Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2530
Original article

PRP injection after manipulation under anesthesia in diabetic frozen shoulder: A prospective observational study.

Dr. Aman Goel[1], Dr. Kavita Gupta[2], Dr. Shashi ranjan kumar[1], Dr. Karan amitoj singh[1]

[1]Department of Orthopaedics, Mata Gujri Memorial Medical College, Kishanganj, Bihar, India.
[2]Department of Anaesthesia, Mata Gujri Memorial Medical College, Kishanganj, Bihar, India.

ABSTRACT

Background:

Adhesive capsulitis is a debilitating condition with increased severity in diabetic patients. Platelet-rich plasma (PRP) offers a potential alternative to corticosteroids without metabolic side effects.

Methods:

This prospective observational study included 31 diabetic patients with frozen shoulder treated with manipulation under anesthesia followed by intra-articular PRP injection. Pain and function were assessed using the Visual Analogue Scale (VAS) and Constant Shoulder Score (CSS) at baseline, 2 weeks, and 4 weeks.

Results:

The mean age was 57.58 ± 8.67 years, with female predominance (64.5%). Mean VAS decreased from 8.58 ± 0.76 to 2.80 ± 1.04 at 4 weeks. Mean CSS improved from 23.81 ± 8.12 to 59.39 ± 8.39. No major complications were observed.

Conclusion:

PRP injection following MUA is a safe and effective treatment for diabetic frozen shoulder, providing significant pain relief and functional improvement.

Recommendation:

Further randomized controlled trials with a larger sample size and longer follow-up are recommended.

Keywords: *Frozen shoulder, Platelet-rich plasma, PRP, Diabetes mellitus, Adhesive capsulitis, Manipulation under anesthesia, Intra-articular injection.*
Submitted: *January 20, 2026* ***Accepted:*** *February 19, 2026* ***Published:*** *March 30, 2026*

Corresponding author: *Dr. Aman Goel*
Email: *goaman5@gmail.com*
Department of Orthopaedics and Department of Anaesthesia, Mata Gujri Memorial Medical College, Kishanganj, Bihar, India

INTRODUCTION

Frozen shoulder, medically termed adhesive capsulitis, is a chronic and debilitating condition of the glenohumeral joint characterized by progressive pain and severe restriction of both active and passive range of motion.[1] The disease typically progresses through three distinct clinical phases: the freezing phase, characterized by pain and gradual onset of stiffness, the frozen phase with predominant stiffness and

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minimal pain, and the thawing phase with progressive recovery of function over several months to years. The prevalence of frozen shoulder is significantly elevated in individuals with diabetes mellitus, with epidemiological studies demonstrating that diabetic patients are up to five times more likely to develop this condition compared to non-diabetic populations.[2] In these patients, the inflammatory process is often more severe, the symptom duration is prolonged, and the response to conventional treatment modalities is typically suboptimal. The pathophysiology in diabetic patients involves non-enzymatic glycosylation of collagen and alterations in the inflammatory cascade, leading to more pronounced capsular contracture and fibrosis.

Conservative management of adhesive capsulitis includes analgesics, non-steroidal anti-inflammatory drugs (NSAIDs), physiotherapy, and corticosteroid injections. While corticosteroids provide rapid pain relief, their intra-articular use in diabetic patients is associated with significant limitations, including transient hyperglycemia, impaired immune response, and increased risk of infection.[3] These considerations necessitate exploration of alternative biologic therapies that are both safe and effective in this vulnerable population.

Platelet-rich plasma (PRP) has emerged as a promising biologic treatment modality in musculoskeletal medicine. PRP is an autologous concentration of platelets suspended in plasma, rich in growth factors including platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF-β), vascular endothelial growth factor (VEGF), and insulin-like growth factor (IGF) [4][5]. These bioactive molecules play pivotal roles in tissue healing, angiogenesis, and modulation of the inflammatory response. Recent meta-analyses and systematic reviews have demonstrated that PRP promotes regenerative processes, enhances fibroblast activity, and accelerates collagen synthesis, rendering it a valuable tool in managing chronic tendon and joint pathologies. Clinical evidence supports favorable outcomes with intra-articular PRP injections in adhesive capsulitis, with improvements in pain scores, shoulder mobility, and overall functional status. Importantly, PRP poses no risk of hyperglycemia or immunosuppression, rendering it particularly suitable for diabetic patients who cannot tolerate corticosteroid therapy [6][7].

