



Original Article

## Ultrasound-Guided Leucocyte-Poor Platelet-Rich Plasma in Subacromial Impingement Syndrome: Short-Term Clinical and Radiological Outcomes in Degenerative Supraspinatus Disease

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### ABSTRACT

**Background:** Subacromial impingement syndrome (SAIS) is a common cause of chronic shoulder pain and functional disability. Degenerative pathology involving the supraspinatus tendon contributes significantly to persistent symptoms and progressive dysfunction. Conventional treatment modalities frequently provide temporary symptomatic relief without promoting tendon healing. Leucocyte-poor platelet-rich plasma (LP-PRP) has emerged as a biologic treatment option because of its regenerative and anti-inflammatory potential.

**Purpose:** To evaluate the short-term clinical, functional, and radiological outcomes of ultrasound-guided LP-PRP injection in patients with subacromial impingement syndrome.

**Study Design:** Prospective single-arm interventional study; Level of evidence, 2.

**Methods:** Thirty patients with clinically and radiologically confirmed SAIS refractory to conservative treatment were included in this prospective study. All patients underwent ultrasound-guided subacromial injection of 5 mL LP-PRP prepared using a standardized double-spin centrifugation technique. Clinical outcomes were assessed using Visual Analog Scale (VAS), Disabilities of the Arm, Shoulder and Hand (DASH) score, and Constant score at baseline, 6 weeks, and 4 months. MRI evaluation was performed before treatment and at final follow-up to assess tendon healing.

**Results:** Progressive improvement was observed in pain and functional outcome measures during follow-up. Mean VAS score improved from  $6.8 \pm 1.1$  at baseline to  $1.6 \pm 1.0$  at 4 months. DASH score improved from  $58.3 \pm 11.2$  to  $18.6 \pm 8.3$ , while Constant score improved from  $46.2 \pm 9.8$  to  $82.7 \pm 8.6$  during follow-up ( $p < 0.001$ ). MRI evaluation demonstrated interval healing response in partial supraspinatus tears in 23.3% of patients, with complete radiological normalization in 3.3% of patients. Mild transient local inflammatory reaction occurred in two patients and resolved conservatively.

**Conclusion:** Ultrasound-guided LP-PRP injection demonstrated sustained improvement in pain, shoulder function, and radiological tendon healing in patients with SAIS. LP-PRP may serve as an effective minimally invasive biologic treatment

option in chronic degenerative supraspinatus pathology.

**Keywords:** Platelet-rich plasma; subacromial impingement syndrome; supraspinatus tendinopathy; orthobiologics; rotator cuff disease.

## INTRODUCTION

Shoulder pain represents one of the most common musculoskeletal complaints encountered in routine orthopaedic practice, with subacromial impingement syndrome accounting for a substantial proportion of these cases. SAIS is characterized by mechanical compression and repetitive microtrauma involving the rotator cuff tendons and subacromial bursa beneath the coracoacromial arch. Over time, chronic irritation may lead to tendon degeneration, fibrosis, tendinosis, and eventually partial-thickness or full-thickness rotator cuff tears.

The supraspinatus tendon is particularly vulnerable because of its anatomical position beneath the anterior acromion and coracoacromial ligament. Repetitive overhead activity, altered scapular kinematics, age-related tendon degeneration, and vascular compromise collectively contribute to the development of supraspinatus pathology. Patients commonly present with pain during overhead activity, nocturnal discomfort, weakness, and progressive restriction of shoulder function.

Conservative management remains the first-line treatment for SAIS and typically includes physiotherapy, oral non-steroidal anti-inflammatory drugs, activity modification, and local injections. Although corticosteroid injections may provide rapid symptomatic relief, concerns persist regarding their potential adverse effects on tendon integrity, collagen organization, and long-term tendon healing.

In recent years, regenerative medicine and orthobiologic therapies have gained increasing interest in musculoskeletal disorders. Platelet-rich plasma (PRP) is an autologous blood-derived biologic concentrate containing supraphysiological platelet concentrations capable of releasing multiple growth factors involved in tissue repair. These include platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF- $\beta$ ), vascular endothelial growth factor (VEGF), insulin-like growth factor (IGF), fibroblast growth factor (FGF), and epidermal growth factor (EGF).

