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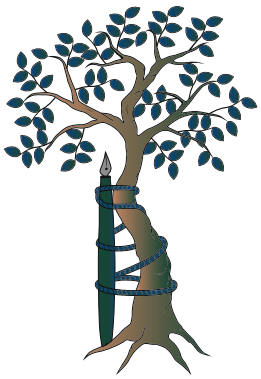

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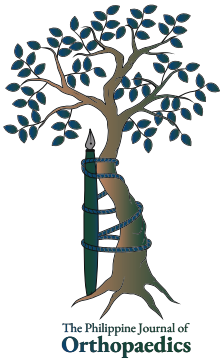
SPECIAL ISSUE: CASE REPORTS

CASE REPORTS / CASE SERIES



ABOUT THE LOGO: THE TREE OF ANDRY

Nicholas Andry coined the French term “orthopédie” which is derived from the Greek words “orthos” (correct or straight) and “paidion” (child). As implied in its etymology, “orthopédie” was first practiced treating childhood spinal and bone deformities.

The main elements of the logo are the tree of Andry; the Philippine Journal of Orthopaedics wordmark; and the fountain pen. The fountain pen, in replacement of the stake, represents how research has been the backbone of orthopaedic learning and practice.

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The **Philippine Journal of Orthopaedics,** the official journal of the **Philippine Orthopaedic Association, Inc.** is an open-access, English language, web-based, medical science journal published by the Association. The Journal is guided by the International Committee of Medical Journal Editors (ICMJE) **"Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals."**

The **Philippine Journal of Orthopaedics** shall advance the art and science of orthopaedics in the country by publishing high quality original clinical investigations, epidemiological studies, case reports, review articles, evaluations of diagnostic and surgical techniques, and the latest updates on management guidelines. The journal's target audience are local and international practitioners, clinicians, and other scientists, researchers. It shall accept manuscript submissions from consultants, fellows, residents, and other allied medical professions and specialties, not only from the Philippines but also from Asia and the rest of the world as long as these are within scope and relevant to the practice. Non-members of the Association may submit scientific manuscripts to the journal.

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It is with great pleasure that I present the second issue of our **Philippine Journal of Orthopaedics** for 2026. This edition reflects our Association's continuing commitment to advancing orthopaedic knowledge through high-quality research and the sharing of valuable clinical experiences.

Featured in this issue is a collection of noteworthy case reports and case series that highlight the management of challenging orthopaedic conditions. These contributions demonstrate the dedication of our authors, reviewers, and Editorial Board to promoting evidence-based practice and lifelong learning.

I extend my sincere gratitude to our Editorial Board, contributors, reviewers, and everyone who worked diligently to make this publication possible. Your efforts ensure that our journal remains a valuable platform for sharing knowledge and fostering professional growth.

I encourage all our members to read, learn from, and share the knowledge presented in this issue. May these scholarly works inspire continued research, collaboration, and excellence in patient care.

Marcelino T. Cadag, MD, FPOA
President, Philippine Orthopaedic Association, Inc.

The Philippine Journal of Orthopaedics

Making the Case for Case Reports

This issue of the **Philippine Journal of Orthopaedics** is notable because it highlights a form of research often belittled and overlooked. It sits at the bottom of the pyramid of scientific evidence and yet forms the basis of many significant discoveries throughout the history of medical practice. I am, of course, referring to the case report. When a case report is published, it is often labelled as level 5 clinical evidence – inferior to almost every other research design, except for animal studies. It should come as no surprise then that case reports receive the fewest citations of all study designs.[1] This begs the question: why write these reports at all? After all, the lack of scientific rigor and anecdotal nature of these articles run contrary to the principles of evidence-based medical practice.

Authors use case reports to present rare conditions, a rare presentation of a common condition, an unexpected association between diseases or symptoms, unexpected event in the course of a patient, a novel treatment, to illustrate hypotheses in etiology, and to highlight mistakes in management. These reports also fill a gap that is frequently not addressed by scientific studies with more rigorous designs. Uncommon cases or injuries surely cannot be studied using a randomized controlled trial.

To appreciate the value of case reports, let me cite two reports which have stood the test of time and have left their impact on modern medicine. The first was published in 1817, by James Parkinson, entitled "An Essay on the Shaking Palsy." The name of the author should be a giveaway on what disease he was describing.[2] Two hundred years after it was first published, this text is still considered a comprehensive description of what we now know as Parkinson's disease. Its place in history as a milestone publication is secure and seemingly unshakeable.

The second article I would highlight is one from 2005, describing a group of patients undergoing anti-osteoporotic therapy who paradoxically developed atypical fractures.[3] The decade before this report came out was a significant one for those of us who treated patients with fragility fractures because of the introduction and widespread use of anti-osteoporotic agents – finally, a way to prevent fragility fractures by strengthening bone! This report, however, highlighted an adverse effect of the therapy which may have been too rare to detect or needed too long to manifest and was not seen in the clinical trials. Consequently, the concept of a holiday or a break from anti-osteoporosis therapy was introduced to clinicians.

A search through your favorite search engine should yield many more case reports that have gone on to change clinical practice. It is with the goal of not allowing isolated findings to be missed that these continue to find a platform and an audience. In this issue, the Philippine Journal of Orthopaedics highlights the case report, from novel strategies to treat common conditions, twists on established treatments, to unusual combinations of common conditions, this issue hopes to encourage all our readers to take a closer look at these reports and hopefully gain insights that may help in their own clinical practices.

Tammy L. Dela Rosa, MD, MMedSc
Editor-in-Chief, Philippine Journal of Orthopaedics

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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

Marlon P. Mejia MD, Antonio Manuel T. Saludo MD, FPOA, FPSS, Andrie Lorenzo F. Ortega MD, FPOA

Department of Orthopaedic Surgery and Traumatology, Victoriano Luna General Hospital, Quezon City, Philippines

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,

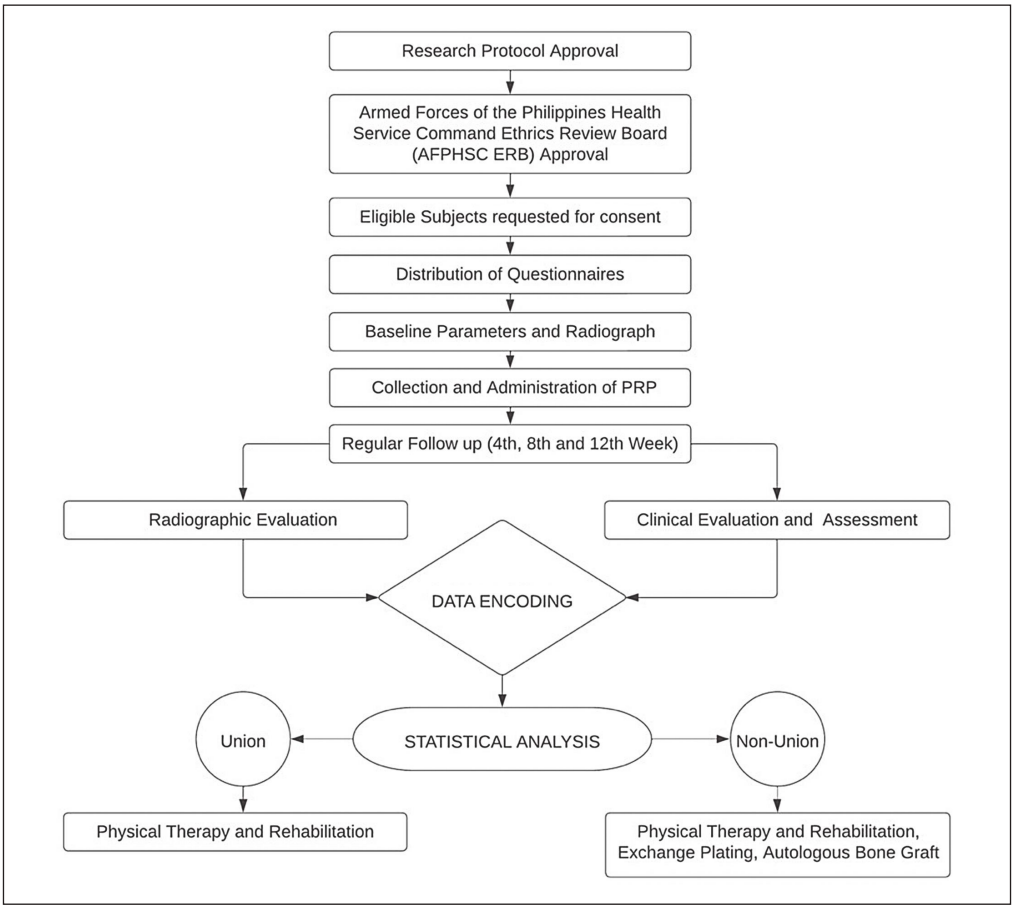

Figure 1. Flow diagram methodology.

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).

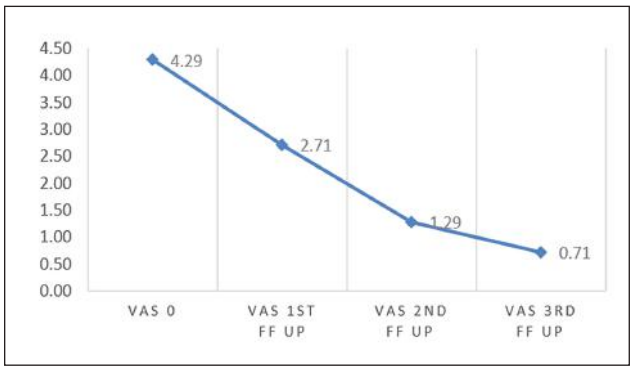

Figure 4. Line graph of Post-PRP VAS score.

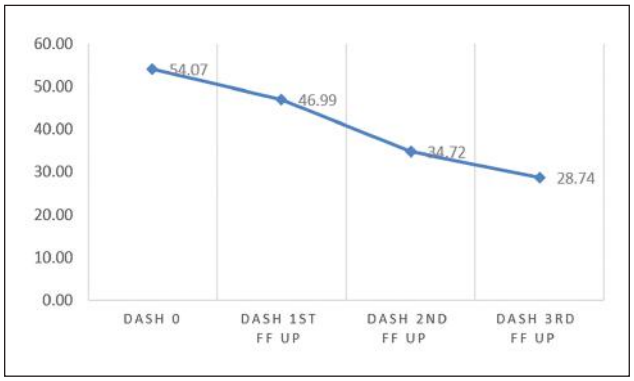

Figure 5. Line graph of DASH score.