In cases where conservative treatment fails after an adequate duration, manipulation under anesthesia (MUA) is employed to mechanically break capsular adhesions and restore joint mobility [11][12]. The combination of MUA with subsequent intra-articular PRP injection may synergize the mechanical release of adhesions achieved through manipulation with the biological stimulus provided by growth factors and cytokines, potentially facilitating faster and more complete recovery. This prospective observational study was designed to evaluate the efficacy and safety of intra-articular PRP injection administered immediately after manipulation under anesthesia in diabetic patients with frozen shoulder. The study aims to assess pain reduction and functional improvement over the short-term follow-up period to explore the therapeutic potential of this combined approach in a population with limited therapeutic options.

MATERIALS AND METHODS

Study Design and Setting

This was a hospital-based prospective observational study conducted in the Department of Orthopaedics at Mata Gujri Memorial Medical College, Kishanganj, Bihar, India, between September 2024 and December 2024. Mata Gujri Memorial Medical College is a tertiary care teaching hospital in Bihar, India, providing multispecialty services, catering to both urban and rural populations.

Bias

To minimize selection bias, consecutive sampling was used. Standardized protocols were followed for intervention and outcome assessment. Observer bias was minimized by using validated scoring systems (VAS and CSS).

Ethical considerations

Ethical approval was obtained in June 2024 from the Institutional Ethics Committee of Mata Gujri Memorial Medical College prior to patient enrollment.

Informed consent

Informed consent was obtained from all participants included in the study.

Patient Selection and Inclusion/Exclusion Criteria

Inclusion criteria for the study were as follows: adults aged 40-75 years, clinically confirmed diagnosis of adhesive capsulitis of the shoulder, documented Type 2 Diabetes Mellitus, symptom duration exceeding three months, and failure of conservative treatment modalities, including physiotherapy and anti-inflammatory medications, for at least three months.

Exclusion criteria were as follows: prior shoulder surgery affecting the involved joint, intra-articular injection within

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the preceding three months, imaging evidence of rotator cuff tears, glenohumeral arthritis, or other structural abnormalities, uncontrolled diabetes with HbA1c greater than 9%, active local or systemic infection, and bleeding diathesis or ongoing anticoagulant therapy.

Study Sample and Recruitment

A total of 31 diabetic patients with clinically confirmed frozen shoulder were enrolled consecutively during the study period from September 2024 to December 2024. Patients were recruited from the Orthopaedics outpatient department and selected based on consecutive presentation meeting the inclusion criteria. All enrolled participants completed the study protocol and follow-up assessments.

Sample Size Calculation

Sample size calculation was performed using the formula: $n = (z_{1-\alpha/2})^2 p(1-p)/d^2$, where $z_{1-\alpha/2} = 1.96$ at 95% confidence interval, anticipated proportion $p = 2\%$, and margin of error with absolute precision $d = 5\%$. This yielded a required sample size of 30 patients, which was met with the enrollment of 31 participants.

Preoperative Assessment and Investigations

All patients underwent a comprehensive baseline evaluation, including detailed history and clinical examination. Routine haematological investigations were performed, including hemoglobin, total leukocyte count, differential leukocyte count, platelet count, random blood sugar, and serum creatinine. Radiological investigations included anteroposterior and axial views of the affected shoulder to exclude other pathologies. Physical examination assessed pain using the Visual Analogue Scale (VAS) and baseline shoulder function using the Constant Shoulder Score (CSS).

Procedure Overview

All patients underwent manipulation under anesthesia (MUA) followed by a single intra-articular PRP injection during the same operative sitting. The procedures were performed under total intravenous anesthesia (TIVA) with strict adherence to aseptic precautions.

Preoperative Preparation

Patients were marked preoperatively on the affected shoulder per institutional protocol. A skin sensitivity patch test using 2% lignocaine was administered and assessed after 30 minutes to rule out allergic reactions. Subsequently, 5 milliliters of 2% lignocaine was injected intra-articularly into the affected shoulder for local analgesia prior to induction of general anesthesia.

