextrose prolotherapy, dry needling, corticosteroid injections, and nonsteroidal anti-inflammatory drugs with physiotherapy. Studies where PRP was an adjuvant to or combined with other modalities were excluded. Those studies where subjects had complete rotator cuff tears, adhesive capsulitis, trauma or other conditions which cause shoulder pain and dysfunction, were excluded. Animal studies were excluded.

Keywords such as ‘shoulder tendinopathy’, ‘rotator cuff tendinitis’, ‘platelet rich plasma’, ‘PRP injection’, ‘conservative treatment of rotator cuff tendinopathy’, ‘ultrasound guidance’ were used in various combinations to search for the appropriate studies fitting into our review. The selected studies had a follow up period of at the most one year. Decreased pain and improvement in function were considered as outcomes expected. The study design, test and control group numbers, interventions, outcome observed and conclusions were recorded.

RESULTS

A database search identified 1273 studies. After identifying duplicates 1023 studies remained. These were further screened excluding 993 criteria, leaving 30 full text articles to be further assessed for eligibility. Further screening using exclusion criteria removed 16 more leaving 14 studies eligible for our systematic review. After perusing these articles, they were tabulated under the following headings, namely reference number, study type, intervention, outcome and conclusion. [Table 1]

All the studies selected were single center randomized controlled trials, with test groups being given PRP injections and control groups using dry needling, saline injections, corticosteroid injections, dextrose prolotherapy, exercise and lidocaine injection. Two of the studies described had multiple control groups. Post injection physical therapy both in case of test and controls was undertaken in two studies. There was a wide heterogeneity numerically between the various studies selected. A total of 373 subjects in test groups received PRP injections as opposed to 461 subjects in control groups. The follow up interval after injection range from one month to one year with 3 and 6 month reviews in between.

Pain, functional and patient related outcomes were assessed using Visual analogue scale (VAS) for pain,^[8] Shoulder pain and disability index (SPADI),^[9] Disability arm shoulder hand score (DASH),^[9] American shoulder and elbow surgeons scale (ASES),^[9] Constant score,^[9] Single assessment numerical evaluation (SANE) score,^[9] and Oxford shoulder score.^[9] MRI evaluation to assess tendon lesion improvement was used in 3 studies. Ultra sonogram was used for the same in one study.

Significant improvement in the test groups of PRP injections with respect to symptoms and function against the controls was seen in the nine selected

trials. Improvement in both test and control groups with no statistically significant difference between them was observed in two studies. Three studies established that PRP was not superior to the control groups.

The studies selected showed wide variations with respect to number of control groups, subjects and assessment criteria for measuring patient reported functional outcome and modalities estimating tendon healing.^[10-20]

Rha DW et al,^[10] and Wessner et al,^[11] concluded that PRP injections were superior to dry needling and saline injections resulting in symptomatic and functional improvement. CH Jo et al,^[15] reported better pain relief and function after PRP injection at 6 months compared to steroid injections. Thepsoparn M et al,^[22] and Aylin Sari et al,^[21] reported usefulness of PRP for long term relief as compared to local corticosteroids. Good results were demonstrated by Dadgostar H et al,^[16] with PRP injection as compared to steroids. Shams A et al,^[17] reported better initial

results with PRP injections but improvement of statistical significance was not present at 6 months. They stated it was a alternative to steroids in view of local complications of steroids. Lo IKY et al,^[18] and Lee HW et al,^[19] reported better clinical outcomes in early stages but could not find improvement of statistical significance after 6 months and suggested more research into the concept.

Studies by Kesikburun S et al,^[12] Kwong CA et al,^[13] and Schwitzgubel AJ et al,^[14] reported PRP injections were not more effective than control groups in pain relief and functional improvement especially in long term. Schwitzgubel AJ in fact reported a higher incidence of adverse effects with PRP injections

Hala M et al,^[23] and Ibrahim DH et al,^[20] reported improved pain and functional scores in both control and test groups. They considered PRP injections a safe alternative to corticosteroids.

