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CASE SERIES

Outcomes of Percutaneous Administration of Platelet-Rich Plasma for Long Bone Nonunion in the Upper Extremities: A Case Series

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ABSTRACT

Nonunion occurs when a fracture fails to heal within the anticipated time, which varies depending on the location and degree of related soft-tissue injury. Pain, poor quality of life, and psychological, social, and economic consequences greatly impact these orthopedic patients. Recent studies have proposed percutaneous injection of platelet-rich plasma (PRP) to treat nonunion. Platelets are present in the early inflammatory stages of fracture healing, in theory enhancing angiogenesis and the recruitment of mesenchymal cells. This study aimed to determine if percutaneous administration of a single 5 mL dose of platelet-rich plasma for long bone nonunion would result in bone union within a span of 3 months of follow-up. We present seven patients diagnosed with nonunion of long bones of the upper extremity. PRP was administered into the nonunion site percutaneously via imaging guidance. Improvements in pain scale and function were monitored using VAS and DASH scores. Radiographic union was assessed using the Modified Lane Radiographic Scoring System. The initial mean VAS score was 4.29 (SD = 2.56), decreasing to 2.71 (SD = 1.38) on the first follow-up, and 0.71 (SD = 0.76) on the third and last follow-up. Functional scores also improved, with a mean DASH score of 28.74 (SD = 4.06) on the last follow-up. The mean MLSRS score was 1.98 (MLSRS 1) and increased to 7.10 (SD = 1.59, MLSRS 3). Platelet-rich plasma (PRP) can be used to treat upper extremity long bone nonunion. The study showed improvements in pain, clinical, and radiographic union.

Keywords. nonunion, PRP, platelet rich plasma, Modified Lane and Sandhu scoring

INTRODUCTION

Nonunion is defined as the failure of a fracture to heal within the anticipated time, which varies depending on the bone involved.[1] The diagnosis is typically established nine months after injury, wherein the fracture has not shown progression of healing for three months. It can be alternatively defined, in the view of the treating physician, as a fracture with no chance of healing without further intervention.[2] Delayed union, on the other hand, is diagnosed when a fracture does not heal within the expected time range, and can be considered a forerunner to nonunion.[2] There is a 1.94% overall risk of developing nonunion after a fracture.[3] The said conditions cause significant morbidity and clinical impact. Around nine million patients globally suffer from pain, poor quality of life, and related psychological, social, and economic consequences.[3] The current standard of care typically involves bone grafting with application, replacement, or revision of an orthopedic implant, necessitating operation (or reoperation), exposing the patient to higher costs and surgical risk.

Platelet-rich plasma (PRP) has recently been gaining popularity for treating various conditions. Since platelets are present in the early inflammatory stages of fracture healing, introducing PRP could theoretically enhance angiogenesis and the recruitment of MSCs.[3]

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While some studies have discussed how PRP can hasten bone healing, the evidence is difficult to interpret due to the heterogeneity of methods and outcome metrics reported. There is also no consensus on the ideal PRP dosage for treating nonunion. This study explores the possibilities of achieving clinical and radiographic union through percutaneously administering a single dose of PRP.

METHODOLOGY

We screened for patients who were diagnosed with nonunion of long bones of the upper extremities, following either appropriate conservative or surgical treatment. Patients were recruited from the wards and ambulatory care services of the Department of Orthopaedics and Traumatology, Victoriano Luna Medical Center.

Inclusion criteria

- All patients aged 21 to 60 years old
- Diagnosed with oligotrophic or atrophic nonunion in the upper extremity long bones

Exclusion criteria

- Patients with underlying disease or condition affecting bone healing and platelet count (autoimmune disorders, malignancy, hematologic disease, pregnancy)
- Patients diagnosed with gap nonunion, hypertrophic nonunion, pseudoarthrosis
- Patients with signs of infected or septic nonunion, or osteomyelitis (erythematous wound with sinus tract, purulent discharge, and/or elevated WBC count, Erythematous Sedimentation Rate, and/or C-Reactive Protein)
- Patients with fractures with unacceptable length, alignment, and/or rotation warranting surgical correction
- Patients with soft tissue defects
- Patients who underwent other treatment modalities to address nonunion (shockwave therapy, ultrasound, autologous bone graft)

The protocol underwent the review process of the Armed Forces of the Philippines Health Service Command Ethics Review Board (AFPHSC ERB) and was approved on 19 January 2024. The final manuscript was submitted within a year. A letter of request, written consent containing the research title, objective, purpose, and expected outcomes, together with a survey questionnaire for respondents' general profile, was distributed to the qualified subjects meeting the inclusion criteria (Figure 1).