Anesthesia Protocol

Patients were positioned supine on the operating table, and standard American Society of Anaesthesiologists (ASA) monitors were applied, including electrocardiogram, pulse oximetry, non-invasive blood pressure monitoring, and capnography. An 18-gauge intravenous cannula was inserted for drug administration. Total intravenous anesthesia was administered using propofol at 1-2 milligrams per kilogram as a bolus followed by infusion at 50-150 micrograms per kilogram per minute, and fentanyl at 1-2 micrograms per kilogram as a bolus. In selected patients, low-dose ketamine or dexmedetomidine was used to supplement analgesia and sedation. Adequate depth of anesthesia was confirmed by the absence of eyelash reflex and no response to verbal or painful stimuli. Most patients maintained spontaneous respiration throughout the procedure.

Manipulation Under Anesthesia Procedure

With the patient under sufficient anesthesia, the shoulder was systematically manipulated through all planes of motion to break capsular adhesions. The manipulation sequence included the following: forward flexion with gradual elevation of the arm in the sagittal plane, abduction with elevation in the coronal plane to overhead position, external rotation performed with the arm adducted and elbow flexed to 90 degrees, internal rotation with posterior movement of the hand behind the back, and cross-body adduction to stretch the posterior capsule. Each movement was performed gently and progressively until encountering resistance or endpoint stiffness. Care was taken to avoid excessive force to prevent iatrogenic injuries such as humeral fractures or rotator cuff tears.

Platelet-Rich Plasma Preparation

Peripheral venous blood (20 milliliters) was collected under aseptic precautions from each patient using an 18-gauge butterfly needle. The blood was transferred into sterile tubes containing sodium citrate as an anticoagulant. PRP was prepared using a standardized two-step double-spin centrifugation protocol. The first centrifugation (soft spin) was performed at 1500 revolutions per minute for 10 minutes to separate plasma from red blood cells. The plasma supernatant was then subjected to a second centrifugation (hard spin) at 3000 revolutions per minute for 10 minutes to

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concentrate the platelets. The resulting 3-5 milliliters of PRP were carefully extracted and loaded into a sterile syringe. Platelet counts were verified using standard hematological methods to ensure a 3-5 fold increase compared to baseline.

Intra-articular PRP Injection

Following manipulation, intra-articular PRP injection was administered under strict aseptic conditions. Patients were placed in a seated position, and anatomical landmarks were palpated to identify the posterior glenohumeral portal. The injection site was cleaned with povidone-iodine and alcohol-based antiseptic solutions. Local anesthesia with 1% lidocaine (2 milliliters) was administered subcutaneously. Using a 22-gauge needle, PRP was injected slowly into the joint space via the posterior portal. Proper needle placement was confirmed by minimal resistance on injection. No corticosteroids or additional agents were used in conjunction with PRP.

Postoperative Care and Rehabilitation

Post-injection, patients were observed for 30 minutes for any immediate adverse reactions. They were advised to rest the shoulder for 48 hours, followed by a standardized physiotherapy regimen beginning 48-72 hours post-procedure. Patients were discharged on analgesic medications and given detailed instructions for at-home shoulder mobility exercises.

Outcome Assessment

Pain and functional outcomes were assessed at multiple time points using standardized measurement tools. The Visual Analogue Scale (VAS) was used to quantify pain intensity on a scale of 0-10, where 0 represents no pain, and 10 represents the worst imaginable pain. The Constant-Murley Shoulder Score (CSS) was used to assess functional status and shoulder mobility, with scores ranging from 0 to 100, where higher scores indicate better function. Assessments were conducted at baseline (preoperatively), 2 weeks post-procedure, and 4 weeks post-procedure.

Statistical Analysis

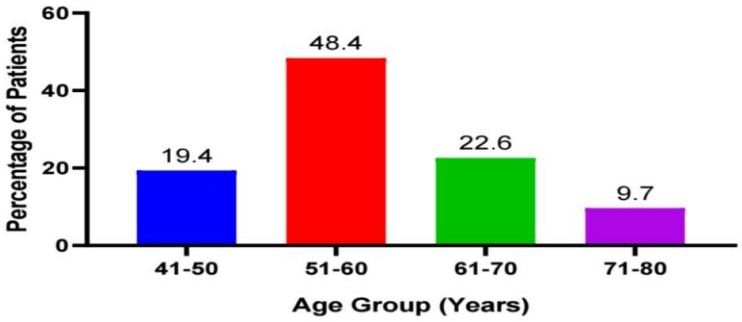
Statistical analysis was performed using SPSS (Statistical Package for the Social Sciences) version 25.0. Descriptive statistics, including mean, standard deviation, and frequency distributions, were calculated for all variables. Paired t-tests were used to compare. A p-value of less than 0.05 was considered statistically significant. Data were presented as mean ± standard deviation for continuous variables and as frequency and percentage for categorical variables.