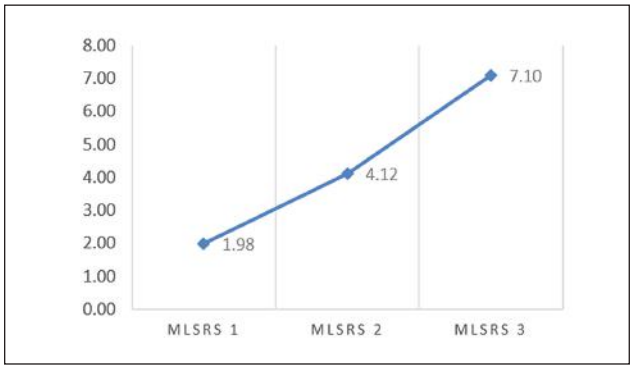

Figure 6. Line graph of Modified Lane and Sandhu scoring.

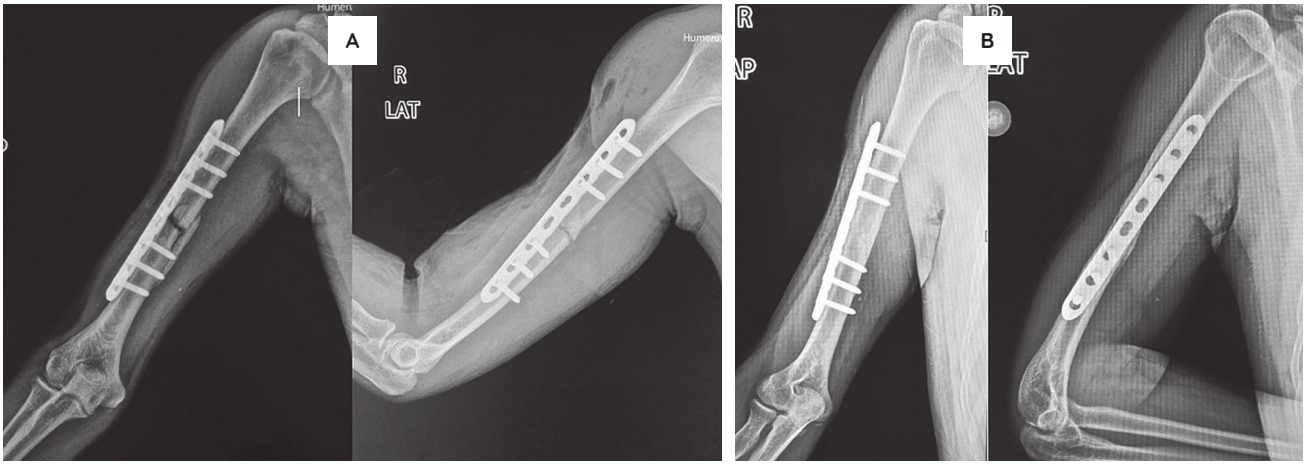

Figure 7. A 34-year-old male diagnosed with oligotrophic nonunion of the middle third shaft of the humerus 4 months post-operatively after serial radiographic monitoring. Pre-PRP Radiograph **(A)** reveals no progression of callus formation. Post-PRP Radiograph after 5 months **(B)** reveals absence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

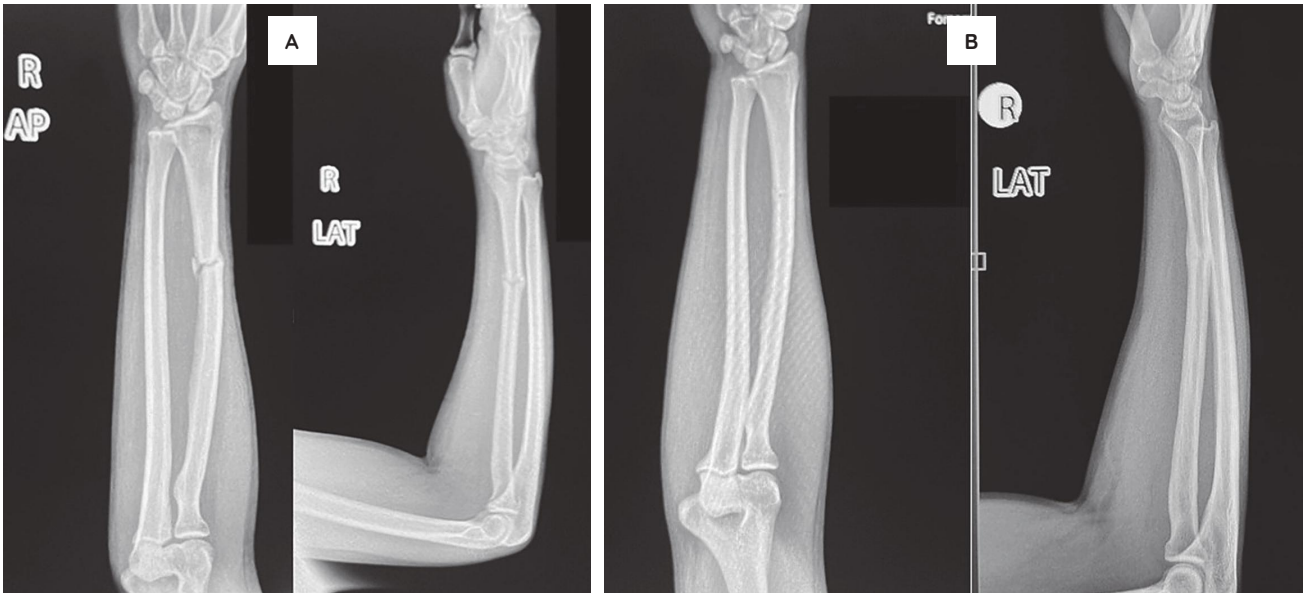

Figure 8. A 25-year-old male diagnosed with atrophic nonunion of the distal third radius after 7 months of conservative management with cast immobilization. Pre-PRP Radiograph **(A)** reveals no callus formation. Post-PRP Radiograph after 5 months **(B)** reveals absence of fracture line and recanalization.

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

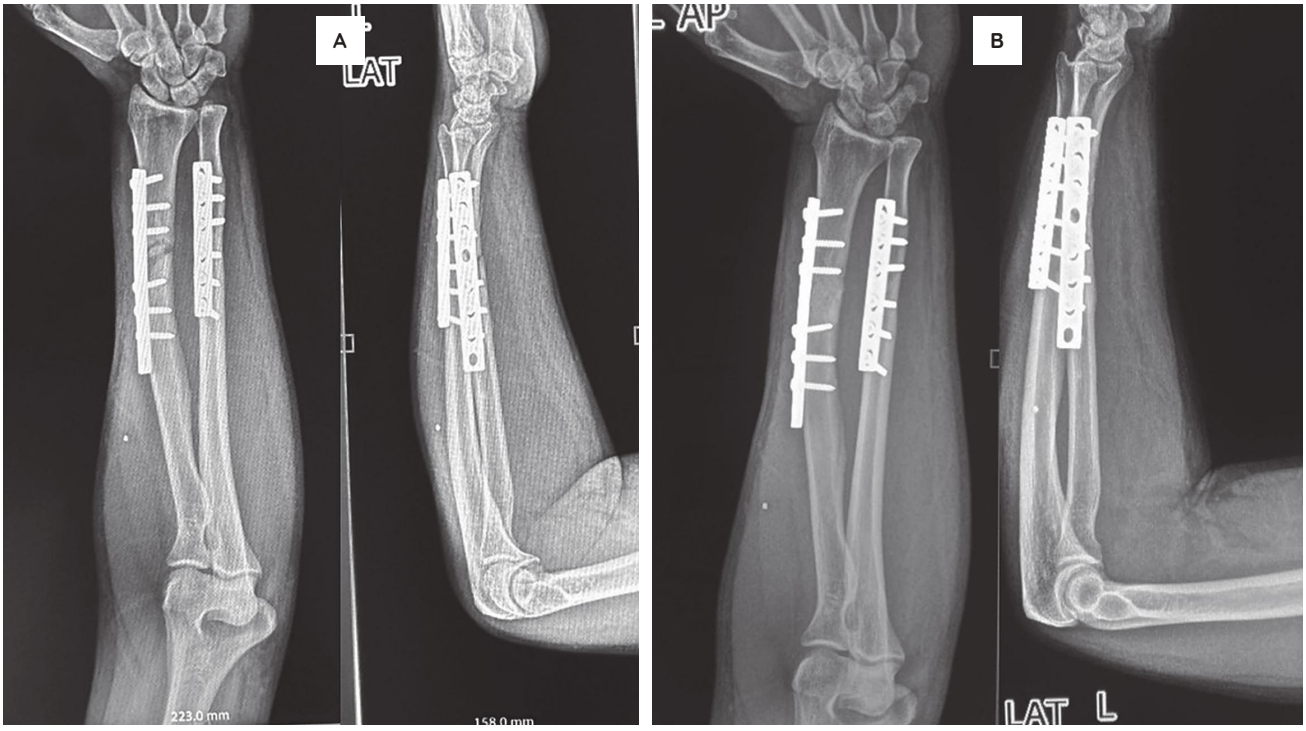

Figure 9. A 41-year-old male diagnosed with oligotrophic nonunion of the radius 6 months post-operatively. Pre-PRP Radiograph **(A)** reveals no callus formation. Post-PRP Radiograph after 6 months **(B)** reveals absence of fracture line and recanalization.

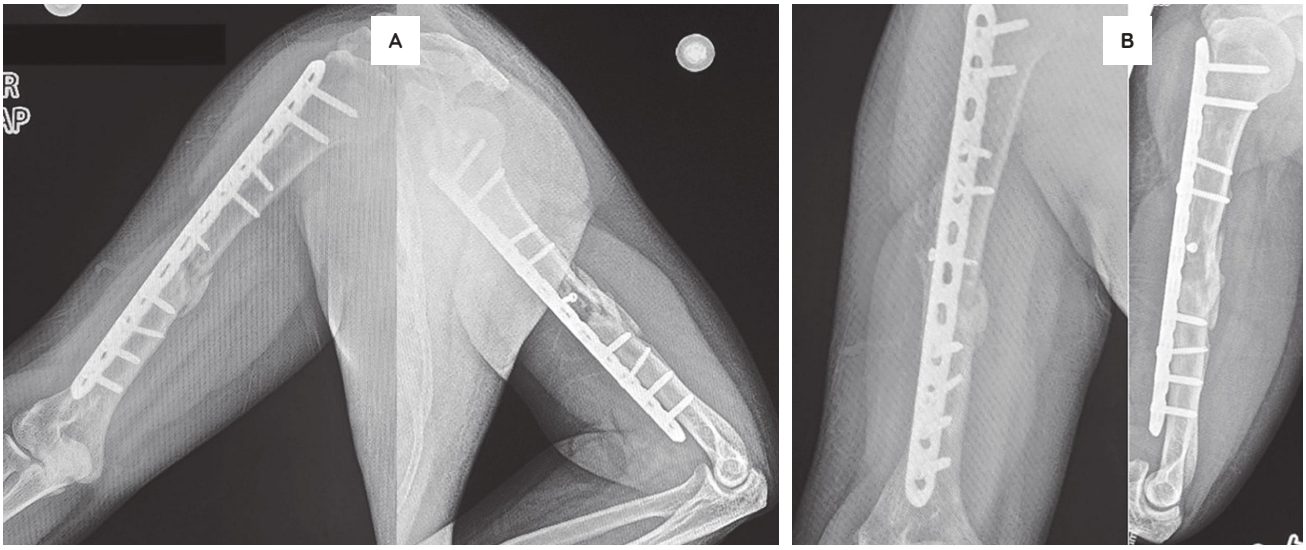

Figure 10. A 31-year-old male diagnosed with oligotrophic nonunion of the humerus 10 months post-operatively. Pre-PRP Radiograph **(A)** reveals no progression of callus formation. Post-PRP Radiograph after 7 months **(B)** reveals absence of fracture line and recanalization.