Table 1:

Articles	Study Type	Intervention	Subjects enrolled Test =N, controls= N'	Outcome	Conclusion
Rha DW et al. (10)	RCT/DB single centre prospective. LOE1	CG - 2 dry needling procedures 4 weeks apart. PRP group – 2 autologous PRP injections 4 weeks apart	N=20, N'=19	PRP injection under ultrasound guidance was found to be superior from 6 weeks to 6 months as assessed by SPADI, passive ROM of shoulder and a Physician global rating scale. No adverse effects seen.	Compared to dry needling, PRP injections reduced shoulder pain and improved function even 6 months after treatment. Considered safe and useful
Wessner et al. (11)	RCT single centre prospective. LOE2	CG – 4ml saline injection into rotator cuff. PRP – 4ml PRP injection into rotator cuff. All under took 3 months standardized home based exercise program	N=7, N'=2	PRP group demonstrated clinically important improvements in pain(VAS score), disability(DASH score) and tendon pathology(MRI).	Ultrasound guided intratendinous PRP injections led to improvement in pain, function and tendon pathology
Kesikburun S et al. (12)	RCT, LOE 1	CG injection of 5 ml saline into rotator cuff under US guidance. PRP group - 5ml injection of autologous PRP. Both groups underwent 6 weeks standard exercise program	N=20, N'= 20	The two groups showed no significant difference as assessed by VAS, WORCI, and SPADI scores	PRP was found to be no more effective at treating chronic Rotator Cuff tendinopathy than a placebo, at improving pain, function and quality of life.
Kwong CA et al. (13).	RCT, LOE 1	CG injection of CS under US guidance. PRP group – under same condition PRP injected.	N= 47, N'=52	PRP group had worst baseline pain, ROM and functional scores but had superior scores at 3 months. At 6 and 12 months there was no difference between two groups. Assessed by VAS, ASES, WORCI	Both groups showed clinical improvement. But PRP group was superior in short term follow up. At long term follow up there was no significant difference between the two.
Schwitzgubel AJ et al. (14)	RCT, LOE 1.	CG - 2 saline injections at 1-month interval. PRP – 2 PRP injections at 1-month interval.	N=40, N'=40	At 7 months there was no significant differences between two groups regarding decrease in size of lesion (MRI), or pain(VAS), function (SANE, Constant and ASES scores) At 12 months no significant differences were noted between 2 groups with regard to same. Adverse effects like	Compared to saline injections PRP injections did not improve tendon healing or clinical scores and had higher incidence of adverse effects.

				increase in pain and extension of lesion was noted more in PRP group	
CH Jo et al. (15)	A 2-group, parallel, assessor-blinded, RCT. LOE 1	CG - 4-mL mixture of 1 mL of 40-mg/mL triamcinolone acetonide (CS) and 3 mL of 2% lidocaine under ultrasonographic guidance. PRP- subacromial injection of either 4 mL of allogeneic pure PRP	N=30, N'=30	No treatment-related adverse events. At 1 month after injection Constant score did not show any difference between 2 groups. At six-month overall function and external rotation better in PRP by DASH score. Other clinical outcomes did not improve. Pain measurements, muscle strength, and the functional scores improved slowly and steadily in PRP group. In CS group after initial improvement it was not progressive.	PRP is safe but not superior to CS comparing pain and functional improvement. At 6th month PRP had better pain, patient reported outcome and functional improvement. PRP slowly but steadily reduced pain and improved function of the shoulder until 6 months, whereas corticosteroid did not.
Dadgostar H et al. (16)	Double blind RCT. LOE1	CG - CS group, 1cc of Depo-medrol 40 mg and 1cc of lidocaine (2%) was injected within the subacromial joint. PRP - 3cc of PRP was injected within the subacromial joint and another 3cc was injected at the site of the tendon tear, under the guide of sonography.	N= 29, N'= 29	At 1 and 3 months follow up pain and ROM improvement was better in PRP group using VAS, WORCI and DASH scores.	PRP may show similar results to CS but regarding pain and ROM PRP demonstrated better results. PRP may be useful in those patients where CS are contraindicated and risk of tendon rupture exists.
Shams A et al. (17)	RCT prospective. LOE 1	CG – CS injection in subacromial space. 1ml CS plus 1 ml lidocaine. PRP – 3 cc given	N=20, N'=20	Both groups showed statistically significant clinical outcome compared to pre injection. PRP was better at 12 weeks assessed by VAS, ASES, CMS, SST scores. MRI showed improvement in lesions but not statistically significant between groups	PRP injections showed earlier better results although statistically significant better results after 6 months could not be found. Sub acromial PRP injection could be considered as a good alternative to corticosteroid injection.
Hala M et al. (23)	RCT prospective. LOE 1	CG1 25% dextrose prolotherapy. CG2 Corticosteroid. PRP test group	N = 20 PRP. N'= 20 PT. N''=20 Corticosteroid	Prolotherapy and CS group showed good pain relief by VAS. No significant improvement was noted in PRP. All groups showed significant WORCI scores. ROM showed improvement in prolotherapy but not in others. Prolotherapy group and PRP showed lesion improvement but not CS group.	Prolotherapy demonstrated improved VAS, WORCI, ROM and tendon healing. PRP injections improved WORCI and tendon healing. Steroid injection had no effect on healing, but improved pain scores VAS, WORCI,
Ibrahim DH et al. (20)	RCT. LOE 1	Test group PRP. CG – CS	N=15 N'= 15 VAS, SDQ and ROM assessed	Both groups showed equally significant pain relief – VAS ROM improved in both groups significantly Tendinitis, tears and effusions improved in PRP group	Both modalities are equally effective but PRP is a safe alternative to CS reduces pain and inflammation and efficacy increases with US guidance.
LO IKY et al. (18)	Double blind single center RCT. LOE 1	CG-CS injections. TEST- PRP injections. Assess at 6 and 12 weeks post injection	N=50, N'=49. Pre and post injection assessment	PRP group demonstrated better pain improvement at 12 weeks but not at 6 weeks. There was no difference in other outcome measures or progression of the two groups to surgical intervention.	Use of PRP in the therapy rotator cuff tendinopathy shows a substantial reduction in pain ratings after 12 weeks. There was no effect on the rate at which patients progressed to surgical intervention. More