RESULTS

Participant flow

A total of 38 patients were assessed for eligibility. Of these, 5 did not meet the inclusion criteria, and 2 declined participation. A total of 31 patients were enrolled, all of whom completed the intervention and follow-up and were included in the final analysis. All enrolled participants were administered intra-articular PRP injections following MUA. Following the procedure, participants were assessed for pain levels utilizing the Visual Analogue Scale (VAS) score and shoulder mobility employing the Constant Shoulder Score (CSS) at 2-week and 4-week intervals.

Figure 1: Distribution of the cases according to age



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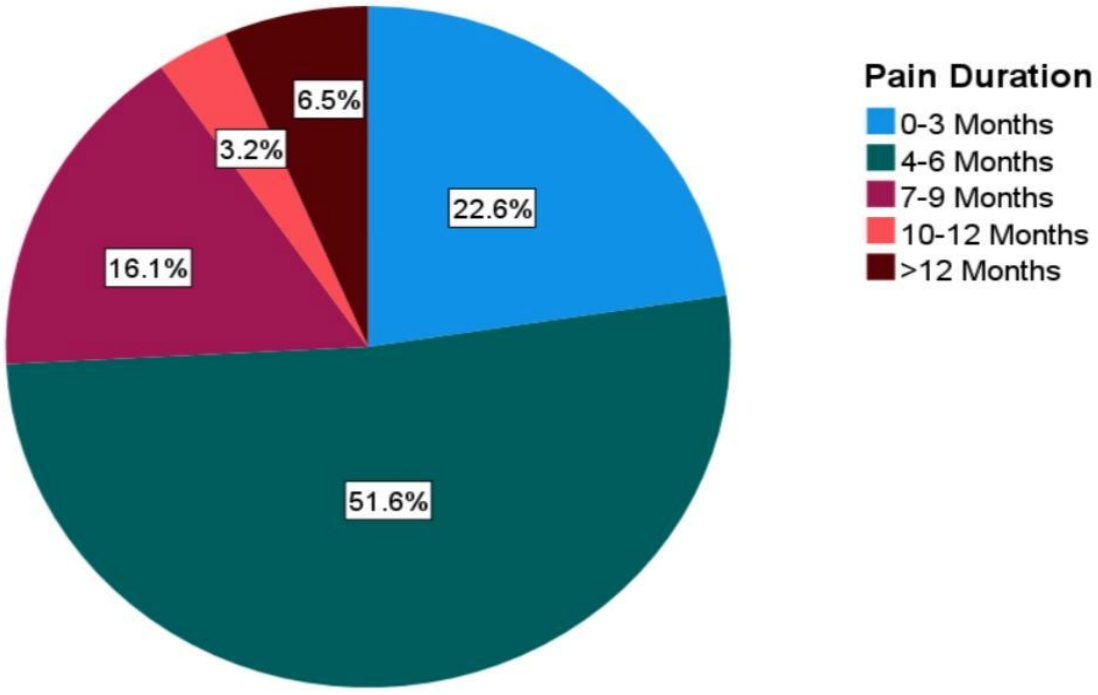
Demographic Characteristics

The study population had a mean age of 57.58 ± 8.67 years. Age distribution showed that 6 patients (19.4%) belonged to the 41-50 year age group, 15 patients (48.4%) were in the 51–60-year group, 7 patients (22.6%) were in the 61-70 year group, and 3 patients (9.7%) were in the 71–80 year age group.

Gender distribution demonstrated notable female predominance, with 20 females (64.5%) and 11 males (35.5%) in the study population. Pain localization varied among patients: 16 patients (51.6%) reported pain in the right shoulder, 13 patients (41.9%) in the left shoulder, and 2 patients (6.5%) experienced discomfort in both shoulders simultaneously.

The mean duration of pain before intervention was 6.03 ± 4.18 months. Seven patients (22.6%) reported pain duration of less than three months, while the majority of patients (51.6%) had experienced pain for four to six months. Only 2 patients reported pain duration exceeding one year. All patients fulfilled the inclusion criterion of failed conservative treatment for at least three months duration.