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.

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The Philippine Journal of Orthopaedics

CASE REPORT

Surgical Management of Gout-Complicated Humeral Nonunion: A Case Report

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ABSTRACT

Humeral shaft fractures may progress to nonunion despite operative management. We report a 50-year-old male with repeated surgical failure of a left humeral shaft fracture, found intraoperatively to have uric acid crystal deposition within the pseudoarthrosis site. The patient underwent implant removal, excision of the pseudoarthrosis, and rigid plate fixation augmented with an intramedullary fibular strut graft. At six months postoperatively, clinical evaluation demonstrated mechanical stability and satisfactory functional recovery. Although fibular strut grafting is not universally considered standard treatment for humeral nonunion, this case highlights its potential role in complex, biologically compromised nonunions associated with gout.

Keywords. humeral shaft fracture, nonunion, pseudoarthrosis, uric acid crystals, fibular strut graft, gout

INTRODUCTION

Nonunion of the humeral shaft remains a challenge in orthopedic practice. It is generally defined as failure of fracture healing after at least six months and occurs in approximately 10–23% of conservatively managed cases and 2–10% of cases treated with internal fixation.[1] Multiple factors contribute to nonunion and are broadly categorized as mechanical or biological. Mechanical causes include inadequate reduction or stabilization, whereas biological factors involve local tissue compromise, infection, and systemic conditions that impair bone healing.[1]

Systemic metabolic and endocrine disorders have increasingly been recognized as potential contributors to impaired fracture healing.[1] These include diabetes mellitus, thyroid and parathyroid disease, vitamin D deficiency, and other disorders affecting bone metabolism. However, definitive causal relationships remain difficult to establish, and many cases of nonunion continue to be attributed primarily to mechanical instability.

Gout is a common inflammatory condition characterized by hyperuricemia and deposition of monosodium urate crystals in joints and periarticular tissues.[2] Chronic gout may lead to bone erosion and, less commonly, intraosseous tophus formation.[2] Although gout has been reported in pathologic fractures, its role in fracture healing remains poorly understood.[3,4] Reported gout-associated fractures most frequently involve the femoral neck and patella, with limited literature describing long-bone involvement.[3,4]

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To our knowledge, reports describing uric acid crystal deposition within a humeral shaft pseudoarthrosis are exceedingly rare. This case highlights an unusual presentation of humeral nonunion complicated by urate crystal deposition and explores the possible role of gout as a biological factor affecting fracture healing.

CASE

Our patient was a 50-year-old right-handed Filipino male from Pangasinan. Five years before admission, he was involved in a motor vehicle accident that resulted in a left humeral shaft fracture. He underwent open reduction and internal fixation with plate application at a private hospital. The patient reported that wrist drop began after the first surgery and persisted thereafter. Four years before admission, he developed recurrent left arm pain, and evaluation revealed implant failure. He subsequently underwent hardware removal and intramedullary nailing of the humerus with iliac crest bone grafting at another institution. Following this procedure, he regained functional use of the arm and was able to perform household activities.

Two years before admission, he sustained another injury after falling from standing height and striking his left arm directly against a concrete surface. He subsequently noted progressive deformity and pain but did not seek immediate medical consultation. Although the pain gradually subsided, he continued to experience subjective instability of the arm. Later evaluation in our clinic demonstrated humeral instability with radiographic findings consistent with nonunion. Definitive surgery was recommended.

His family history was unremarkable. He had been previously diagnosed with gout prior to admission; however, the exact duration of disease, maintenance medications, and treatment compliance could not be reliably ascertained from the available history. He reported a five-year history of cigarette smoking at approximately one pack per day, which he discontinued after his injury, although he continued to have exposure to second-hand smoke.

He was a moderately built male with multiple firm subcutaneous nodules over the periarticular regions of both upper and lower extremities, clinically consistent with chronic tophaceous gout (Figure 1). The left arm demonstrated gross deformity with a well-healed anterolateral surgical scar. Abnormal motion at the mid-shaft of the humerus was elicited on gentle manipulation, independent of elbow and shoulder movement, consistent with pseudoarthrosis. A wrist drop was present, indicating radial nerve palsy. Bilateral iliac crest surgical scars, approximately 5 cm in length, corresponded to prior bone graft harvest sites. The Disabilities of the Arm, Shoulder and Hand (DASH) score was 68.3/100, indicating significant functional limitation.

Baseline laboratory investigations revealed serum electrolytes within normal reference ranges (Na 137.3 mmol/L, K 3.81 mmol/L, Cl 101.1 mmol/L, ionized Ca 1.28 mmol/L). White blood cell count was mildly elevated at 11.98 $\times 10^9$/L with neutrophil predominance. Hemoglobin and platelet counts were within normal limits. Procalcitonin was <0.10 ng/mL, not suggestive of bacterial sepsis. C-reactive protein was 6.61 mg/L (within laboratory reference range), whereas erythrocyte sedimentation rate was elevated at 70 mm/hr. Serum uric acid was elevated at 10.3 mg/dL, consistent with active hyperuricemia. Renal function, fasting glucose, and lipid profile were within acceptable limits.

Radiographs of the left humerus showed a displaced midshaft fracture, with significant gapping and no signs of callus formation. There was an intramedullary nail, broken at the level of the distal locking screw hole, with "wiper" sign noted at this level (Figure 2).

The patient was co-managed with internal medicine for metabolic evaluation and optimization of hyperuricemia.

The admitting diagnosis was implant failure of the left humerus secondary to aseptic nonunion with radial nerve palsy, in the setting of chronic tophaceous gout.

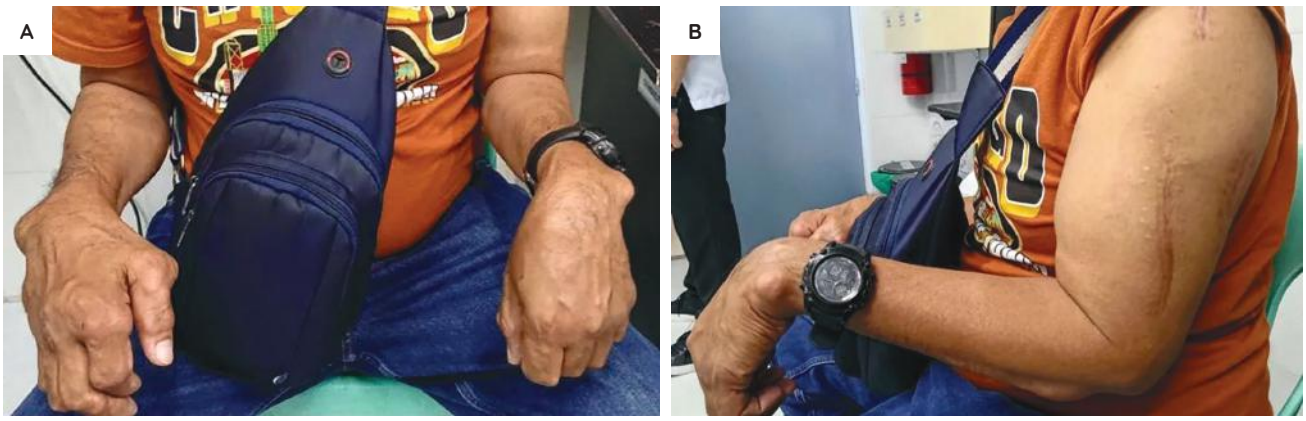

Figure 1. Clinical photographs demonstrating tophaceous gout. Anterior view of the upper extremities showing multiple subcutaneous nodular deposits consistent with tophaceous gout **(A)**. Lateral view of the left arm demonstrating periarticular tophaceous enlargement and soft tissue thickening along the upper extremity **(B)**.

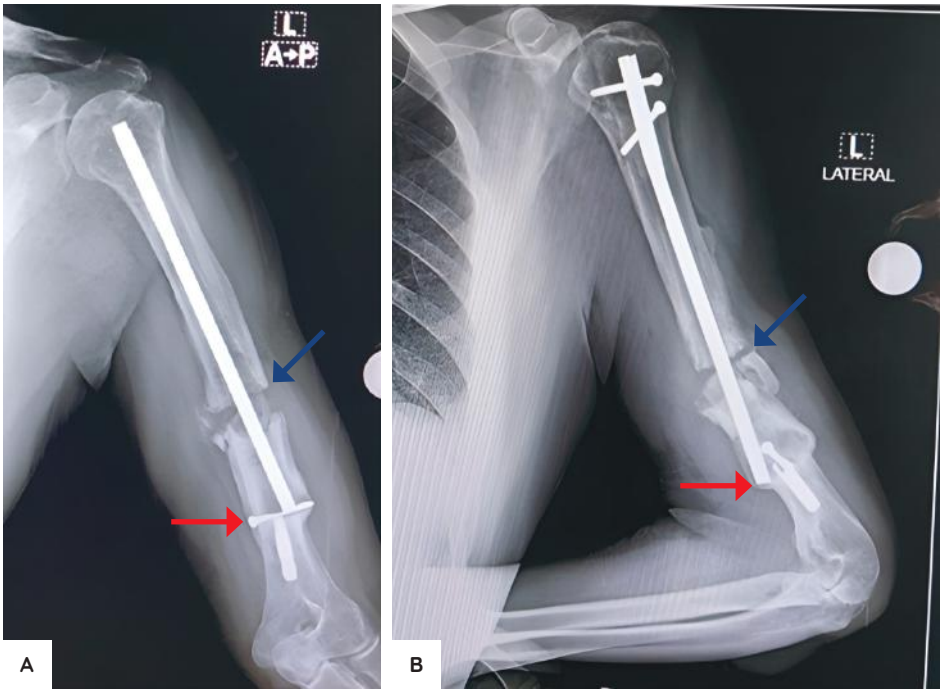

Figure 2. Anteroposterior **(A)** and lateral **(B)** radiographs of the left humerus demonstrating implant failure, with breakage of the intramedullary nail at the distal locking screw hole *(red arrow)*, persistent fracture gap at the midshaft nonunion site *(blue arrow)*, and a healed distal fracture segment.