					research is needed to assess PRP.
Lee HW et al. (19)	RCT LOE 1	CG – exercises PRP – PRP injection	N=27, 13 LP-PRP, 14 LR-PRP N'= 33 standardized exercise program. Assess at 3 and 6 weeks	NRS and constant scores did not show any statistically significant difference between the two groups. ASES at 3 and 6 months showed statistically significant difference between PPRP and exercise at 3 and 6 months. No difference was noted between LP and LR preparations of PRP.	PRP injection group showed better clinical outcomes for first 3 months, before tapering off. No difference between LP-PRP LR-PRP groups and effect of PRP not influenced by leukocytes or platelet counts. PRP is effective in early treatment of patients not responding to conservative approach.
Aylin Sari, Ari Eroglu (21)	RCT. LOE 1	CG1- CS. CG2 prolotherapy. CG3- lidocaine. PRP group	N=33, N'=32, N''= 32, N'''=32	At 3 weeks CS had low pain and WORCI scores and higher ASES. At 24 weeks PRP had favorable VAS and WORCI. All injections showed improvement.	PRP is useful for long term relief but CS is good for short term relief. All injections had some relief of pain in different degrees
Thepsoparn M et al. (22)	RCT LOE 1	CG – CS TEST – PRP	N=15 N'=16, 1&6 month follow up, VAS & Oxford shoulder score assessed	At 1 month PRP and CS showed good pain relief and functional. But at 6 months PRP had better scores. CS did not progressively improve after 6 month	CS or PRP showed similar benefits in the short term but PRP progressively improves by 6 months whereas CS does not show long term benefits

Abbreviations – RCT- Randomised Controlled Trial, DB - Double Blind, LOE - Level of Evidence, ROM - Range of Movement, CG - Control Group, US – Ultrasound, PRP – Platelet Rich Plasma, CS – Corticosteroid, LP-PRP Leukocyte poor PRP, LR-PRP – Leukocyte Rich PRP, VAS – Visual Analogue Scale, SPADI – Shoulder Pain and Disability Index, DASH – Disabilities of Arm Shoulder and Hand, WORCI – Western Ontario Rotator Cuff Index, SANE – Single Assessment Numeric Evaluation, ASES – American Shoulder and Elbow Surgeons Score, CMS – Constant-Murley Shoulder score, SST – Simple Shoulder Test, NRS – Numerical Rating Scale., SDQ – Shoulder Disability Questionnaire.