The diagnosis of nonunion was based on subjective complaints of pain and limited function, radiographic absence of signs of bone healing (absent callus, absent recanalization, and/or visible fracture line or gap) nine months after injury,

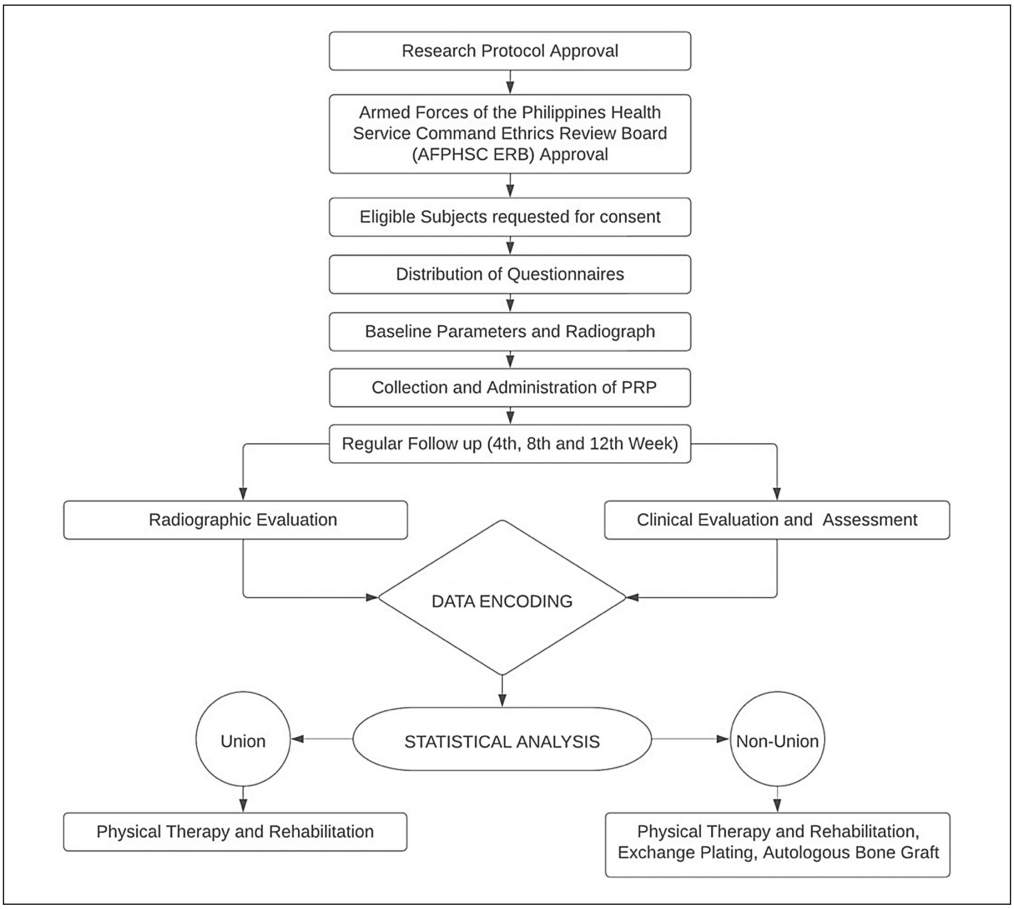

Figure 1. Flow diagram methodology.

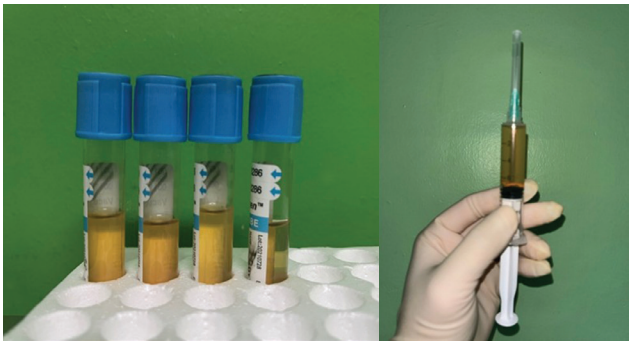

Figure 2. Collection of platelet-rich plasma.