These biologically active mediators are believed to stimulate collagen synthesis, tenocyte proliferation, angiogenesis, extracellular matrix remodeling, and tendon healing. Experimental studies have demonstrated that PRP may improve tendon cell proliferation and enhance collagen organization during tendon repair.

Different PRP formulations exist depending on platelet concentration and leucocyte content. Leucocyte-poor platelet-rich plasma has been proposed to provide a more favorable biologic environment by minimizing excessive inflammatory cytokine release while preserving anabolic growth factor activity. Reduced leucocyte concentration may decrease post-injection inflammatory reaction and potentially improve tendon healing in chronic degenerative pathology.

Although several studies have evaluated PRP in rotator cuff disease, evidence specifically examining ultrasound-guided LP-PRP in subacromial impingement syndrome remains limited. Therefore, the present study aimed to evaluate the short-term clinical, functional, and radiological outcomes following ultrasound-guided LP-PRP injection in patients with degenerative supraspinatus pathology associated with SAIS.

## MATERIALS AND METHODS

### Study Design

A prospective single-arm interventional study was conducted following institutional ethics committee approval. Written informed consent was obtained from all patients.

### Patient Recruitment

Patients presenting with shoulder pain suggestive of SAIS underwent clinical evaluation using:

- Painful arc sign
- Neer's impingement test
- Hawkins-Kennedy test

Radiological evaluation included:

- Plain radiographs
- MRI of the shoulder

Patients with MRI-confirmed supraspinatus tendinosis or partial-thickness tear who failed conservative treatment for at least six months were included.

### Inclusion Criteria

- Age 18–75 years
- Clinical diagnosis of SAIS

- MRI-confirmed supraspinatus tendinosis or partial tear
- Failure of conservative treatment for at least six months

#### Exclusion Criteria

- Full-thickness rotator cuff tear
- Previous shoulder surgery
- Shoulder instability
- Systemic inflammatory disorders
- Coagulopathy
- Active infection

#### PRP Preparation

Autologous LP-PRP was prepared using a standardized double-spin centrifugation technique.

#### Centrifugation Protocol

- First spin: 1200 rpm for 6 minutes
- Second spin: 1900 rpm for 9 minutes

The final preparation demonstrated:

- Mean platelet concentration:  $14,18,367 \pm 3,50,583$  platelets/ $\mu$ L
- Mean leucocyte count:  $601.9 \pm 487.2$ / $\mu$ L

No external activating agent was used.

#### Injection Technique

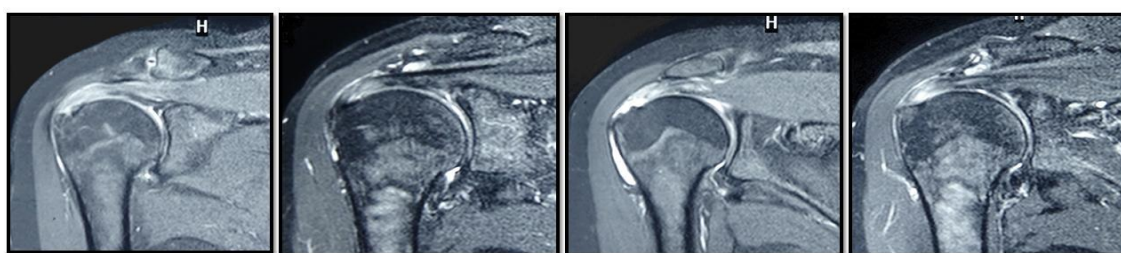
All injections were performed under ultrasound guidance using strict aseptic precautions.

The patient was positioned in a sitting posture with the affected shoulder exposed. A high-frequency linear ultrasound probe was used to identify the:

- Deltoid muscle
- Subacromial-subdeltoid bursa
- Supraspinatus tendon
- Greater tuberosity
- Humeral head

After infiltration with local anesthetic, a spinal needle was advanced into the subacromial space using an in-plane lateral approach under real-time ultrasound visualization.

A total of 5 mL LP-PRP was injected into the subacromial space with additional peritendinous infiltration around the supraspinatus tendon when indicated sonographically.