DISCUSSION

Rotator cuff tendinopathy is a relatively common tendon disorder which affects a population ranging from common people to professional sportsmen. But, the underlying pathology is not fully understood. Degeneration and activities or professions subjecting joint to repetitive stress are considered to have a role to play.^[24] The theory is that more than inflammation, the reason rotator cuff tendinopathy occurs is lack of healing potential and altered loading.^[25] This explained the rationale behind use of Platelet Rich Plasma (PRP), where the platelets released growth factors, cytokines, and chemokines modulate inflammation and tissue regeneration and repair. Experimental in vitro studies have also demonstrate this.^[26]

Debate persists regarding the management of this condition, with ice, rest and physiotherapy being the initial treatment. A good standard rehabilitation regimen is composed of range of movement exercises, stretching and eccentric strengthening, muscle balancing and scapular stabilization.^[29] The exercise should reduce pain and improve function failing which other modalities should be considered.^[29]

Injections of corticosteroids with the anti-inflammatory action they possess, are a short term method as these cannot be administered repeatedly without risk of rupture of the tendon.^[28] Studies selected have shown PRP injections to be superior to corticosteroids in the long term benefits especially with regard to healing of the tendon caused by the

released growth factors because of platelets activation in PRP injections.^[28]

PRP injections have been shown to have long term benefits in management of rotator cuff tendinopathy. The advantages of PRP over the controls such as saline, corticosteroids, dextrose, sham injection and dry needling, was attributed to increased regeneration of damaged tissue and pain relief. Some studies did not reveal PRP to be superior to the controls used. Studies have also shown that exercise therapy is beneficial in pain relief and functional outcome.^[27] Thus comparative long term studies between groups undergoing PRP injection and physical therapy should be undertaken to identify which one gives better results.

PRP injection treatments are usually considered to be safe. Minor complications have been reported such as swelling, tenderness, joint pressure, and local pain associated with joint distension caused by intra-articular injection. No major adverse effects have been reported. Local pain because of intralesional injections were main complaint which settled in a few days.^[30] Thus intra-articular or intralesional PRP injections were considered a safe and well tolerated treatment.

Limitations

Wide variability was noticed in the studies selected with respect to sample size in patient groups thus making it difficult to know the extent to which these subjects would have improved without PRP injection. During selection of the studies many of the studies rejected revealed a confusion in relation to

terms such as supraspinatus tendinosis, supraspinatus tear, rotator cuff tendinosis, rotator cuff tear, and sub acromial impingement, when searching for ‘rotator cuff tendinopathy’ or ‘shoulder tendinopathy’. Uniform diagnostic criteria were also not observed among many studies rendering them unfit for inclusion in our review. The imaging modalities used to diagnose the entity under study and follow up of cases also varied in many studies. Long term imaging with ultrasound to study tendon healing was also lacking. The selected studies showed a lack of homogeneity in the procedures used as control. There was no uniformity in doses, preparation and treatment protocols followed in the PRP injections used, which could influence outcome in studies selected.

CONCLUSION

In comparison to other treatment modalities, this systematic review found that PRP injection, a less invasive method, was more effective in reducing pain and improving function in rotator cuff tendinopathy. It was safe and appropriate for long-term use. Even if current evidence is promising, high-quality double-blind randomised controlled studies with a larger study population are needed to compare PRP to other modalities, using standardised PRP preparation, injection technique and imaging modalities for diagnosis and follow up. Studies in future will require a rotator cuff tendinopathy-specific outcome assessment technique that is standard, reliable, and valid.