Figure 3. Centrifuge machine used in two-step centrifugation to separate and concentrate platelets.

or the absence of progressive signs of healing for three months. Patients were selected after history taking, physical examination, and radiographic review. Patients who met the inclusion criteria were enrolled in the study.

PRP was prepared and administered uniformly for all patients. Fifteen to 20 mL of whole blood was collected in a tube containing sodium citrate (anticoagulant) (Figure 2). The blood samples underwent a two-step centrifugation process to separate and concentrate platelets. Specimen tubes were processed initially for 15 minutes at a rate of 3,200 rpm, followed by a second spin for 10 minutes at 3,500 rpm. The PRP in the supernatant was extracted and separated from the platelet-poor plasma and red blood cells (Figure 3). Lastly, 5 mL of this PRP in a 10cc syringe was administered percutaneously into the nonunion site guided by an image intensifier.

After PRP administration, all patients continued to take 1,500 mg/day of Calcium and Vitamin D3. Patients were followed up at four, eight, 12 weeks, and until clinical and radiographic signs of union were achieved. VAS and DASH scores were taken before treatment, and at each follow-up. Repeat radiographs were taken and assessed using the Modified Lane and Sandhu Radiographic Scoring System by radiologists.

Patients who demonstrated clinical and radiographic evidence of union or healing were classified as having achieved union and continued with physical therapy. Patients who did not show signs of healing were classified as continuing to have nonunion and were treated appropriately.

Data were collected and encoded into a Microsoft Excel spreadsheet. Demographic data and primary outcomes (time to union) were encoded with a number answerable by yes or no, except for the age, sex, weight, height, and scoring tools for the outcomes (VAS scores, DASH Scores, Modified Lane Radiographic Score).

Descriptive statistics and measures of central tendency, such as the mean, median, and standard deviation, were used to summarize the demographic data. Percentages and graphs were used to report the results. Frequencies, percentages, weighted means, and standard deviations were used to summarize treatment outcomes, and patients' perceived improvements in pain and function were calculated. Time to bone healing was summarized using weighted means and standard deviations.

The Modified Lane and Sandhu Radiographic Scoring System is a quantitative tool used to assess bone healing and union radiographically by grading key features such as new bone formation, cortical continuity, and remodeling. In this scoring tool, bone formation is scored from 0 to 4 based on the percentage of defect filled (none to 100%), reflecting progressive callus maturation. Union is evaluated separately at the proximal and distal interfaces (each scored 0–2), where 0 indicates nonunion, 1 suggests possible union, and 2 represents definite radiographic union. These union criteria correlate with established radiographic signs such as the presence of bridging callus across at least three out of four cortices on two orthogonal views, recanalization of the medullary canal, and obliteration or absence of the fracture line. Remodeling (scored up to 2) captures the restoration of normal bone contour and structure, indicating advanced healing. The total maximum score is 10, integrating these domains into a comprehensive measure of healing progression. Clinically, the modified Lane-Sandhu score provides a standardized and reproducible framework to monitor fracture repair, compare treatment outcomes, and guide decision-making by aligning graded radiographic findings with biologic healing stages.[4] Similar to other outcomes, various statistical methods were applied, including frequencies, percentages, weighted means, and standard deviations, to comprehensively analyze the data obtained from this scoring system.

RESULTS

A total of 20 patients were screened, of whom seven were included in the study. Among the twenty patients screened, five had infection, three had gap nonunion or hypertrophic nonunion, and two had renal disease that could potentially impair bone healing. All included participants were male, with a mean age of 36 years. The time from injury to study enrolment ranged from four months to 10 months, with a mean of six months (Table 1).

Table 1. Demographic profile

Demographic profile	Frequency (n = 7)	Percentage
Gender	7	100%
ESR (Normal value <10)		
1	1	14%
2	2	29%
3	1	14%
4	1	14%
5	2	29%
CRP (Normal value <6)	7	100%
Site		
Forearm	4	57%
Arm	3	43%
Comorbidities		
None	5	71%
Diabetes	1	14%
Hypertension	1	14%
Time from injury to study enrolment		
4 months post-operative	2	29%
5 months post-operative	1	14%
6 months post-injury	1	14%
7 months post-operative	2	29%
10 months post-operative	1	14%
	Mean	**StDev**
Age (years)	36.14	11.44
CBC (WBC)	5.58 x 10^9/L	1.12