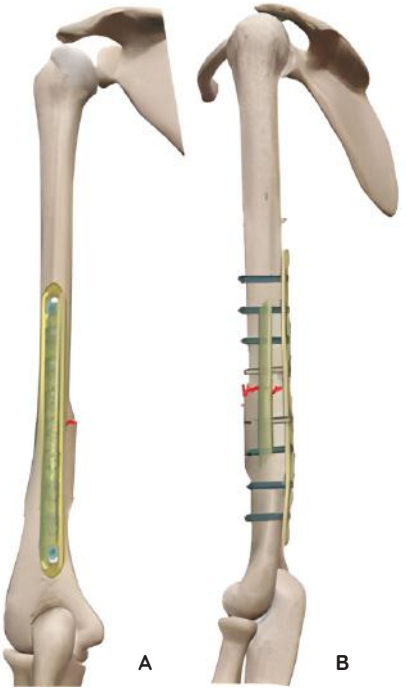

Figure 3. Our template for the Open reduction internal fixation (locking plate) with intramedullary fibular strut graft shown in AP **(A)** and lateral **(B)** view.

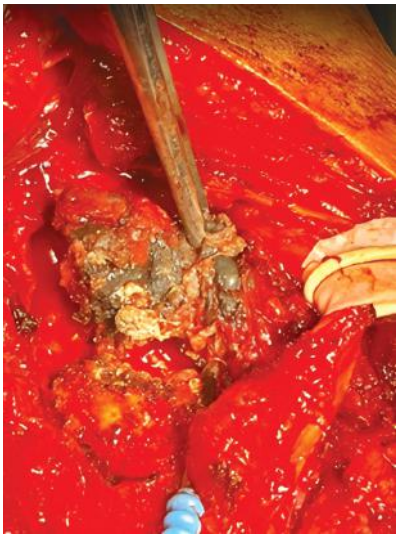

Figure 4. Pseudoarthrosis site and visible metallosis.

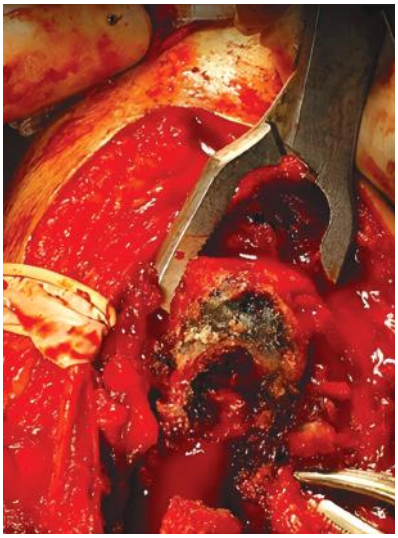

Figure 5. Intraosseous uric acid deposition with white chalky paste-like tissue.

Definitive surgical management consisted of implant removal, excision of the pseudoarthrosis, and open reduction and internal fixation using a locking plate augmented with an intramedullary fibular strut graft (Figure 3).

The humerus was approached posteriorly. Pseudoarthrosis was confirmed intraoperatively by the presence of pathologic motion, fibrous tissue with synovial characteristics lining the nonunion cavity, and absence of osseous continuity between fracture fragments. Metallosis was also observed within the pseudoarthrosis cavity, supporting the chronicity of the nonunion and prior implant breakdown (Figure 4). Dissection of the capsule after removal of the intramedullary nail revealed uric acid crystals, which appeared as white chalky pasty deposits. Intraosseous deposition was also noted with the white chalky paste-like tissue on both proximal and distal ends of the fracture (Figure 5).

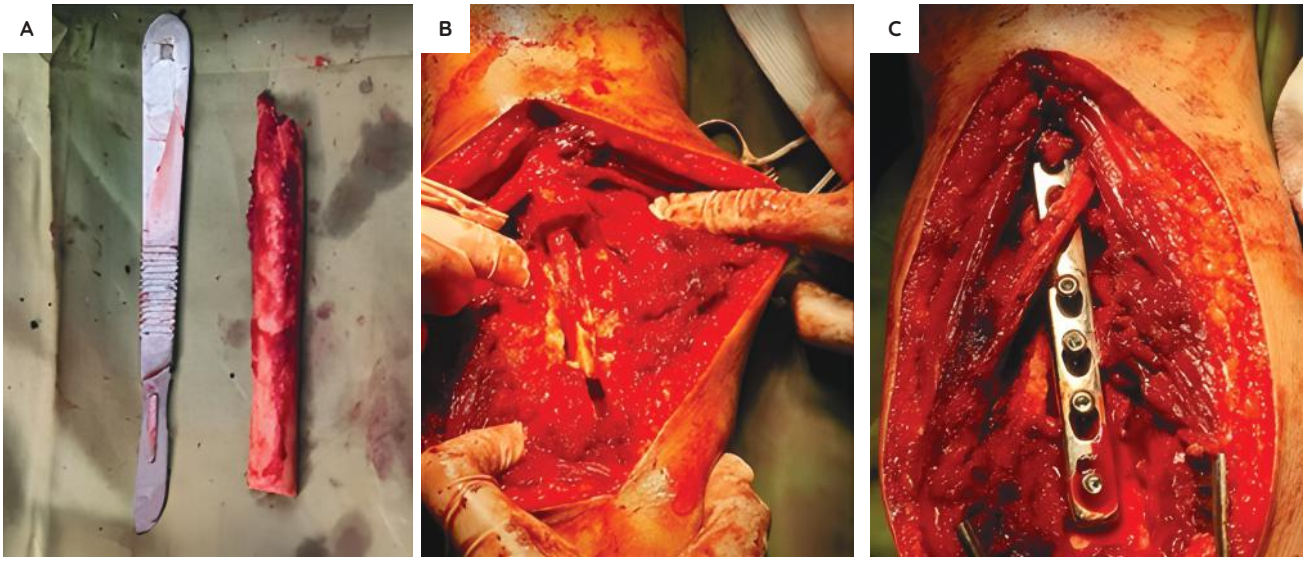

Figure 6. Definitive fixation with fibular strut graft and plate. Non-vascularized fibular strut graft fashioned on the back table (around 8 cm) prior to insertion **(A)**. Strut graft shown press-fit to the intramedullary canal **(B)**. Final construct showing a press-fit fibular strut within the medullary canal bridged by a locking plate; the radial nerve was identified and preserved **(C)**.

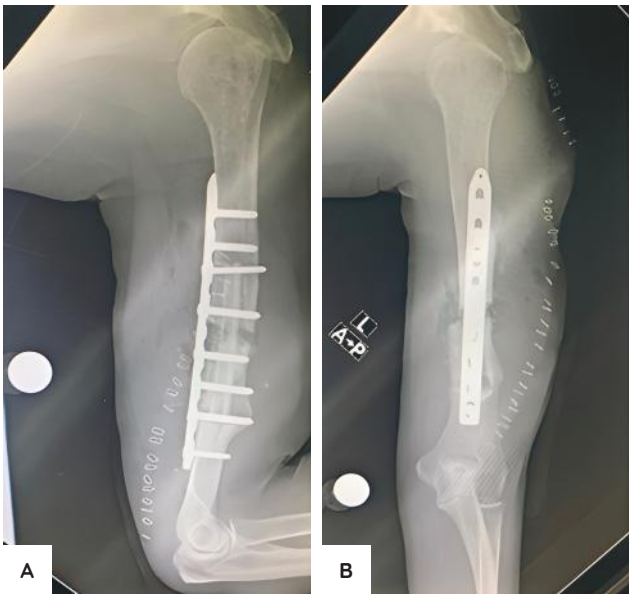

Figure 7. Postoperative x-rays of the left humerus in anteroposterior **(A)** and lateral **(B)** views, showing stable fixation of the fracture segments with an intramedullary strut graft bridging the fracture gap.

A non-vascularized fibular strut graft (8 cm long) was harvested and fashioned, and press-fit into the intramedullary canal, spanning the fracture site (Figure 6). A locking plate was applied, spanning the graft and fracture site (Figure 7). The radial nerve was identified intact and was preserved throughout the procedure (Figure 6).

The patient was discharged on oral medications with instructions for early range-of-motion exercises. The final diagnosis was implant failure of the left humerus secondary to aseptic nonunion with pseudoarthrosis and uric crystal deposition, in a patient with gouty arthritis.

Six months postoperatively, the patient reported no pain. The surgical incision was well-healed without signs of infection. There was no tenderness over the fracture site, and no motion at the mid-shaft of the humerus, indicating mechanical stability.

He was able to do active elbow flexion and extension, and wrist and finger extension, consistent with recovery of radial nerve function. The patient was able to perform activities of daily living independently without significant limitation.

Follow-up radiographs were not obtained at six months; therefore, radiographic union could not be objectively confirmed. Nonetheless, clinical findings were consistent with stable fixation and satisfactory functional recovery at the time of last follow-up.

DISCUSSION

A literature search using the keywords "nonunion," "tophi," "gout," "fractures," "long bone fractures," and "pseudoarthrosis" did not reveal any similar reported cases, suggesting that this presentation is rare and further supporting our decision to report this case.

Pseudoarthrosis refers to a chronic nonunion in which a false joint forms at the fracture site, characterized by fibrous tissue interposition, abnormal mobility, and often a synovial-like lining between bone ends. Metallosis is the pathological accumulation of metallic debris in surrounding soft tissues, resulting from implant wear, corrosion, or mechanical failure. It is seen grossly as dark gray to black discoloration of tissues and is commonly associated with chronic implant failure.