PRE-INJECTION (TYPE IIB)

POST-INJECTION (TYPE IIA)

PRE-INJECTION (TYPE IIB)

POST-INJECTION (TYPE IIA)

#### Post-Injection Rehabilitation Protocol

Patients were advised:

- To avoid NSAIDs for one week
- To avoid heavy lifting for two weeks
- To begin shoulder range-of-motion exercises after one week
- To use paracetamol for pain control if required

A structured physiotherapy program focusing on rotator cuff strengthening and scapular stabilization was initiated after the acute inflammatory phase subsided.

#### Outcome Measures

##### Primary Outcome

- Visual Analog Scale (VAS)

### Secondary Outcomes

- DASH score
- Constant score
- MRI tendon healing

Assessments were performed at:

- Baseline
- 6 weeks
- 4 months

MRI assessment was repeated at 4 months follow-up.

### Statistical Analysis

Data analysis was performed using Stata 11.0 software. Continuous variables were expressed as mean  $\pm$  standard deviation. Within-group comparison was performed using paired t-test. A p-value  $<0.05$  was considered statistically significant.

## RESULTS

### Baseline Characteristics

A total of 30 patients with clinically and radiologically confirmed subacromial impingement syndrome were included in the study. The mean age of the study population was  $43.5 \pm 11.9$  years, with the majority of patients belonging to the fourth and fifth decades of life. Female patients constituted a larger proportion of the cohort. Dominant shoulder involvement was observed in most cases, likely reflecting repetitive use and occupational strain.

The duration of symptoms before intervention ranged from 6 months to 3 years, with most patients reporting chronic shoulder pain resistant to conventional conservative treatment modalities including physiotherapy, oral anti-inflammatory medication, and activity modification.

Clinical examination revealed positive Neer's impingement sign and Hawkins-Kennedy test in all patients. Painful arc during shoulder abduction was frequently observed, particularly between  $60^\circ$  and  $120^\circ$  of abduction.

Baseline MRI findings demonstrated varying degrees of degenerative supraspinatus pathology including:

- Supraspinatus tendinosis
- Partial-thickness supraspinatus tears
- Subacromial bursitis
- Tendon thickening
- Type II acromial morphology

Partial-thickness supraspinatus tears represented the predominant MRI finding among patients with advanced symptoms.

### Clinical Outcomes

#### Visual Analog Scale (VAS)

Progressive and statistically significant reduction in pain intensity was observed following LP-PRP injection.

**Table 1. Evolution of VAS Score During Follow-up**

Follow-up Period	Mean VAS Score
Baseline	$6.8 \pm 1.1$
6 Weeks	$3.1 \pm 1.2$
4 Months	$1.6 \pm 1.0$

The mean VAS score decreased substantially from baseline to 6 weeks follow-up, indicating early clinical improvement following LP-PRP administration. Further reduction in pain was observed at 4 months, suggesting continued biological healing and progressive symptomatic recovery over time.

Most patients reported improvement in:

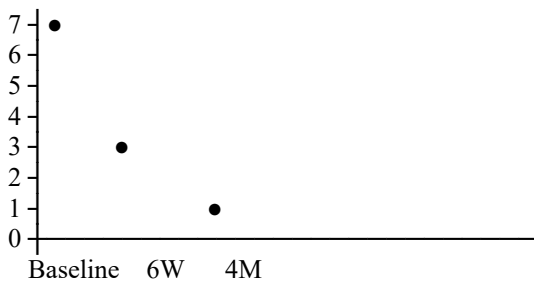
- Nocturnal shoulder pain
- Pain during overhead activities
- Pain while lifting objects
- Discomfort during daily activities

- Sleep disturbance associated with shoulder pain

Several patients described gradual reduction in pain rather than immediate relief, which may support the regenerative mechanism of LP-PRP rather than transient analgesic effect alone.

### Graphical Representation

VAS SCORE



The reduction in VAS score from baseline to final follow-up was statistically significant ( $p < 0.001$ ).

### DASH Score

The Disabilities of the Arm, Shoulder and Hand (DASH) score demonstrated progressive improvement throughout the follow-up period, indicating substantial functional recovery following LP-PRP injection.