Table 2. Post-PRP VAS score

Subject	VAS 0	VAS 1	VAS 2	VAS 3
1	5	4	2	0
2	6	3	2	2
3	2	1	0	0
4	9	5	2	0
5	3	2	1	1
6	2	2	1	1
7	3	2	1	1
Mean	**4.29**	**2.71**	**1.29**	**0.71**
St Dev	**2.56**	**1.38**	**0.76**	**0.76**

Table 3. DASH score

Subject	DASH 0	DASH 1	DASH 2	DASH 3
1	40.20	29.00	28.30	24.10
2	53.30	42.50	40.00	35.83
3	30.00	28.30	26.60	24.10
4	82.50	70.00	36.60	29.16
5	55.83	53.33	47.50	30.83
6	50.83	45.00	31.60	29.28
7	65.83	60.83	32.42	27.89
Mean	**54.07**	**46.99**	**34.72**	**28.74**
St Dev	**16.99**	**15.59**	**7.27**	**4.06**

Table 4. Modified Lane and Sandhu scoring

Subject	MLSRS 1	MLSRS 2	MLSRS 3
1	0.33	4.33	9.50
2	1.00	5.33	6.17
3	3.50	6.83	8.17
4	2.17	3.00	8.17
5	1.50	2.00	5.50
6	3.00	3.50	5.17
7	2.33	3.83	7.00
Mean	**1.98**	**4.12**	**7.10**
St Dev	**1.11**	**1.58**	**1.59**

The mean VAS score at the initial assessment (VAS 0) was 4.29 (SD = 2.56), decreasing to 2.71 (SD = 1.38) on the first follow-up, to 1.29 (SD = 0.76) on the second, and 0.71 (SD = 0.876) on the third (Table 2, Figure 4).

The mean DASH score at initial assessment (DASH 0) was 54.07, improving to 46.99 on the first follow-up, 34.72 on the second, and 28.74 on the third (Table 3, Figure 5).

The mean MLSRS score on initial evaluation (MLSRS 1) was 1.98, reflecting the early stages of bone healing, increasing to 4.12 on the second (MLSRS 2) showing moderate progress in bone healing, and 7.10 (1.59 SD) on the third evaluation (MLSRS 3) (Table 4, Figure 6).

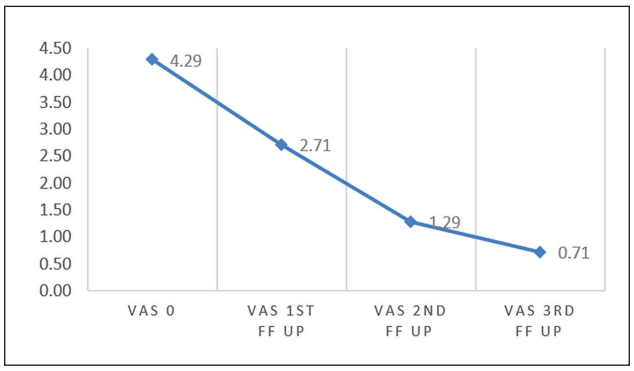

Figure 4. Line graph of Post-PRP VAS score.

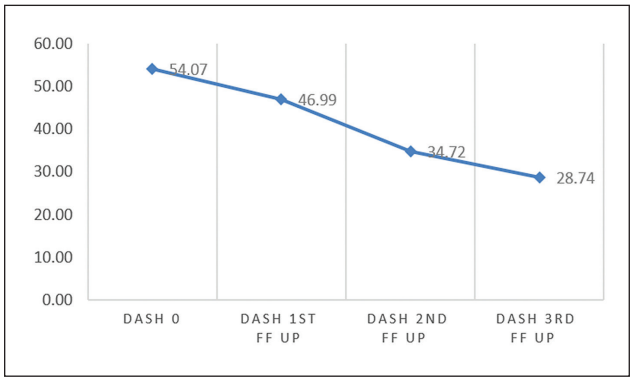

Figure 5. Line graph of DASH score.

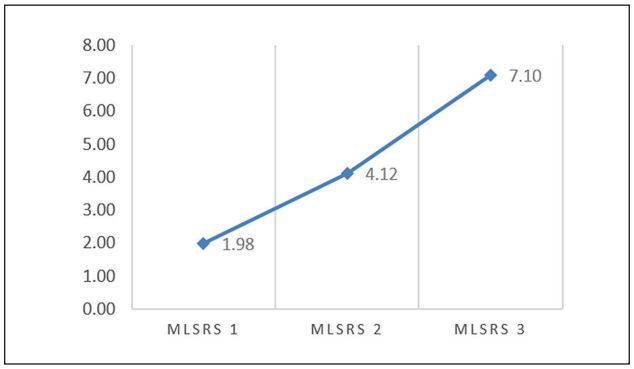

Figure 6. Line graph of Modified Lane and Sandhu scoring.