The mean duration of pain was 6.03 ± 4.18 months. Seven (22.6 %) patients reported pain duration < 3 months, while more than half of the patients (51.6%) had pain for 4-6 months. Only 2 patients had pain for more than one year.

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TABLE 1: DEMOGRAPHIC CHARACTERISTICS OF STUDY POPULATION

Demographic Parameter	Number of Patients	Percentage (%)
Age Group (years)		
41-50	6	19.4
51-60	15	48.4
61-70	7	22.6
71-80	3	9.7
Gender		
Female	20	64.5
Male	11	35.5
Affected Shoulder		
Right	16	51.6
Left	13	41.9
Bilateral	2	6.5

Pain Assessment Using Visual Analogue Scale (VAS)

The severity of pain as measured by VAS scores significantly decreased after platelet-rich plasma therapy. Baseline assessment showed 30 patients (96.8%) reported severe pain (VAS 7-10). Following PRP intervention, there was progressive improvement at each assessment interval. At 2 weeks post-treatment, 30 patients (96.8%) showed a reduction to moderate pain levels (VAS 4-6). By 4 weeks, 24 patients (77.4%) experienced further reduction to mild pain levels (VAS 0-3), while 7 patients (22.6%) remained in the moderate pain category.

The mean VAS score demonstrated significant quantitative improvement. Preoperatively, the mean VAS score was 8.58 ± 0.76. Following PRP intervention, mean VAS scores showed a substantial decrease at both assessment points: at 2 weeks post-treatment, scores averaged 5.74 ± 1.03, and by 4 weeks post-treatment, scores further decreased to 2.80 ± 1.04. These reductions in pain scores exceeded the minimal clinically important difference threshold, indicating meaningful pain relief for patients.

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TABLE 2: DISTRIBUTION OF CASES ACCORDING TO VISUAL ANALOGUE SCALE (VAS) AT DIFFERENT TIME INTERVALS

Time Point	Severe Pain (VAS 7-10)	Moderate Pain (VAS 4-6)	Mild Pain (VAS 0-3)	Mean VAS ± SD
Baseline	30 (96.8%)	1 (3.2%)	0 (0%)	8.58 ± 0.76
2 Weeks	0 (0%)	30 (96.8%)	1 (3.2%)	5.74 ± 1.03
4 Weeks	0 (0%)	7 (22.6%)	24 (77.4%)	2.80 ± 1.04

Functional Assessment Using Constant Shoulder Score (CSS)

Before platelet-rich plasma therapy, all 31 patients had poor shoulder mobility according to the Constant-Murley Shoulder Score (CSS ≤ 30). Assessment at 2 weeks showed initial functional improvement, with 5 patients (16.1%) achieving a fair mobility level (CSS 31-70) and 26 patients (83.9%) remaining in the poor category. Substantial functional recovery was evident by 4 weeks: 17 patients (54.8%) had achieved a fair mobility level, 3 patients (9.7%) had achieved a good mobility level (CSS 71-100), and 11 patients (35.5%) remained in the poor category.

The mean Constant-Murley Shoulder Score demonstrated significant improvement throughout the follow-up period. Baseline mean CSS was 23.81 ± 8.12. At 2 weeks post-intervention, mean CSS had increased significantly to 48.81 ± 8.50, representing a mean improvement of 25 points. This improvement continued with further gains observed at 4 weeks post-treatment, where mean CSS reached 59.39 ± 8.39, representing a total improvement of 35.58 points from baseline.

TABLE 3: SEVERITY OF CONSTANT SHOULDER SCORE (CSS) AND FUNCTIONAL OUTCOMES

Time Point	Poor (CSS ≤30)	Fair (CSS 31-70)	Good (CSS 71-100)	Mean CSS ± SD
Baseline	31 (100%)	0 (0%)	0 (0%)	23.81 ± 8.12
2 Weeks	26 (83.9%)	5 (16.1%)	0 (0%)	48.81 ± 8.50
4 Weeks	11 (35.5%)	17 (54.8%)	3 (9.7%)	59.39 ± 8.39

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Clinical Case Illustrations

The following case reports illustrate the clinical improvement observed in representative patients from the study population. Photographic documentation shows preoperative range of motion limitations, intraoperative manipulation and injection procedures, and postoperative functional recovery.