**Table 2. DASH Score During Follow-up**

Follow-up Period	Mean DASH Score
Baseline	58.3 ± 11.2
6 Weeks	32.1 ± 10.5
4 Months	18.6 ± 8.3

At baseline, patients reported significant disability involving:

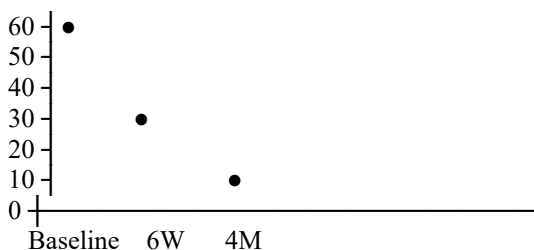
- Overhead activities
- Dressing
- Lifting weights
- Carrying objects
- Personal hygiene activities
- Occupational tasks

At 6 weeks follow-up, considerable improvement was observed in routine daily activities and shoulder mobility. Further functional recovery was noted at 4 months, with many patients returning to near-normal functional status.

Improvement in DASH score appeared to correlate with reduction in pain intensity and increased confidence in shoulder use during routine activities.

### Graphical Representation

DASH SCORE



The improvement in DASH score during follow-up was statistically significant ( $p < 0.001$ ).

### Constant Score

The Constant shoulder score demonstrated significant improvement during follow-up, reflecting improvement in pain, range of motion, shoulder strength, and overall shoulder function.

**Table 3. Constant Score During Follow-up**

Follow-up Period	Mean Constant Score
Baseline	46.2 ± 9.8
6 Weeks	68.5 ± 8.9
4 Months	82.7 ± 8.6

Improvement in Constant score was observed across all major components:

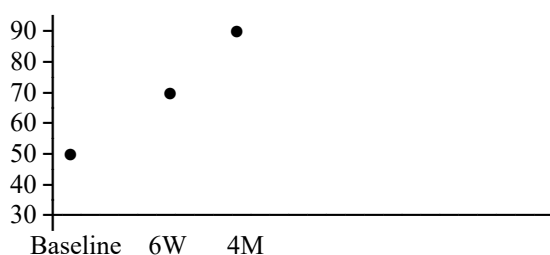
- Pain relief
- Range of motion
- Activities of daily living
- Muscle strength

Patients demonstrated improved shoulder abduction, forward flexion, and external rotation during clinical evaluation. Functional overhead activities became progressively less painful during follow-up.

At final follow-up, many patients demonstrated near-normal shoulder mobility with substantial reduction in activity-related pain.

### Graphical Representation

CONSTANT SCORE



The improvement in Constant score from baseline to 4 months follow-up was statistically significant ( $p < 0.001$ ).

### Radiological Outcomes

MRI evaluation performed at 4 months follow-up demonstrated interval healing response in patients with degenerative supraspinatus pathology.

**Table 4. MRI Healing Response Following LP-PRP Therapy**

MRI Finding	Number of Patients	Percentage
Type IIb converted to Type IIa	7	23.3%
Complete normalization	1	3.3%
No significant interval change	22	73.4%

MRI findings suggesting interval healing included:

- Reduced tendon edema
- Improved tendon fiber continuity
- Decreased bursal fluid collection
- Reduction in signal intensity within supraspinatus tendon
- Improvement in partial-thickness tear morphology

Patients demonstrating radiological healing generally also showed greater clinical and functional improvement.

Although complete radiological normalization was observed in only a small number of patients, interval healing response in partial-thickness tears suggests biologic modulation of tendon remodeling following LP-PRP therapy.

### Graphical Representation

MRI HEALING RESPONSE

Type IIb → IIa 23.3%

Complete healing 3.3%

No interval change 73.4%

Radiological improvement observed on follow-up MRI supported the regenerative potential of LP-PRP in chronic degenerative supraspinatus pathology.

### Complications and Adverse Events

No major complications or systemic adverse events were observed during the study period.

Two patients experienced transient:

- Injection site pain
- Mild erythema
- Local inflammatory reaction

Symptoms resolved conservatively within 2–3 days without additional intervention.

No cases of:

- Infection
- Neurovascular injury
- Shoulder stiffness
- Allergic reaction
- Hematoma formation

were encountered during follow-up.