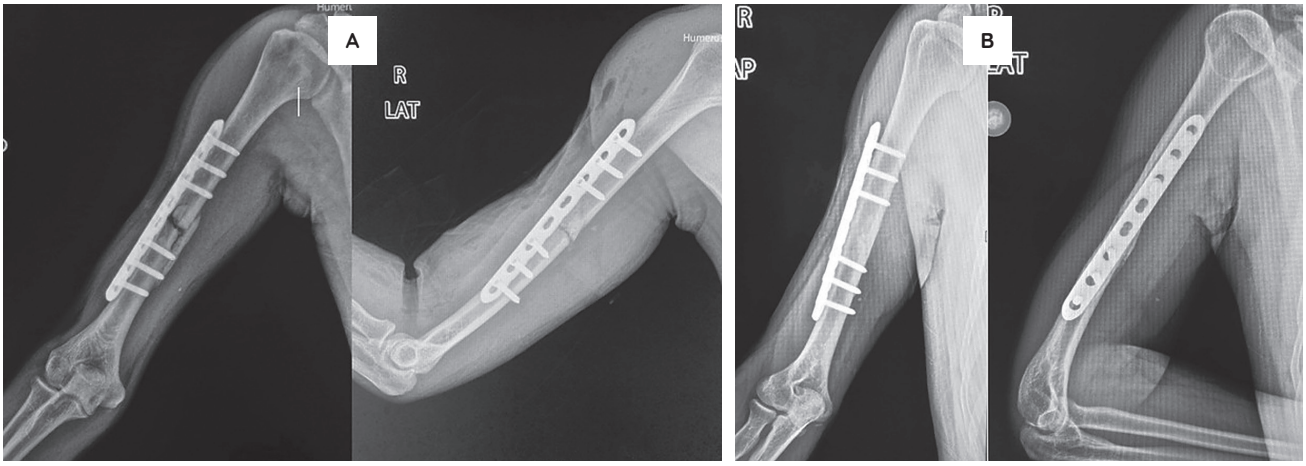

Figure 7. A 34-year-old male diagnosed with oligotrophic nonunion of the middle third shaft of the humerus 4 months post-operatively after serial radiographic monitoring. Pre-PRP Radiograph **(A)** reveals no progression of callus formation. Post-PRP Radiograph after 5 months **(B)** reveals absence of fracture line and recanalization.