Case 1: A 58-year-old female with Type 2 Diabetes Mellitus presented with right shoulder pain for 5 months, unresponsive to conservative management. Preoperative examination revealed severely restricted shoulder mobility with forward flexion limited to approximately 30 degrees and external rotation minimal. Following MUA and PRP injection, progressive improvement was noted with complete resolution of pain by 4 weeks and restoration of near-normal shoulder mobility, including forward flexion to 160 degrees and external rotation to 70 degrees.

Figure 1 – Pre-procedure range of motion (Case 1)

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Figure 2 – Procedure pictures of Case 1

Figure 3 – Post-procedure ROM

Case 2: A 52-year-old male with poorly controlled diabetes (HbA1c 8.5%) presented with left shoulder adhesive capsulitis for 4 months. Preoperative imaging showed no structural abnormality. Following MUA and PRP injection, pain resolved significantly by 2 weeks, and functional mobility steadily improved, achieving nearly complete range of motion restoration by 4 weeks with good functional status for activities of daily living.

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Figure 4: Pre-procedure ROM of Case 2

Figure 5: Procedure photos of Case 2

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Figure 6) Post-procedure photos of case 2

Case 3: A 62-year-old female with Type 2 Diabetes Mellitus presented with bilateral shoulder symptoms for 7 months. The right shoulder was treated in this study. Dramatic improvement in pain and range of motion was documented following the procedure, with pain reduced from severe baseline to minimal at 4 weeks, and functional status substantially improved as documented by Constant score improvement from 18 to 64.

Figure 7: pre-procedure photos of case 3

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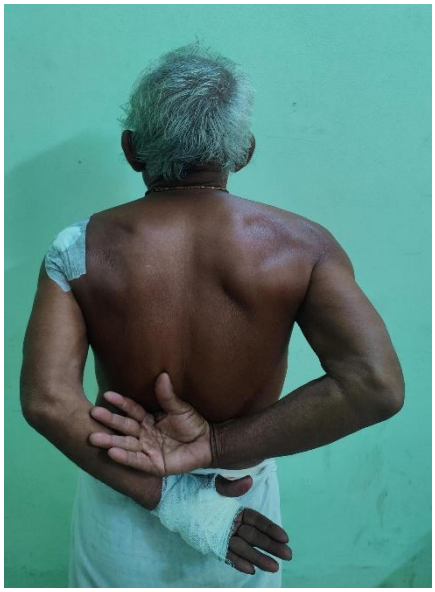
Figure 8: Procedure photos of case 3

Figure 9: Post-procedure photos of case 3



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Adverse Events and Safety Profile

The procedure was well-tolerated with minimal adverse events. No serious complications were encountered in any of the 31 patients. Postoperative observations revealed minimal postoperative discomfort, which responded well to oral analgesics. All patients were able to tolerate the early physiotherapy regimen beginning at 48-72 hours post-procedure. No cases of infection, neurovascular compromise, or rotator cuff injury were documented. No patient experienced transient hyperglycemia or immune dysfunction as documented by postoperative blood glucose measurements and clinical observation. The safety profile of the combined MUA and intra-articular PRP approach demonstrated clear superiority over corticosteroid-based interventions in this diabetic population.

DISCUSSION

The results of the present study demonstrate that intra-articular PRP injection administered immediately after manipulation under anesthesia is a safe and effective treatment modality for adhesive capsulitis in diabetic patients. These findings are consistent with and expand upon recent systematic reviews and meta-analyses examining PRP for frozen shoulder treatment.

Efficacy in Pain Management

The study demonstrated significant pain reduction, with mean VAS scores decreasing from 8.58 at baseline to 2.80 at 4 weeks, representing a reduction of 5.78 points on the 10-point scale. This magnitude of improvement exceeds the minimal clinically important difference for VAS pain scores. The results are comparable to findings by Pandey et al.[8] reported mean pain reduction from 8.1 to 2.3 in their prospective study of intra-articular PRP for frozen shoulder. Recent meta-analyses by multiple authors have consistently demonstrated that PRP is more durable in its pain-relieving effects compared to corticosteroid injections, with the advantage becoming more pronounced at later follow-up intervals. The progressive improvement noted in the study at 2 and 4 week intervals is consistent with the biological mechanism of action of PRP, wherein growth factors stimulate tissue healing and modulate the inflammatory response over time.