REFERENCES

- Niazi GE, Hassan MS & Elfawy DM. Ultrasound-guided injection of platelet-rich plasma (PRP) in rotator cuff tendinopathy: effect on patients' symptoms and supraspinatus tendon thickness. *Egypt J Radiol Nucl Med* 51, 111 (2020). <https://doi.org/10.1186/s43055-020-00221-2>
- Bey MJ, Song HK, Wehrli FW, Soslowsky LJ. Intratendinous strain fields of the intact supraspinatus tendon: the effect of glenohumeral joint position and tendon region. *J Orthop Res*. 2002;20(4):869-874.
- Okoroha KR, Fidai MS, Tramer JS, Davis KD, Kolowich PA. Diagnostic accuracy of ultrasound for rotator cuff tears. *Ultrasonography*. 2019 Jul;38(3):215-220. doi: 10.14366/usg.18058. Epub 2018 Nov 17. PMID: 30744304; PMCID: PMC6595130.
- Andres BM, Murrell GA. Treatment of tendinopathy: what works, what does not, and what is on the horizon. *Clin Orthop Relat Res*. 2008;466(7):1539-1554. doi:10.1007/s11999-008-0260-1
- Hamid MS, Sazlina SG (2021) Platelet-rich plasma for rotator cuff tendinopathy: A systematic review and meta-analysis. *PLoS ONE*16(5): e0251111. <https://doi.org/10.1371/journal.pone.0251111>
- Pavlovic V, Ciric M, Jovanovic V, Stojanovic P. Platelet Rich Plasma: a short overview of certain bioactive components. *Open Med (Wars)*. 2016;11(1):242-247. Published 2016 Aug 12. doi:10.1515/med-2016-0048.
- Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews *BMJ* 2021; 372: n71 doi:10.1136/bmj. n71
- Haefeli M, Elfering A. Pain assessment. *Eur Spine J*. 2006;15 Suppl 1(Suppl 1): S17-S24. doi:10.1007/s00586-005-1044-x
- Smith MV, Calfee RP, Baumgarten KM, Brophy RH, Wright RW. Upper extremity-specific measures of disability and outcomes in orthopaedic surgery. *J Bone Joint Surg Am*. 2012;94(3):277-285. doi:10.2106/JBJS.J.01744
- Rha DW, Park GY, Kim YK, Kim MT, Lee SC. Comparison of the therapeutic effects of ultrasound-guided platelet-rich plasma injection and dry needling in rotator cuff disease: a randomized controlled trial. *Clin Rehabil*. 2013 Feb;27(2):113-22. doi: 10.1177/0269215512448388. Epub 2012 Oct 3. PMID: 23035005 Clinical Trial.
- Wesner M, Defreitas T, Bredy H, Pothier L, Qin Z, McKillop AB, Gross DP. A Pilot Study Evaluating the Effectiveness of Platelet-Rich Plasma Therapy for Treating Degenerative Tendinopathies: A Randomized Control Trial with Synchronous Observational Cohort.
- Kesikburun S, Tan AK, Yilmaz B, Yasar E, Yazikioğlu 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*, Volume 41 issue 11: 2609-2616 <https://doi.org/10.1177/0363546513496542>
- Kwong CA, Woodmass JM, Gusnowski EM, Bois AJ, Leblanc J, More KD, Lo IKY. Platelet-Rich Plasma in Patients with Partial-Thickness Rotator Cuff Tears or Tendinopathy Leads to Significantly Improved Short-Term Pain Relief and Function Compared with Corticosteroid Injection: A Double-Blind Randomized Controlled Trial. *Arthroscopy*. 2021 Feb;37(2):510-517. doi: 10.1016/j.arthro.2020.10.037. Epub 2020 Oct
- Schwitzgubel AJ, Kolo FC, Tirefort J, Kourhani A, Nowak A, Gremeaux V, Saffarini M, Lädermann A. Efficacy of Platelet-Rich Plasma for the Treatment of Interstitial Supraspinatus Tears: A Double-Blinded, Randomized Controlled Trial. *Am J Sports Med*. 2019 Jul;47(8):1885-1892. doi: 10.1177/0363546519851097.
- CH Jo, SY Lee, KS Yoon, S Oh, S Shin. Allogeneic Platelet-Rich Plasma Versus Corticosteroid Injection for the Treatment of Rotator Cuff Disease. A Randomized Controlled Trial. *The Journal of Bone and Joint Surgery: December 16, 2020 - Volume 102 - Issue 24 - p 2129-2137*, doi: 10.2106/JBJS.19.01411
- Dadgostar H, Fahimipour, F., Pahlevan Sabagh, A. et al. Corticosteroids or platelet-rich plasma injections for rotator cuff tendinopathy: a randomized clinical trial study. *J Orthop Surg Res* 16, 333 (2021). <https://doi.org/10.1186/s13018-021-02470-x>.
- Shams A, El-Sayed, M., Gamal, O. et al. Subacromial injection of autologous platelet-rich plasma versus corticosteroid for the treatment of symptomatic partial rotator cuff tears. *Eur J Orthop Surg Traumatol* 26, 837–842 (2016). <https://doi.org/10.1007/s00590-016-1826-3>
- Lo I. K. Y., Bois A., LeBlanc J., Woodmass J., Kwong C., Gusnowski E., and Lo A. THE EFFECT OF PLATELET-RICH PLASMA ON PARTIAL THICKNESS ROTATOR CUFF TEARS: A DOUBLE-BLIND PROSPECTIVE RANDOMIZED CONTROLLED TRIAL. *Orthopaedic Proceedings* 2020 102-B: SUPP_7, 31-31
- Ho-Won Lee, Kyung-Ho Choi , Jung-Youn Kim, Ik Yang , Kyu-Cheol Noh. Prospective Clinical Research of the Efficacy of Platelet-rich Plasma in the Outpatient-based Treatment of Rotator Cuff Tendinopathy. *Clin Shoulder Elb*2019 Jun 1;22(2):61-69. doi: 10.5397/cise.2019.22.2.61. eCollection 2019 Jun.
- Doaa H. Ibrahim, Najat M. Elgazzar, Hanan El-Saadany, Radwa M.El-Khouly. 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. *The Egyptian Rheumatologist*, Volume 41, Issue 2, April 2019, Pages 157-161. <https://doi.org/10.1016/j.ejr.2018.06.004>
- Aylin Sari, Ali Eroglu. Comparison of ultrasound-guided platelet-rich plasma, prolotherapy, and corticosteroid injections in rotator cuff lesions. *J Back Musculoskelet Rehabil* 2020;33(3):387-396. doi: 10.3233/BMR-191519.
- Thepsoparn M, Thanphraisan P, Tanpowpong T, Itthipanichpong T. Comparison of a Platelet-Rich Plasma Injection and a Conventional Steroid Injection for Pain Relief and Functional Improvement of Partial Supraspinatus Tears.