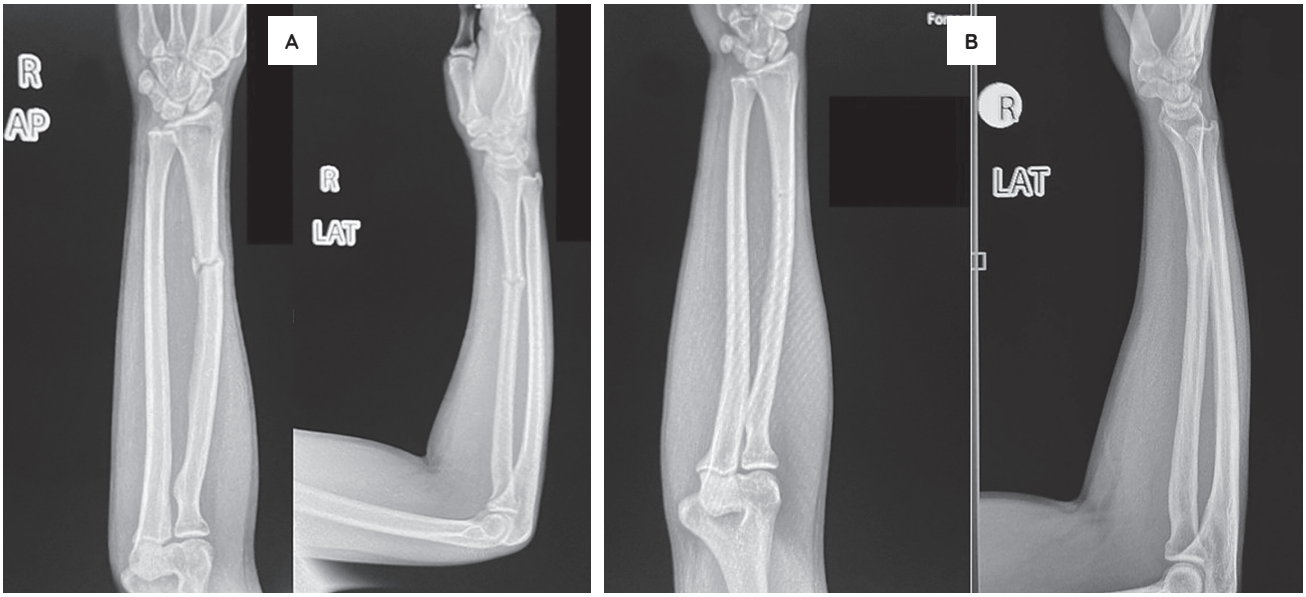

Figure 8. A 25-year-old male diagnosed with atrophic nonunion of the distal third radius after 7 months of conservative management with cast immobilization. Pre-PRP Radiograph **(A)** reveals no callus formation. Post-PRP Radiograph after 5 months **(B)** reveals absence of fracture line and recanalization.

Union was achieved in 86% of patients, with the time to union ranging from five to seven months (Figures 7 to 10). The remaining patient did not achieve union within a year of follow up and observation and was advised surgical intervention. (Table 5).

Throughout the study and during follow-up, there were no noted adverse events such as infection, neurovascular injury, increasing pain, or decreased range of motion or functionality.

Table 5. Time to achieve union post-administration

	n	Percentage
5 Months	3	43%
6 Months	2	29%
7 Months	1	14%
Did not achieve union within one year	1	14%

DISCUSSION

The biological rationale for PRP use is supported by its high concentration of growth factors, including platelet-derived growth factor (PDGF), vascular endothelial growth factor (VEGF), transforming growth factor-beta (TGF-β), and insulin-like growth factor (IGF), which promote angiogenesis, cellular proliferation, and osteogenic differentiation.[1,2] These factors may enhance the local biological environment at the nonunion site, facilitating mesenchymal stem cell recruitment and differentiation into osteoblasts. Additionally, PRP may augment early inflammatory and reparative phases of bone healing, although the precise mechanisms and optimal dosing strategies remain incompletely defined.[5,6]

Previous systematic reviews showed different methods of PRP administration (e.g., single dose and multiple doses) to