Functional Recovery

Functional improvement measured by Constant-Murley Shoulder Score showed a mean improvement from 23.81 at baseline to 59.39 at 4 weeks, an improvement of 35.58 points. By 4 weeks, 54.8% of patients achieved a fair mobility level, and 9.7% achieved a good mobility level, compared to 100% having poor mobility at baseline. These functional gains directly translate to improved activities of daily living and quality of life for patients. Comparison with the literature shows our results align with findings from Halim et al.[7] reported mean CSS improvement from 23.5 to 60.8 over 12 weeks in PRP-treated frozen shoulder patients. The results are particularly notable given the short 4-week follow-up period, suggesting rapid functional recovery with the combined MUA-PRP approach compared to conservative measures alone.

Mechanism of PRP Action in Diabetic Frozen Shoulder

Platelet-rich plasma exerts its therapeutic effect through multiple biological mechanisms. The concentrated platelets release multiple growth factors, including PDGF, TGF-β, VEGF, and IGF, which promote tissue healing, angiogenesis, and anti-inflammatory modulation. In the context of frozen shoulder, PRP reduces synovial inflammation, promotes fibroblast proliferation and collagen remodeling, and facilitates restoration of normal glenohumeral joint capsule properties. Recent meta-analysis by Ouyang et al.[9] demonstrated that PRP is more durable and safer than corticosteroids in treating frozen shoulder, with advantages particularly pronounced in mid-term follow-up (4-24 weeks). This durability is particularly important in diabetic patients, who experience more severe and prolonged inflammatory responses.

Advantages Over Corticosteroid Therapy in Diabetic Patients

A critical advantage of PRP over intra-articular corticosteroid injections in diabetic patients is the absence of metabolic and immunological side effects. While corticosteroids provide rapid pain relief, their use in diabetic patients is associated with transient hyperglycemia, impaired glycemic control, and increased infection risk. The patient population experienced no episodes of hyperglycemia, no immune dysfunction, and no infections following PRP injection. This safety profile is particularly important given the chronic nature of diabetes and its associated complications. The present study corroborates

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findings from Habib et al.[3] documented that corticosteroid injections in diabetic patients with musculoskeletal diseases cause a significant transient elevation in blood glucose levels.

Synergistic Effect of Combined MUA and PRP

The combination of mechanical release through MUA with biological stimulus through PRP appears to provide synergistic benefit. MUA physically breaks adhesions and restores passive range of motion, while PRP provides growth factors that prevent re-adhesion and promote tissue healing. This complementary approach may explain the rapid functional improvement noted in our cohort. Pandey et al.[8] demonstrated in their comparative study that combining MUA with PRP injection yields superior outcomes compared to MUA alone. The timing of PRP injection immediately following MUA appears optimal, allowing direct application of growth factors to freshly released tissue surfaces.

Comparison with Recent Meta-Analytical Findings

A 2024 systematic review and meta-analysis by Ouyang et al.[9] examined clinical efficacy and safety of PRP for frozen shoulder across international databases, analyzing outcomes through January 2024. Their findings demonstrated that PRP was most effective during the mid-term follow-up period (4-24 weeks), which aligns with our 4-week assessment showing substantial improvement. Their meta-analysis confirmed that PRP showed statistically significant advantages over corticosteroid controls in pain reduction (VAS), range of motion in all planes, and functional scores, including UCLA and DASH. Our short-term results are consistent with this trajectory and suggest continued improvement can be expected beyond the 4-week assessment period.

Another 2023 systematic review by Lum et al.[10] analyzing PRP efficacy in adhesive capsulitis found that among 19 included studies, all demonstrated improvement in VAS pain scores, DASH functional scores, and SPADI disability scores with PRP treatment. Notably, when PRP was compared to corticosteroid controls, PRP showed statistically significantly greater improvements in passive forward flexion (151 degrees vs 144.1 degrees, p=0.024) and SPADI scores (14.6 vs 18.6, p=0.009). These comparative findings provide strong context for recommending PRP as superior to corticosteroid therapy.