The overall safety profile of LP-PRP injection was favorable, supporting its use as a minimally invasive biologic treatment option in chronic degenerative shoulder pathology.

### Overall Clinical Outcome

At final follow-up:

- Majority of patients reported subjective satisfaction with treatment outcome
- Most patients resumed routine daily activities with minimal discomfort
- Significant reduction in nocturnal pain was observed
- Functional overhead activity improved substantially
- Shoulder mobility improved progressively during follow-up

The overall pattern of improvement observed in the present study suggests that ultrasound-guided LP-PRP injection may provide progressive and sustained symptomatic as well as functional recovery in patients with subacromial impingement syndrome associated with degenerative supraspinatus pathology.

### DISCUSSION

The present prospective single-arm study evaluated the clinical, functional, and radiological outcomes of ultrasound-guided leucocyte-poor platelet-rich plasma (LP-PRP) injection in patients with subacromial impingement syndrome associated with degenerative supraspinatus pathology. The findings demonstrated significant improvement in pain, shoulder function, and MRI-based tendon healing response during short-term follow-up.

Subacromial impingement syndrome represents a multifactorial disorder involving both mechanical compression and intrinsic tendon degeneration. Repetitive microtrauma, altered scapulothoracic biomechanics, age-related tendon degeneration, vascular compromise, and chronic inflammation collectively contribute to progressive supraspinatus tendinopathy and partial-thickness tearing. In many patients, conventional conservative treatment measures fail to adequately address the underlying degenerative pathology, resulting in persistent pain and progressive functional limitation.

The present study demonstrated a marked reduction in pain intensity as measured by the Visual Analog Scale. Mean VAS score improved progressively from baseline to 4-month follow-up. This gradual improvement pattern is clinically important because it suggests that the beneficial effects of LP-PRP may be related to biologic tissue healing and tendon remodeling rather than immediate analgesic action alone.

Several mechanisms may explain the therapeutic effects of PRP in chronic tendon pathology. Platelets contain alpha granules that release numerous bioactive growth factors including platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF- $\beta$ ), vascular endothelial growth factor (VEGF), insulin-like growth factor (IGF), epidermal growth factor (EGF), and fibroblast growth factor (FGF). These mediators are believed to stimulate collagen synthesis, angiogenesis, fibroblast proliferation, extracellular matrix remodeling, and cellular differentiation. Experimental studies

have demonstrated that PRP may improve tendon healing by enhancing fibroblast activity and promoting organized collagen deposition.

The improvement observed in DASH and Constant scores in the present study further supports the clinical utility of LP-PRP in restoring shoulder function. Patients demonstrated progressive improvement in activities involving overhead movement, lifting, dressing, and routine daily tasks. Improvement in Constant score additionally reflected enhanced shoulder mobility, muscle strength, and pain reduction.

The progressive nature of functional recovery observed in the present study may indicate ongoing biological remodeling of degenerative tendon tissue following PRP administration. Unlike corticosteroid injections, which primarily exert anti-inflammatory effects and may produce rapid but temporary symptomatic relief, LP-PRP appears to facilitate a slower but potentially more durable healing response.

MRI evaluation performed at follow-up demonstrated interval healing response in partial supraspinatus tears in a considerable proportion of patients. Conversion of Type IIB lesions to Type IIA tendinosis and complete radiological normalization in selected cases suggest that LP-PRP may influence structural tendon recovery. Although radiological improvement was not universal, the imaging findings support the concept that biologic therapies may alter the underlying disease process rather than merely suppress symptoms.

The role of leucocyte concentration in PRP preparations remains an important topic of discussion in orthobiologic research. PRP formulations can broadly be classified into leucocyte-rich and leucocyte-poor preparations depending on white blood cell concentration relative to baseline blood values. Leucocyte-rich PRP contains higher concentrations of neutrophils and inflammatory cytokines, which may contribute to excessive inflammatory response, increased post-injection pain, and catabolic effects on tendon tissue.

Leucocyte-poor PRP, on the other hand, aims to minimize inflammatory cytokine activity while preserving anabolic growth factor concentration. Boswell et al. demonstrated that increasing leucocyte concentration may negatively influence collagen gene synthesis in tendon tissue. Reduced leucocyte concentration may therefore provide a more favorable biological environment for tendon healing in chronic degenerative conditions such as supraspinatus tendinopathy.