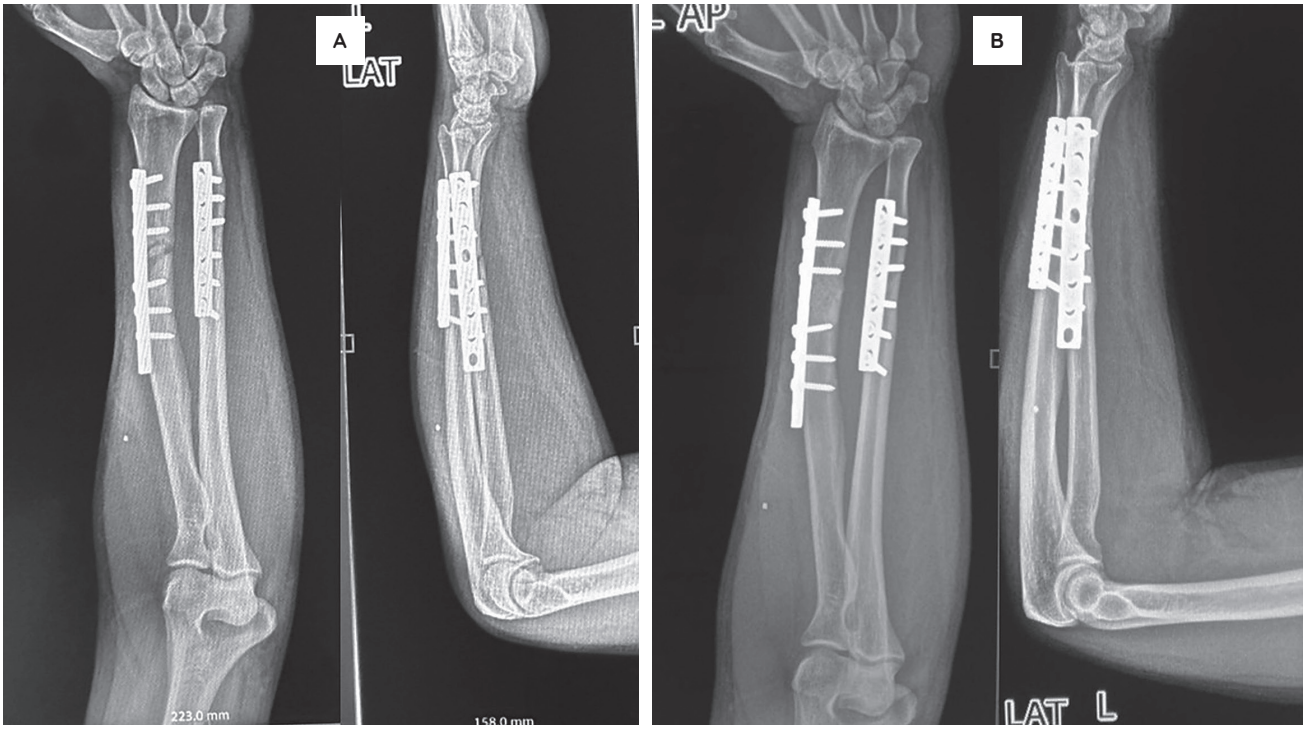

Figure 9. A 41-year-old male diagnosed with oligotrophic nonunion of the radius 6 months post-operatively. Pre-PRP Radiograph **(A)** reveals no callus formation. Post-PRP Radiograph after 6 months **(B)** reveals absence of fracture line and recanalization.

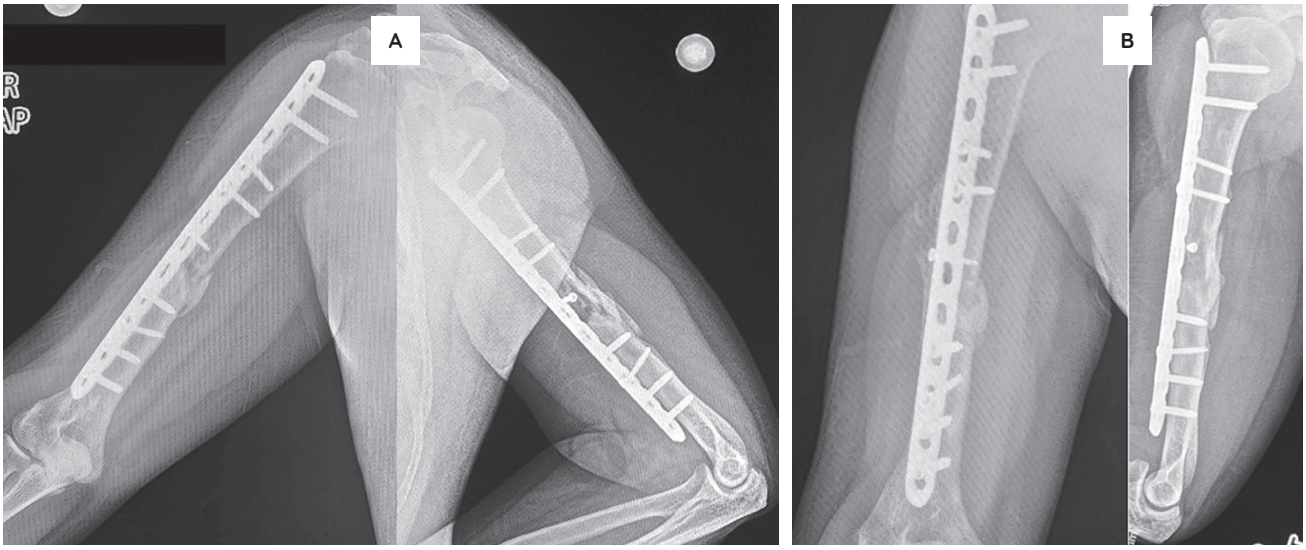

Figure 10. A 31-year-old male diagnosed with oligotrophic nonunion of the humerus 10 months post-operatively. Pre-PRP Radiograph **(A)** reveals no progression of callus formation. Post-PRP Radiograph after 7 months **(B)** reveals absence of fracture line and recanalization.

promote healing; recommendations are still limited and lack standardization. Although it is more common to administer the entire amount to a patient in a single dose, it can also be divided into several injections spaced out over a period of several weeks. Studies have reported success with a dose of at least 5 mL per injection.