Treatment of humeral shaft nonunion focuses on restoring mechanical stability and optimizing the biological environment for healing, typically through rigid internal

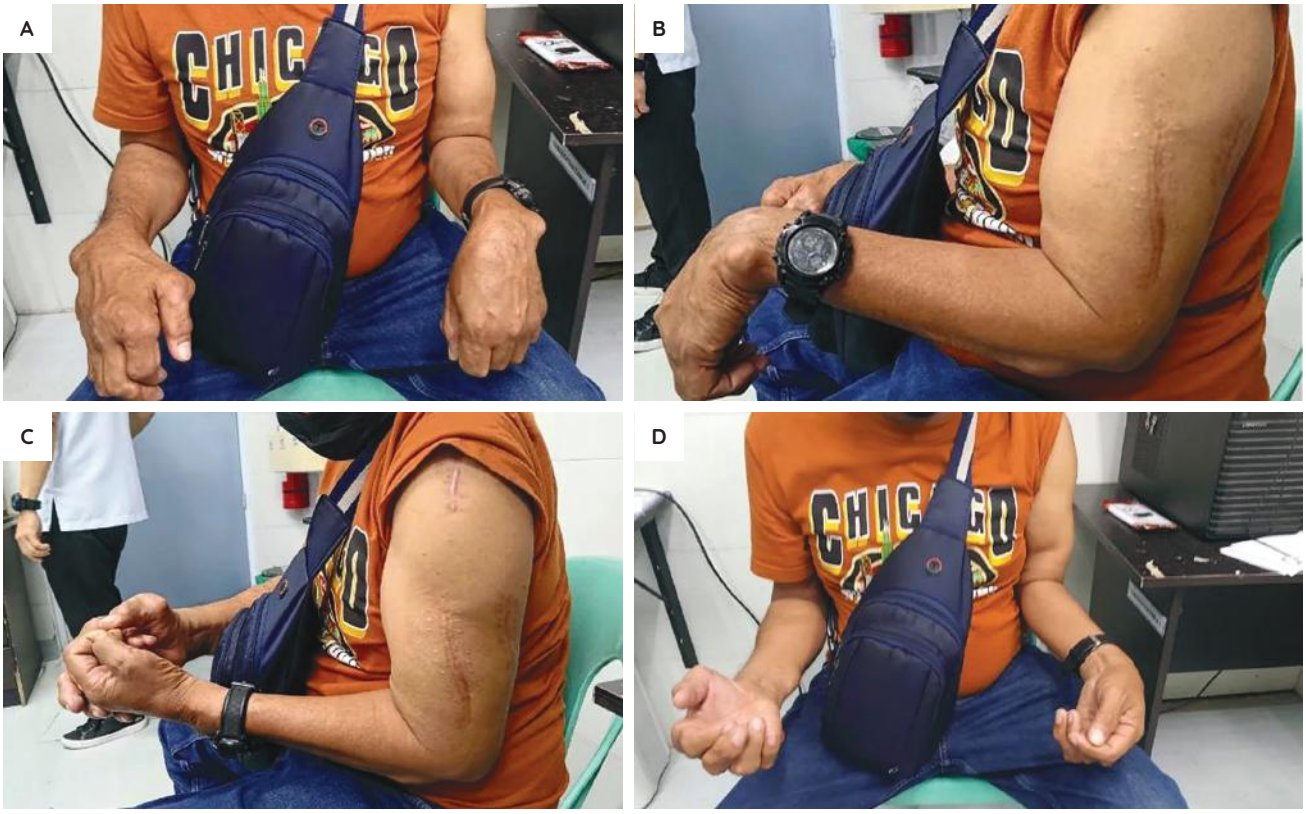

Figure 8. Six-month postoperative clinical follow-up. Anterior view of the patient at rest demonstrating healed surgical incision and symmetric resting position of both upper extremities **(A)**. Lateral view of the left arm showing restoration of arm contour **(B)**. Active elbow flexion and forearm positioning demonstrating functional elbow motion without evidence of instability **(C)**. Active wrist and finger extension indicating recovery of radial nerve function **(D)**.

fixation—most commonly compression plating—with bone graft augmentation when indicated.[1] In complex or recalcitrant cases, particularly those with compromised bone stock, widened medullary canals, segmental bone loss, or prior implant failure, intramedullary fibular strut graft augmentation has been described as a valuable adjunct.[5,6] The fibular strut provides structural support, increases construct stiffness, and serves as a biological scaffold. Although not universally considered standard for all humeral nonunions, literature supports its use in difficult cases with mechanical and biological compromise.[5,6]

In our patient, fracture healing failed after two prior surgeries. Intraoperative findings demonstrated chalky deposits consistent with urate crystal deposition within the pseudoarthrosis. Chronic gout is characterized by monosodium urate crystal deposition and persistent inflammation, which may promote osteoclastic activity, bone erosion, and altered remodeling.[2] While gout as a systemic diagnosis has not consistently been shown to increase overall fracture risk at the population level,[7] intraosseous tophi represent a subset in which localized crystal deposition may compromise structural integrity and predispose to pathological fracture or impaired healing.[2-4] These observations raise the possibility that urate deposition at the nonunion site contributed to a biologically unfavorable environment for fracture repair, particularly when combined with mechanical instability from repeated implant failure.

The stability problem in this case was multifactorial. Recurrent implant failure and persistent abnormal motion at the fracture site suggested inadequate mechanical control. Intraoperative findings of pseudoarthrosis further indicated long-standing instability. Such conditions reduce interfragmentary compression and allow continued motion that inhibits bridging callus formation.[1] Definitive management, therefore, required both meticulous debridement of fibrous tissue and robust fixation capable of controlling rotational and bending stresses across the nonunion site.

Among available literature, the study by Barnes et al. is particularly relevant, as it specifically evaluated humeral shaft nonunions treated with nonvascularized fibular strut allograft augmentation.[5] Their technique demonstrated favorable union rates and functional outcomes in difficult humeral nonunions by improving fixation purchase and structural rigidity while maintaining plate stability.[5] This approach parallels our management strategy, wherein an intramedullary fibular strut graft was used to augment plate fixation in a multiply operated humeral shaft nonunion with compromised biology.

In contrast, Yadav et al. described the fibular strut as a "biological intramedullary nail" for complex long-bone nonunions, emphasizing its mechanical advantages and technical considerations.[6] These studies did not specifically address nonunions related to gout or urate deposition; however, they support the principle that structural augmentation

can improve stability and facilitate healing in challenging cases.[6] In our patient, this principle was applied in the context of suspected gout-complicated nonunion, where both mechanical insufficiency and potential biological impairment likely contributed to healing failure.

This case underscores the importance of a multidisciplinary approach in patients with chronic gout undergoing surgical management for nonunion. Metabolic evaluation and optimization of hyperuricemia should accompany definitive mechanical stabilization. While causality cannot be definitively established from a single case, the presence of urate deposition at the pseudoarthrosis highlights a potential biological factor that merits further investigation.

CONCLUSION

Intraosseous uric acid crystal deposition may predispose to fracture and potentially contribute to impaired healing and nonunion. Surgical management in such cases should be accompanied by appropriate metabolic optimization to address the underlying hyperuricemic state. In the present case, augmentation with a fibular strut graft was selected, considering the patient's history of repeated fracture healing failure and persistent mechanical instability. This approach resulted in improved clinical stability, resolution of pain, and satisfactory functional recovery at six months postoperatively.

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The Department of Orthopedics at Region 1 Medical Center is provisionally accredited by the Philippine Board of Orthopedics. The department remains committed to continually striving to provide optimal quality care for its patients.

ETHICAL CONSIDERATIONS

Patient consent form was obtained before manuscript submission.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

NKPP: Conceptualization, Methodology, Software, Validation, Investigation, Resources, Data Curation, Writing – original draft preparation, Writing – review and editing, Visualization, Project administration, Funding acquisition; **MCC:** Conceptualization, Supervision.

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No datasets were generated or analyzed for this research.

AUTHOR DISCLOSURE

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CASE REPORT

Heterotopic Ossification of the Hindfoot: A Case Report

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ABSTRACT

We present a case of heterotopic ossification that spontaneously developed on the plantar surface of the left heel of a 38-year-old Filipino man. The diagnosis was made using plain radiography and a CT scan. Grossly, the mass resected was composed of discrete, mature bone tissue surrounded by extra-skeletal soft tissue, typical of heterotopic ossification. Histopathologic examination revealed a benign appearing bony tissue admixed with cartilaginous, fibromuscular, fibrocollagenous, and adipose tissues, further confirming the diagnosis.

Keywords. ossification, heterotopic, foot diseases, soft tissue calcification, ectopic ossification, pathologic ossification

INTRODUCTION

Heterotopic ossification (HO) is a pathological condition characterized by the formation of mature lamellar bone in soft tissues where bone does not normally exist. It has been associated with trauma, surgery, neurologic injury, and genetic disorders, but can also occur spontaneously without clear predisposing factors. Although frequently observed in larger joints such as the hip, elbow, and knee, its occurrence in the foot, particularly the hindfoot, is rare. HO can present with pain, swelling, decreased range of motion, and in some cases, functional disability depending on its size and location. Diagnosis typically involves radiographic imaging and histopathological confirmation, while management ranges from conservative therapy to surgical excision in symptomatic cases. This report describes a rare case of heterotopic ossification on the plantar aspect of the heel in an otherwise healthy adult male, emphasizing the diagnostic approach, surgical management, and favorable outcome.

CASE

A 38-year-old, Filipino, city hall employee with an insignificant medical and surgical history, presented at the emergency room (ER) with a painful mass in the plantar aspect of the left heel. He reported that the mass appeared about four years ago, initially painless, without other associated symptoms. He tolerated his condition and did not consult. Eventually, the mass grew in size, causing difficulty in ambulation and, later, pain in the left foot; thus, prompting consultation and eventual admission.

Upon examination at the ER, a hard and tender mass was appreciated grossly on the left heel (Figure 1). We noted hyperkeratosis of the left heel, no draining sinus, no motor

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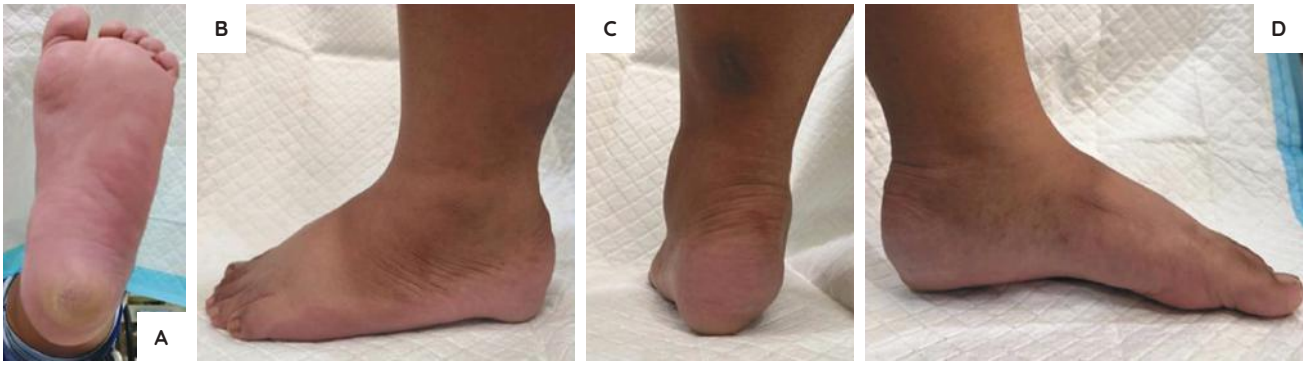

Figure 1. Gross images of the left foot showing a visible tyloma/skin callus on the plantar aspect of the heel **(A)**, lateral view **(B)**, posterior view **(C)**, and medial view **(D)**.