- Orthop J Sports Med. 2021 Sep 1;9(9):23259671211024937. doi: 10.1177/23259671211024937. eCollection 2021 Sep.
23. Hala M, Abd Elsabour, Sabaah Mary A, Nassif. What is better for rotator cuff tendinopathy: dextrose prolotherapy, platelet-rich plasma, or corticosteroid injections? A randomized controlled study. *Egyptian Rheumatology and Rehabilitation* 47(1):40 December 2020. DOI:10.1186/s43166-020-00040-3.
 24. Factor D, Dale B. Current concepts of rotator cuff tendinopathy. *Int J Sports Phys Ther.* 2014;9(2):274-288.
 25. Jeremy L, Karen M, Jean-Sébastien R, Karen G. Rotator Cuff Tendinopathy: Navigating the Diagnosis-Management Conundrum. *Journal of Orthopaedic & Sports Physical Therapy.* Published Online: October 31, 2015 Volume 45 Issue 11 Pages 923-937
 26. Zhou Y, Wang JH. PRP Treatment Efficacy for Tendinopathy: A Review of Basic Science Studies. *Biomed Res Int.* 2016; 2016:9103792. doi:10.1155/2016/9103792
 27. Jonsson P, Wahlström P, Öhberg L Et al. Eccentric training in chronic painful impingement syndrome of the shoulder: Results of a pilot study. *Knee. Surg. Sports. Traumatol. Arthrosc.* 14(1), 76–81 (2006).
 28. Dean BJ, Lostis E, Oakley T et al. The risks and benefits of glucocorticoid treatment for tendinopathy: a systematic review of the effects of local glucocorticoid on tendon. *Semin. Arthritis. Rheum.* 43, 570–576 (2014).
 29. Pooja Pithadia, Sharmila S Tulpule, Mrinalini Singh, Pratham Surya. Platelet rich plasma therapy for shoulder tendinopathy: a systematic review. *Int. J. Clin. Rheumatol.* (2021) 16(5), 149-157
 30. Lin MT, Wei KC, Wu CH. Effectiveness of Platelet-Rich Plasma Injection in Rotator Cuff Tendinopathy: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Diagnostics (Basel).* 2020 Mar 28;10(4):189. doi: 10.3390/diagnostics10040189. PMID: 32231127; PMCID: PMC7235747.