The findings of this study are consistent with previous reports suggesting that PRP may serve as a biological adjunct in the management of nonunion. Systematic reviews and meta-analyses have reported variable but generally favorable outcomes with PRP in long bone delayed union and nonunion, although heterogeneity in preparation methods and administration protocols remains a limitation.[5,7,8] Prospective and randomized studies have also demonstrated improved healing rates with PRP compared to controls, though results are not uniformly conclusive.[9,10] The observed time to union in this study aligns with previously reported healing timelines following PRP augmentation. However, given the small sample size and absence of a control group, results should be interpreted with caution.

Improvements were observed across multiple outcome measures, including pain (VAS), functional status (DASH Scores), and radiographic healing using the Modified Lane and Sandhu Radiographic Score (MLSRS). A progressive decrease in VAS scores suggests a reduction in pain over time; the SD of 0.76 indicates minimal and acceptable deviation from the mean. Our DASH scores likewise improved over time, indicating improved functional capacity; the SD of 4.06 shows significant variation from the mean score, which may be attributed to the subjectivity of the scoring system.

We saw progression in radiographic healing, highlighting bone healing over time as demonstrated by a consistent increase in Modified Lane and Sandhu scores; an SD of 1.59 was deemed acceptable. Prior studies have demonstrated the reliability and validity of the Lane-Sandhu scoring system and its modified versions in evaluating fracture healing, supporting its use as an outcome measure.[4,11] The MLSRS findings in this study correlate with the observed clinical improvements and union rates, reinforcing its utility in monitoring treatment response.

Six subjects (86%) achieved radiographic and clinical union at their last follow-up. Time to union ranged from five to seven months after administration of PRP (Table 5). The remaining patient did not achieve union within a year of follow-up and was advised surgical intervention.

Our use of multiple outcome measures, including validated clinical (VAS, DASH) and radiographic (MLSRS) tools, gave a comprehensive and multidimensional assessment of treatment response. Serial follow-up assessments enabled observation of both early and delayed patterns of bone healing, providing insight into temporal trends following PRP administration.

However, several limitations must be acknowledged. The small sample size and single-center design limit the generalizability of the findings. Furthermore, the study population consisted exclusively of male, military-associated patients, which may not be representative of the broader population with nonunion. The absence of a control group precludes definitive conclusions regarding causality and limits the ability to attribute observed improvements solely to PRP. The relatively short primary follow-up period may have underestimated the time to union, although extended follow-up in select cases demonstrated continued healing. In addition, PRP preparation was not fully characterized in terms of platelet concentration, leukocyte content, and growth factor levels, which may affect reproducibility and comparability with other studies. Potential sources of reporting bias in subjective outcome measures such as VAS and DASH must also be considered. These limitations highlight the need for larger, controlled studies with standardized PRP protocols and more diverse patient populations.

While the results suggest that PRP may have a role as an adjunct in the management of nonunion, the findings should be interpreted as preliminary. Larger, well-designed randomized controlled trials with standardized PRP preparation and administration protocols are needed to better define its efficacy and optimal use.[6–8] Future studies should also explore dose-response relationships, timing of intervention, and combination therapies with other biological or mechanical strategies. Additionally, further validation of radiographic scoring systems such as MLSRS in clinical settings would enhance comparability across studies and improve the assessment of fracture healing outcomes.

CONCLUSION

The authors concluded that platelet-rich plasma (PRP) administration in nonunion of long bones of the upper extremity is a beneficial and feasible minimally invasive initial option in the management of nonunion. The study provided evidence of bone healing, achieving clinical and radiographic union, and improving pain control and functional mobility.

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ETHICAL CONSIDERATIONS

Patients' consent were obtained before the submission of the manuscript.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

MPM: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft preparation, Writing – review and editing, Visualization, Supervision, Project administration, Funding acquisition; **AMTS:** Conceptualization, Methodology, Validation, Investigation, Resources, Writing – original draft preparation, Writing – review and editing, Visualization, Supervision, Project administration, Funding acquisition; **ALFO:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Writing – review and editing, Visualization, Supervision, Project administration, Funding acquisition.

DATA AVAILABILITY STATEMENT

The datasets generated and analyzed in this study are included in the published article.

AUTHOR DISCLOSURE

The authors declared no conflict of interest.

FUNDING SOURCE

None.

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