Another important factor contributing to favorable outcomes in the present study may be the use of ultrasound guidance during injection. Accurate localization of the subacromial space and supraspinatus tendon is essential for optimal biologic delivery. Ultrasound guidance allows real-time visualization of needle placement, improves injection accuracy, minimizes soft tissue trauma, and enhances reproducibility. Several previous studies have demonstrated superior accuracy and clinical outcomes with ultrasound-guided shoulder injections compared with landmark-based techniques.

The rehabilitation protocol followed in the present study may also have contributed to the favorable clinical outcome. Patients were advised to avoid non-steroidal anti-inflammatory drugs after injection in order to preserve the inflammatory cascade necessary for tissue healing. Gradual progression from passive range-of-motion exercises to strengthening exercises may have facilitated tendon remodeling while minimizing reinjury during the early healing phase.

The findings of the present study are consistent with several previous investigations evaluating PRP in rotator cuff tendinopathy and subacromial impingement syndrome. Rha et al. demonstrated superior long-term improvement following ultrasound-guided PRP injection compared with dry needling in rotator cuff disease. Similarly, Say et al. reported improved pain and shoulder function following PRP therapy in patients with subacromial impingement syndrome.

Shams et al. also observed favorable outcomes following PRP injection in partial-thickness rotator cuff tears, including improved pain scores and functional recovery. The radiological healing response observed in the present study is comparable with findings reported in previous studies evaluating PRP in degenerative tendon pathology.

However, not all studies have demonstrated uniformly positive results. Kesikburun et al. reported no significant difference between PRP and placebo injection in chronic rotator cuff tendinopathy. Variability in clinical outcomes across studies may be related to heterogeneity in PRP preparation methods, platelet concentration, leucocyte content, injection technique, rehabilitation protocols, patient selection criteria, and duration of follow-up.

Standardization of PRP preparation remains a major challenge in orthobiologic research. Differences in centrifugation methods, anticoagulant use, platelet concentration, activation methods, and leucocyte content make direct comparison between studies difficult. In the present study, a standardized double-spin protocol was utilized to achieve a reproducible LP-PRP formulation with high platelet concentration and reduced leucocyte count.

The present study has several strengths. First, all injections were performed under ultrasound guidance, ensuring accurate biologic delivery. Second, a standardized LP-PRP preparation technique was utilized. Third, both clinical and radiological outcomes were evaluated. Finally, the prospective study design allowed systematic follow-up assessment.

Nevertheless, several limitations should be acknowledged. The sample size was relatively small, which may limit generalizability of the findings. The absence of a control group restricts direct comparison with alternative treatment modalities. Follow-up duration was relatively short, and long-term tendon remodeling could not be assessed. In addition, variability in individual biologic response and platelet concentration among preparations may have influenced treatment outcomes.

Despite these limitations, the present study demonstrated encouraging short-term clinical and radiological outcomes following ultrasound-guided LP-PRP injection in patients with chronic subacromial impingement syndrome. The findings support the growing role of biologic therapies in the management of degenerative tendon disorders and suggest that LP-PRP may provide a minimally invasive treatment alternative in carefully selected patients who remain symptomatic despite prolonged conservative treatment.

Further multicentric randomized controlled trials with larger sample size, longer follow-up duration, standardized PRP classification systems, and comparative treatment groups are required to better define the precise role of LP-PRP in subacromial impingement syndrome and degenerative rotator cuff disease.

## LIMITATIONS

The present study had several limitations:

- Relatively small sample size
- Short duration of follow-up
- Absence of a control group
- Lack of long-term MRI evaluation
- Variability in platelet concentration among preparations

Further multicentric randomized controlled trials with longer follow-up duration are required.

## CONCLUSION

Ultrasound-guided LP-PRP injection demonstrated significant improvement in pain, shoulder function, and radiological tendon healing in patients with subacromial impingement syndrome.

LP-PRP may therefore serve as a useful minimally invasive biologic treatment option in patients with chronic degenerative supraspinatus pathology who remain symptomatic despite conventional conservative management.

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