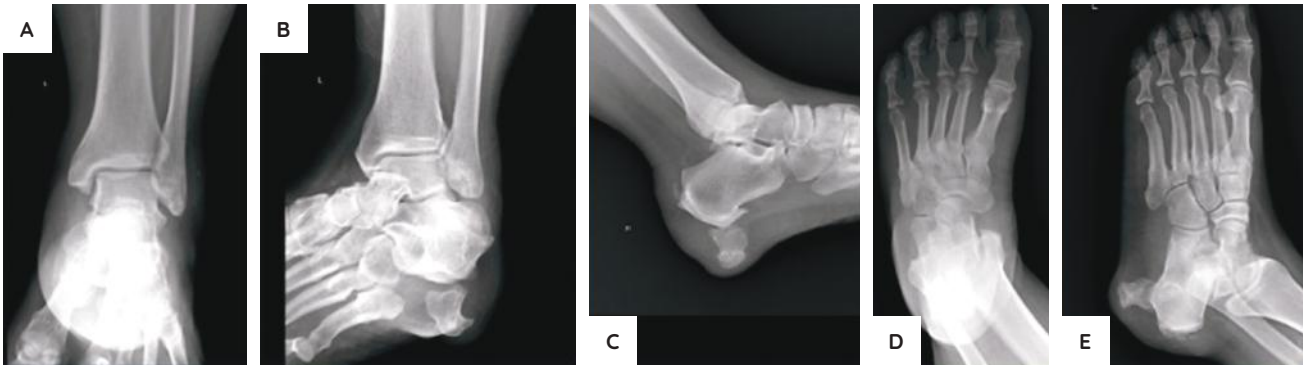

Figure 2. Radiographs of the patient's left ankle and foot showing the anterior-posterior view of the left ankle **(A)**, mortise view of the left ankle **(B)**, lateral view of the ankle clearly showing an extraosseous lesion inferior to the calcaneal tuberosity **(C)**, anterior-posterior view of the left foot **(D)**, and oblique view of the left foot **(E)**.

or sensory deficits, a capillary refill time (CRT) <2s, and strong peripheral pulses. Plain radiographs of the affected foot revealed an osseous lesion and several linear calcific densities on the plantar surface of the left foot. Mature heterotopic ossification was considered (Figure 2).

Computed tomography (CT) scan with 3D reconstruction of the affected foot revealed an irregularly-shaped extra-skeletal bony lesion on the plantar surface of the left foot, suggestive of heterotopic ossification as well as a large left calcaneal spur and calcification within the plantar fascia (Figure 3), strengthening the impression of heterotopic ossification.

We opted for surgical excision of the left pedal mass. In the surgical theater, the patient was placed in right lateral decubitus under anesthesia. We marked a curvilinear incision overlying the lateral border of the calcaneus and performed a modified lateral approach to the calcaneus, straight to the calcaneal periosteum and bone. The periosteum was incised along the line of the skin incision and was subsequently elevated as a whole tissue flap (Figure 4). The mass was exposed by subperiosteal elevation to minimize trauma to the heel fat pad. The soft tissue covering the mass was bluntly dissected, revealing a discrete, ossified formation with no noted bony connection between the lesion and the calcaneus. Yellowish fluid was noted in between the gaps. Additionally, fibrotic ligamentous tissue was discovered adherent to the lesion. The fibrotic ligament was sharply incised and was removed together with the mass en bloc with wide surgical margins. The surgical site was copiously irrigated, closed in layers, dressed loosely, and immobilized with a short leg splint.

Grossly, the mass was approximately 2.5 x 2.5 x 1.7 cm, solid, firm, composed of skeletal tissue, and encased in a capsule with fluid. Small bony outgrowths on the superior and inferior borders covered with hyaline-like tissue were also noted (Figure 5). The lesion was resected along with the small fibro-muscular tissue attached to the lesion and was sent for biopsy.

An immediate postoperative radiograph showed the absence of the previous calcaneal mass and any residual lesion (Figure 6). At postoperative day two, the surgical site was dry and well-apposed, with minimal redness and reduced swelling, signifying resolving postoperative inflammation. Furthermore, the patient reported eventual loss of pain and noted comfort and ease of movement in all ranges of motion of the left heel. Toe touch ambulation was advised to protect the wound bed temporarily. Fourteen days postoperatively, the wound was well-coaptated with no discharge, erythema, or any visible sign of infection. Minimal pain was noted around the wound (Figure 8). Twenty days postoperatively, the wound was completely healed, and sutures were removed. The patient further demonstrated the ability to stand on heel with comfort and without pain. Histopathology reported, grossly a pale tan bone fragment with attached soft tissue and cartilage, 2.5 x 2.5 x 1.7 cm

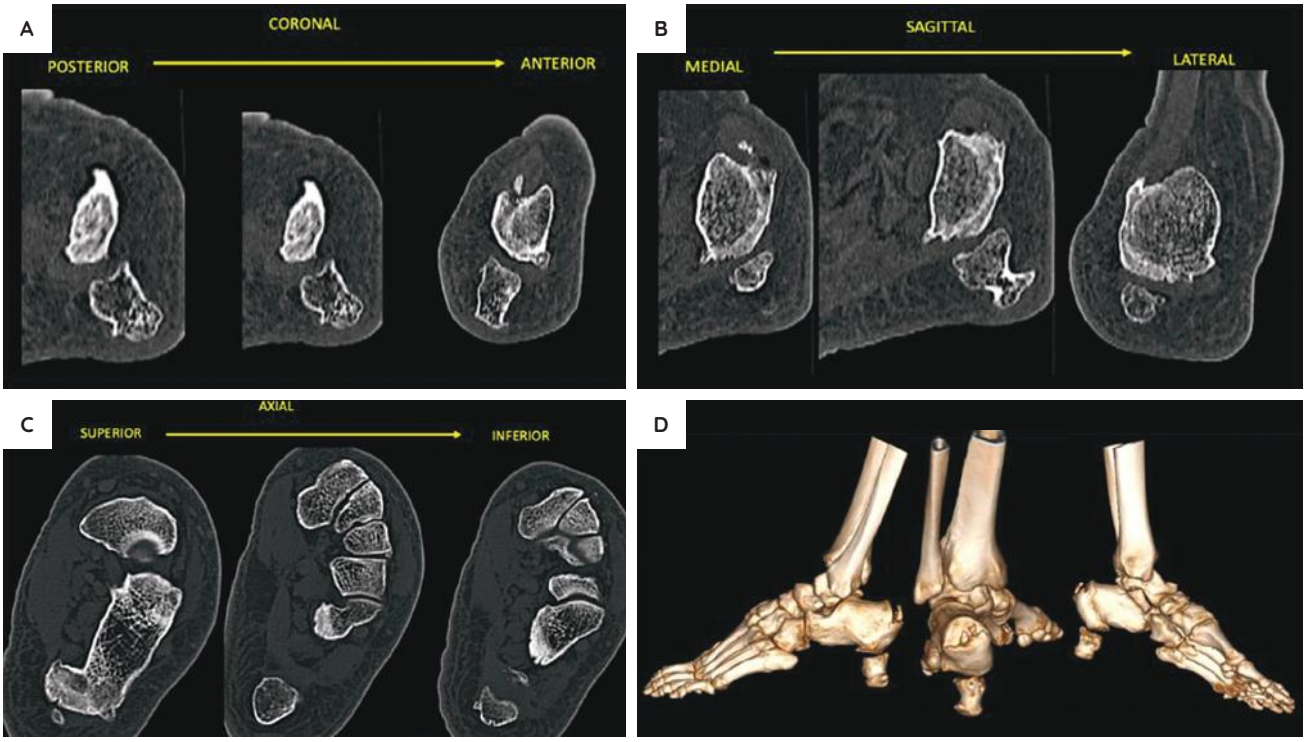

Figure 3. Diagnostic computed tomography scan of the patient's left foot showing coronal plane cuts from posterior to anterior **(A)**, axial plane cuts from superior to inferior **(B)**, sagittal plane cuts from medial to lateral **(C)**, and 3D reconstruction of the foot **(D)**.

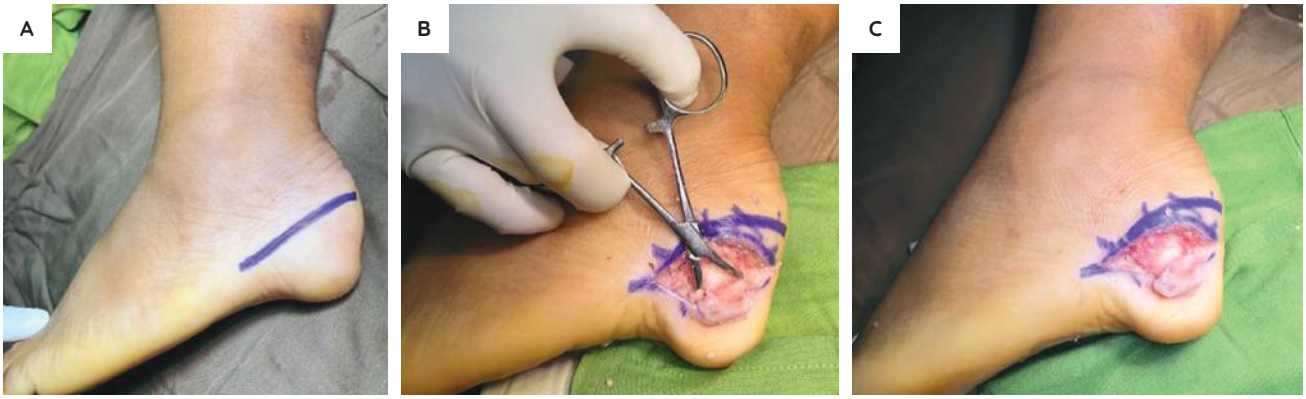

Figure 4. Incision and Exposure showing the marked incision overlying the lateral border of the calcaneus **(A)**, surgical tenaculum grasping the bony outgrowth **(B)**, and exposure of the lesion with the periosteum subperiosteally elevated and incised **(C)**.

in size. On sectioning, the specimen revealed a pale tan, homogenous, solid cut surface. Microscopic examination showed mature lamellar bone admixed with fibrocollagenous connective tissue, cartilaginous tissue, skeletal muscle fibers, and adipose tissue. However, there were no cytologic atypia or pleomorphism suggestive of a neoplastic process (Figure 10). These microscopic findings are suggestive of heterotopic ossification.