Future Research Directions

Future studies should aim to include larger patient populations with longer follow-up periods extending to a minimum of 12 weeks and ideally 6-12 months post-intervention. Randomized controlled trials comparing PRP injection versus corticosteroid injection versus physiotherapy alone in diabetic frozen shoulder patients would provide valuable comparative effectiveness evidence. Further investigation of optimal PRP preparation methods, timing of injection relative to MUA, and potential benefits of serial PRP injections would advance clinical understanding. Studies examining inflammatory biomarkers and synovial fluid analysis before and after PRP treatment would elucidate mechanisms of action. Investigation of outcomes in non-diabetic frozen shoulder populations would determine if benefits are diabetes-specific or broadly applicable.

Generalizability:

The findings of this study may be applicable to similar tertiary care settings managing diabetic patients with adhesive capsulitis; however, caution should be exercised in generalizing results to non-diabetic populations or different healthcare settings.

List of Abbreviations:

PRP – Platelet-Rich Plasma
MUA – Manipulation Under Anesthesia
VAS – Visual Analogue Scale
CSS – Constant Shoulder Score
TIVA – Total Intravenous Anesthesia
ASA – American Society of Anesthesiologists

CONCLUSION

This prospective observational study evaluated the efficacy and safety of intra-articular PRP injection administered immediately after manipulation under anesthesia in 31 diabetic patients with adhesive capsulitis. The findings support the following conclusions: (1) Intra-articular PRP injection following MUA produces significant pain reduction, with mean VAS scores decreasing from 8.58 preoperatively to 2.80 at 4 weeks post-treatment, representing clinically meaningful improvement. (2) Substantial functional improvement was achieved, with mean Constant-Murley Shoulder Score increasing from 23.81 at baseline to 59.39 at 4 weeks, indicating progression from poor to fair functional status in the majority of patients. (3) The combined treatment modality of MUA followed by

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intra-articular PRP injection is safe and well-tolerated in diabetic patients, with no serious adverse events, no episodes of hyperglycemia, and no infections documented. (4) Intra-articular PRP injection therapy combined with MUA represents a safe and effective treatment modality for adhesive capsulitis in diabetic patients, offering advantages over corticosteroid-based approaches by avoiding metabolic and immunological complications. (5) The synergistic combination of mechanical capsular release through manipulation with biological stimulus provided by PRP growth factors appears to facilitate rapid and effective recovery in this patient population. The results support consideration of the combined MUA-PRP approach as a first-line surgical intervention for diabetic patients with refractory frozen shoulder who have failed conservative management.

LIMITATIONS

The present study has several important limitations that should be considered when interpreting findings. First, the sample size of 31 patients, while statistically adequate for the calculated requirements, remains relatively modest in absolute terms and may limit the generalizability of findings to larger, diverse populations. Second, the study employed a prospective observational design without a control group, preventing direct comparative analysis with alternative treatment modalities such as corticosteroid injection, physiotherapy alone, or MUA alone. Third, the follow-up period was limited to 4 weeks post-intervention, which is insufficient to assess long-term durability, recurrence rates, or sustained functional improvement beyond the immediate postoperative period. Fourth, the study was conducted at a single institution in Bihar, India, which may limit its applicability to different geographic regions, healthcare systems, and patient populations with varying demographic characteristics. Fifth, the study population consisted exclusively of Type 2 Diabetes Mellitus patients, limiting generalizability to non-diabetic frozen shoulder populations. Future research should address these limitations through multi-center randomized controlled trials with larger sample sizes, longer follow-up periods, and inclusion of appropriate control groups.

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Declaration

The authors declare that they have no competing interests.

Funding

This research received no specific grant from any public, commercial, or not-for-profit funding agency.

Data availability

The authors affirm that all data and materials supporting this manuscript are available upon request.

Conflict of interest.

Authors declare no conflict of interest, and no part of this manuscript has been published or is under consideration for publication elsewhere.

Author Contributions

Dr. Aman Goel, Dr. Karan Bhullar, and Dr. Shashi Ranjan contributed to conceptualization, study design, patient recruitment, data collection, operative procedures, and manuscript drafting. Dr. Kavita Gupta contributed to anesthesia protocol design, perioperative management, data collection, and manuscript review.

Acknowledgments

The authors acknowledge the Institutional Ethics Committee for approval of the study protocol, the

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2530
Original article

Department of Orthopaedics and Department of Anaesthesia for providing necessary facilities, and all study participants for their cooperation and informed consent

Publisher Details

Student's Journal of Health Research (SJHR)
(ISSN 2709-9997) Online
(ISSN 3006-1059) Print
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