DISCUSSION

Heterotopic ossification (HO) is defined as the formation of mature lamellar bone within soft tissues where bone is not normally present, such as muscle, fascia, and adipose tissue.[1,2] Unlike dystrophic calcification, HO represents true ossification with organized lamellar architecture and, in mature stages, may contain marrow elements.[3] Although most commonly reported around large joints such as the hip and elbow, involvement of the foot and ankle has also been documented, including the hindfoot.[4,5]

Acquired HO is thought to arise from aberrant differentiation of mesenchymal progenitor cells in response to local inflammation, tissue injury, or altered microenvironmental signaling, leading to osteogenic activity.[1,6] Bone morphogenetic proteins and other signaling pathways play key roles in promoting endochondral ossification. Common triggers include trauma, surgery, fractures, burns, neurologic injury, and systemic conditions, although idiopathic cases have been reported.[7-10] The condition is broadly classified into acquired and hereditary forms, with acquired cases being more frequent.[11]

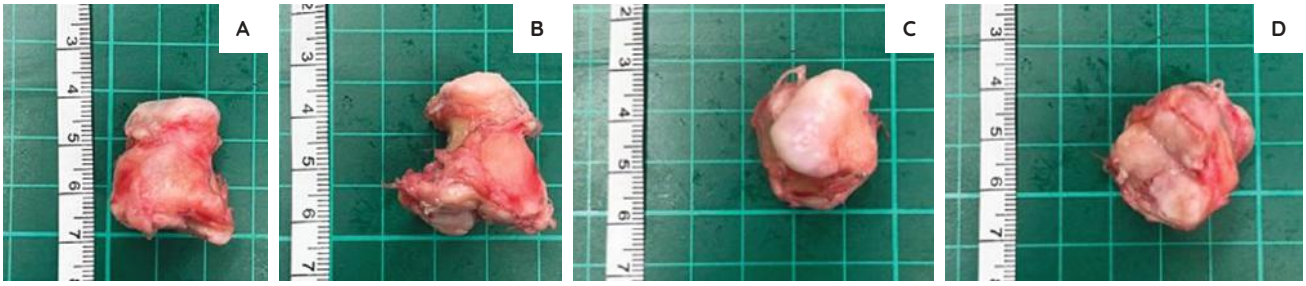

Figure 5. Gross morphological appearance of the excised lesion showing the medial view **(A)**, lateral view **(B)**, inferior view **(C)**, and superior view **(D)** demonstrating that it is discontinuous with the cortex of the calcaneus.

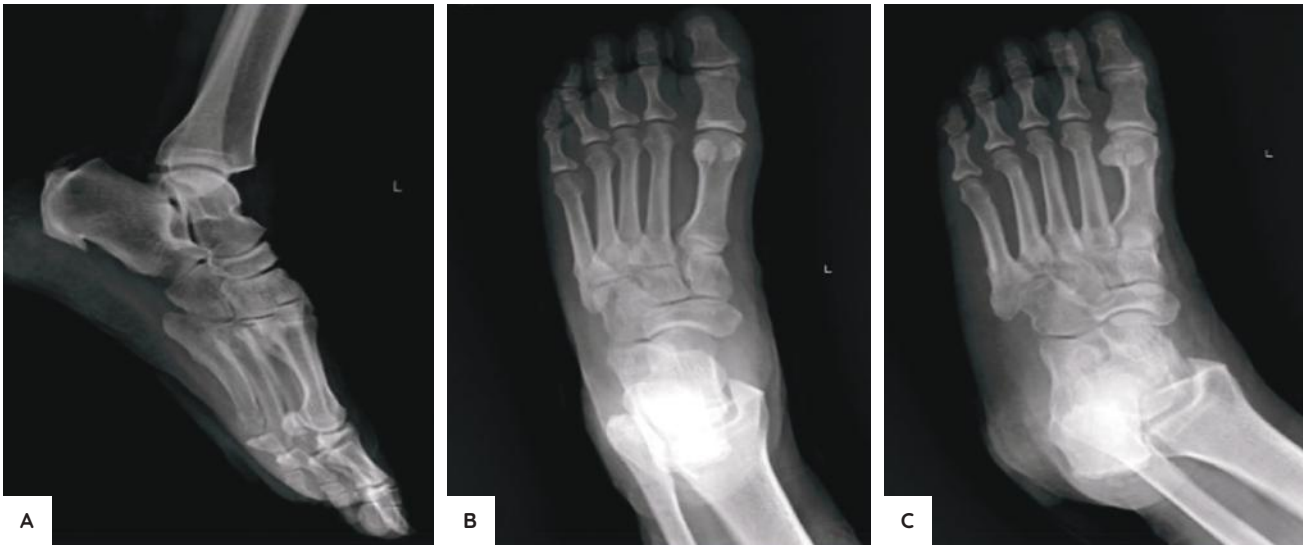

Figure 6. Immediate post-operative foot radiographs showing the lateral view **(A)**, anterior-posterior view **(B)**, and oblique view **(C)**.

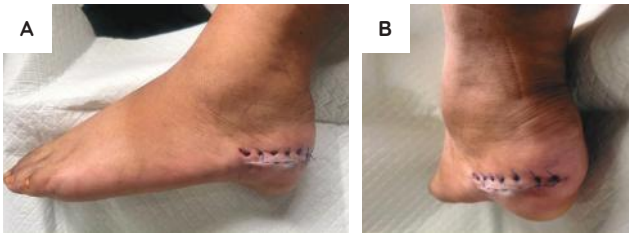

Figure 7. Post-operative Day 1 gross images showing the lateral view **(A)** and posterior view **(B)**.

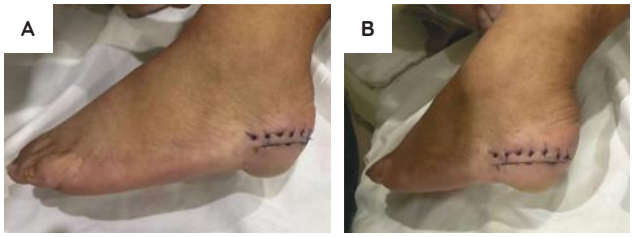

Figure 8. Post-operative Day 14 gross images showing the lateral view **(A)** and posterior view **(B)**.

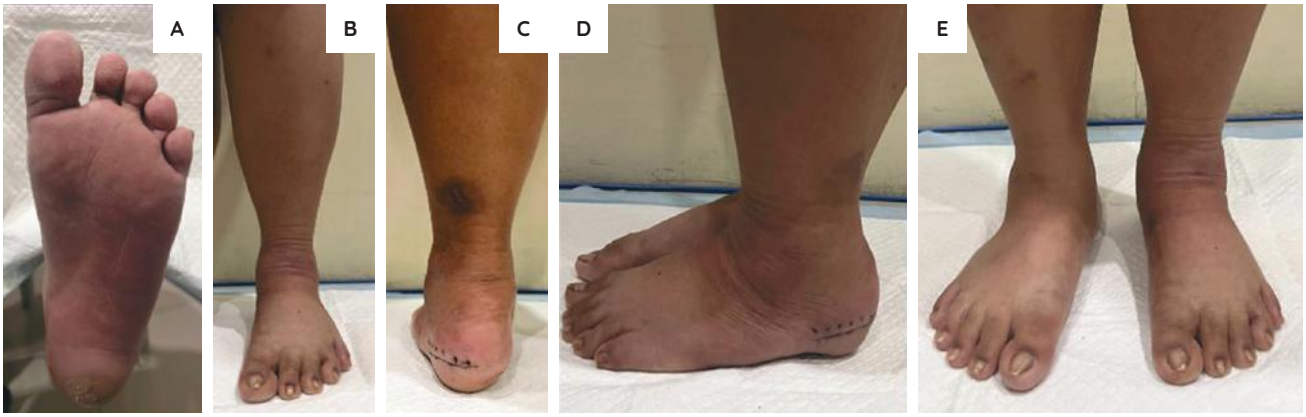

Figure 9. Post-operative Day 19 gross images showing the plantar view **(A)**, anterior view **(B)**, posterior view **(C)**, lateral view **(D)**, and bilateral foot anterior weight-bearing view **(E)**.

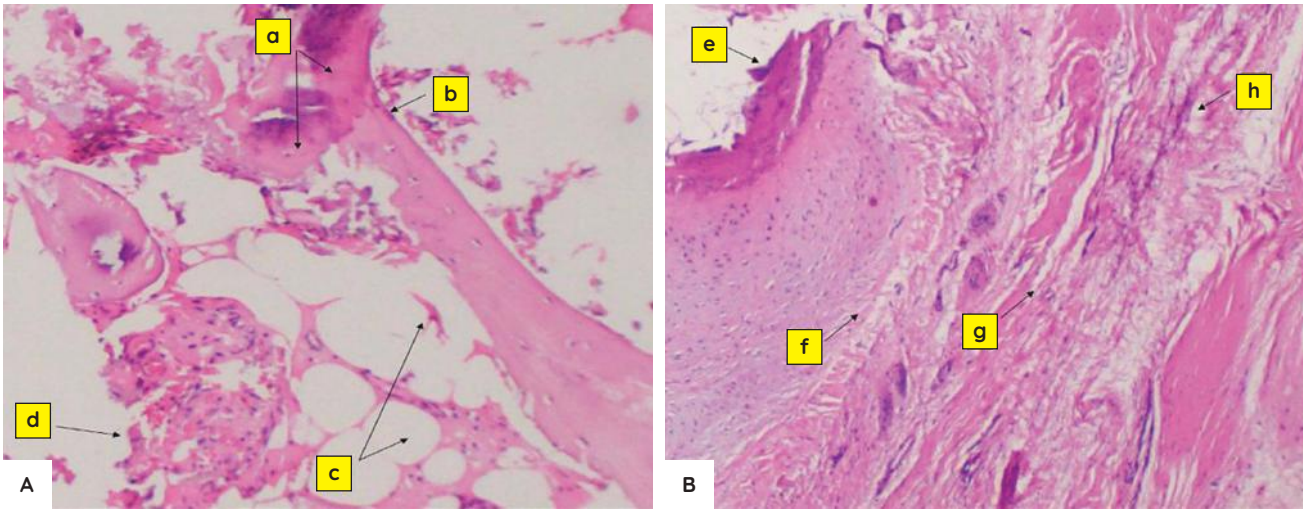

Figure 10. Histopathologic features of the excised plantar heel mass. **(A)** Low-power objective (LPO) showing heterotopic mature compact bone formation (a), prominent osteoblastic rimming (b), surrounding adipose and fibromuscular tissue (c), and areas of granulation tissue (d). **(B)** Scanning power showing zonal architecture identified, including the peripheral zone (outer–most mature) with well-formed lamellar bone and evident osteoblastic rimming (e), the intermediate zone (middle) with osteoid deposition with woven bone formation (f), the central zone (inner–least mature) with spindle-shaped fibroblastic proliferation and fibro-collagenous and fibromuscular tissue (g), and background myxoid stroma with no cytologic atypia or pleomorphism (h).

In this case, HO occurred in the hindfoot without a history of trauma, surgery, neurologic disease, or systemic disorder. Although molecular studies were not performed, the lesion is best classified as acquired HO of uncertain etiology. Repetitive mechanical stress at the plantar heel may have contributed to a localized pro-osteogenic environment due to chronic traction at the plantar fascia enthesis, an area subjected to high biomechanical loading.[1,12] The absence of multifocal lesions and family history makes hereditary HO unlikely.

Radiographically, HO typically demonstrates peripheral ossification with relative central lucency during maturation. Plain radiography is useful once mineralization is established, while computed tomography provides superior delineation of zonal maturation and lesion boundaries. Magnetic resonance imaging may assist in distinguishing HO from malignant soft-tissue tumors in early stages.[4,11,13]

In this case, imaging revealed a well-circumscribed calcified mass separate from the calcaneus, with CT demonstrating peripheral maturation and absence of cortical destruction or aggressive periosteal reaction, findings consistent with mature HO.

Histologically, HO shows characteristic zonal maturation with a central fibroblastic zone and peripheral trabecular or lamellar bone formation.[1] Mature lesions lack cytologic atypia and infiltrative growth, distinguishing them from malignant bone-forming tumors.[3] The present case demonstrated mature lamellar bone within fibrocollagenous, fibrocartilaginous, and adipose tissue without atypia, supporting a benign ossifying process.

The differential diagnosis included myositis ossificans (MO), fasciitis ossificans, soft-tissue osteosarcoma, calcific tendinopathy, and fibro-osseous pseudotumor. MO is a benign fibro-osseous lesion with zonal architecture and is associated with COL1A1::USP6 rearrangements.[14] Although often post-traumatic, it may occur without a clear inciting event. Molecular testing was not performed in this case, limiting definitive exclusion of MO. However, the absence of malignant cytologic features and the overall clinico-radiologic correlation favored HO. Soft-tissue osteosarcoma was unlikely due to the lack of atypia, malignant osteoid, and infiltrative growth. Calcific tendinopathy was excluded based on the presence of organized lamellar bone rather than amorphous calcification.

The presence of a calcaneal spur and plantar fascia calcification suggested that chronic plantar fasciopathy and repetitive traction forces may have contributed to reactive ossification. Mechanical loading at the plantar fascia enthesis is known to be associated with spur formation and may promote a localized osteogenic environment.[15-18]

Surgical excision, with careful preservation of surrounding soft tissues, was performed to treat the progressive pain and functional limitation. The patient had a good postoperative recovery without recurrence, consistent with previously reported successful outcomes in localized HO of the foot and ankle.[4,5]

Overall, this case highlights an unusual presentation of acquired HO in the hindfoot. Diagnosis required integration of clinical, radiologic, and histopathologic findings, and although molecular confirmation was not available, the combined features supported a diagnosis of acquired HO of uncertain etiology.

CONCLUSION

This case demonstrated a rare presentation of heterotopic ossification in the hindfoot without identifiable predisposing factors. Diagnosis was established through careful clinical, radiologic, and histopathologic correlation. Surgical excision proved effective, relieving symptoms and restoring function. The favorable outcome highlights the importance of individualized management in cases with low suspicion for hereditary disease and supports surgical intervention as a safe and definitive treatment for symptomatic, non-genetic HO.

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ETHICAL CONSIDERATIONS

Patient consent form was obtained before manuscript submission.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

JDDC and MCG: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing – original drat preparation, 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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CASE REPORT

Tuberculosis of the Talonavicular Joint: A Case Report

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ABSTRACT

Extrapulmonary, extraspinal tuberculosis is underreported despite being a common presentation of tuberculosis in the Philippines. The ankle and the smaller joints of the foot are infrequent locations of tuberculosis. A 41-year-old female presented with a six-year history of left midfoot swelling, pain, and limited ankle dorsiflexion following trauma. She underwent several wound debridements, with inconclusive biopsy findings. Radiographs showed cortical irregularities with sclerotic changes of the talus and navicular bones, and MRI revealed synovitis with associated bony erosive changes and marrow edema. Debridement, sequestrectomy, and application of antibiotic-laden cement were done. Histopathology revealed caseating necrosis, confirming the diagnosis of tuberculosis. She underwent eight months of antituberculosis therapy. Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) remained normal postoperatively. After two months, the patient underwent removal of antibiotic cement and talonavicular arthrodesis with iliac bone grafting. Follow-up radiographs showed incorporation of the graft with no implant loosening. Patient eventually recovered full weight bearing of the left foot with minimal pain. Diagnosis was difficult due to the insidious onset and non-specific symptoms, delaying treatment and allowing progression of the disease. Antituberculosis therapy (ATT) is the mainstay of treatment of bone tuberculosis, and should be initiated upon diagnosis. Surgical intervention depends on the extent of bony destruction and joint instability.

Keywords. extrapulmonary tuberculosis, talonavicular joint

INTRODUCTION

Tuberculosis (TB) is a chronic infectious disease caused by the bacteria *Mycobacterium tuberculosis*, affecting approximately ten million people worldwide annually. As of 2016, the Philippines remains among the top 20 countries with the highest TB burden, with an estimated 760,000 people affected of its population of 107 million.[1,2]

Pulmonary TB is the most common presentation, with extrapulmonary TB seen in only 1–15% of cases.[1,3,4] Of the extrapulmonary cases, tuberculous spondylitis is the most common form, accounting for approximately 50% of cases, while extraspinal musculoskeletal TB is among the least common manifestations of TB.[5] TB of the foot and ankle is uncommon in literature, with only 8% to 10% of the patients having osteoarticular tuberculosis, representing approximately only 0.1% to 0.3% of all patients with extrapulmonary disease.[6] In the foot and ankle, the ankle joint and the calcaneus are the most frequently affected, representing 25% and 22% of the cases, respectively. The talonavicular joint is rarely involved, although cases may also be underreported.[7] We now present a case of an adult female with a rare presentation of tuberculosis of the talonavicular joint.

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CASE

A 41-year-old female office worker presented with a history of chronic pain and swelling of the left foot. Six years before the consultation, a heavy object fell on her left midfoot, resulting in pain and swelling but no open wounds. She consulted a doctor and was managed conservatively. After a few months, due to persistent symptoms, she consulted at the local hospital, where an MRI revealed a mass on the dorsomedial aspect of the left foot. The patient underwent excision biopsy of the mass. The specimen was submitted for culture and histopathological examination, which turned out negative for infection or neoplasm. After the procedure, poor healing of the post-biopsy site was noted, requiring constant dressing and wound care. She eventually noted cheesy, semi-solid discharge from the wound. The patient consulted with an infectious disease specialist, where she was started on anti-Koch's medications for six months: two months of intensive phase with isoniazid (H), rifampicin (R), pyrazinamide (Z), and ethambutol (E), then four months of continuation phase with HR. Despite treatment and wound care, there was persistent pain and non-healing of the wound.

Patient eventually sought a second opinion, eight months after the index surgery. A repeat wound debridement and biopsy were performed. The specimen was submitted for culture and histopathology, which, according to the patient, were negative for infection or neoplasm. The patient was treated with un-recalled antibiotics for one month. During the interim, the post-op site healed with on-and-off pain and swelling on the midfoot, which were tolerable.

The patient noted increasing severity of pain in the left midfoot on ambulation and range of motion for a year, which prompted an initial consult at our institution. The patient did not present with fever, weight loss, chronic cough, or constitutional signs.

On physical examination, there was swelling on the dorsum of the left midfoot with a hyperpigmented, healed post-biopsy scar on the medial malleolar aspect (Figure 1). There was no noted erythema, warmth, or open wound. Plantarflexion was full, but dorsiflexion was limited due to pain.

Plain radiographs revealed cortical irregularities with sclerotic changes of the talus and navicular bones, along with arthritis of the talonavicular joint (Figure 2). T2-weighted MRI revealed a lobulated fluid signal abnormality with intermediate signal intensity in the talonavicular joint, indicative of synovitis with associated bony erosive changes and reactive marrow edema of the talar head and navicular (Figure 3).

The patient underwent debridement, sequestrectomy, and application of antibiotic bone cement of the talonavicular joint. No cheese-like material was seen intraoperatively. Friable fragments of the talus and navicular bones were submitted for Gram stain and culture studies, KOH, AFB smear, and MTB PCR (GeneXpert), which yielded negative results. Histopathology revealed chronic granulomatous inflammation with caseation necrosis. The patient started another antituberculosis treatment regimen comprising two months HRZE, followed by two months HRE, then four months HR.

During the interim, the patient was compliant with non-weight-bearing with no untoward wound complications. Patient was readmitted after two months for removal of antibiotic spacer and talonavicular arthrodesis via lag screw fixation with iliac bone grafting for the definitive treatment (Figure 4). Intraoperatively, we saw no gross purulence but noted cheesy material upon curetting the lateral navicular. Specimens, including talonavicular joint curettings and navicular bone chips, were obtained intraoperatively and submitted for Gram stain and culture studies and MTB-PCR. This time, MTB-PCR revealed positive results while Gram stain and culture studies yielded no growth. The patient was maintained on a short leg posterior mold and allowed gentle ROM for four weeks. At six weeks post-operatively, radiographs noted no signs of implant loosening or peri-implant lucencies. Weight bearing was progressed with a walking boot and assistive device. Full weight bearing without a boot was allowed four months post-operatively, with follow-up radiographs showing graft incorporation (Figure 5).

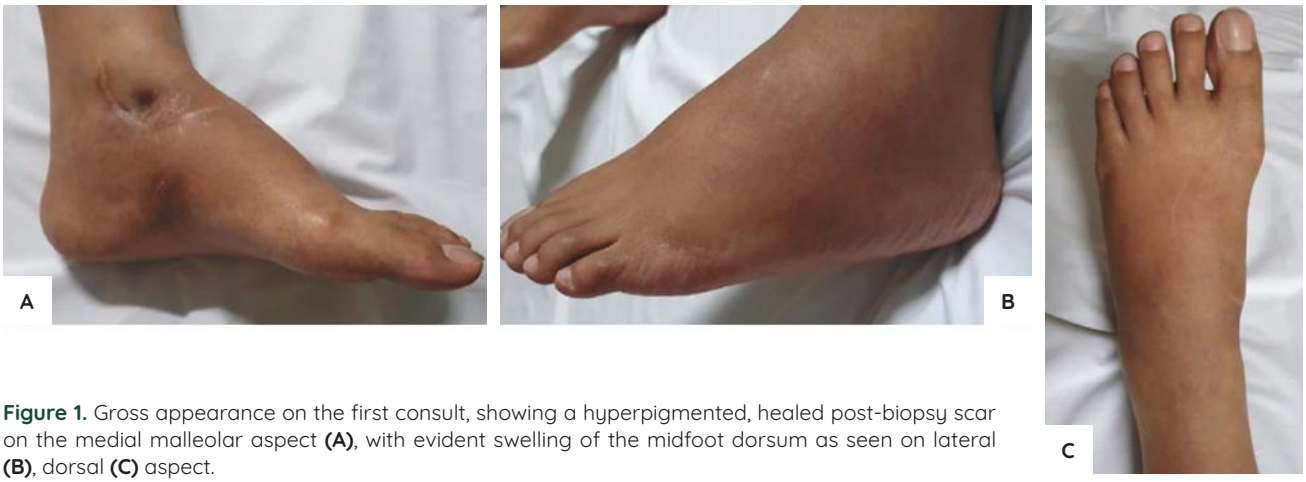

Figure 1. Gross appearance on the first consult, showing a hyperpigmented, healed post-biopsy scar on the medial malleolar aspect **(A)**, with evident swelling of the midfoot dorsum as seen on lateral **(B)**, dorsal **(C)** aspect.

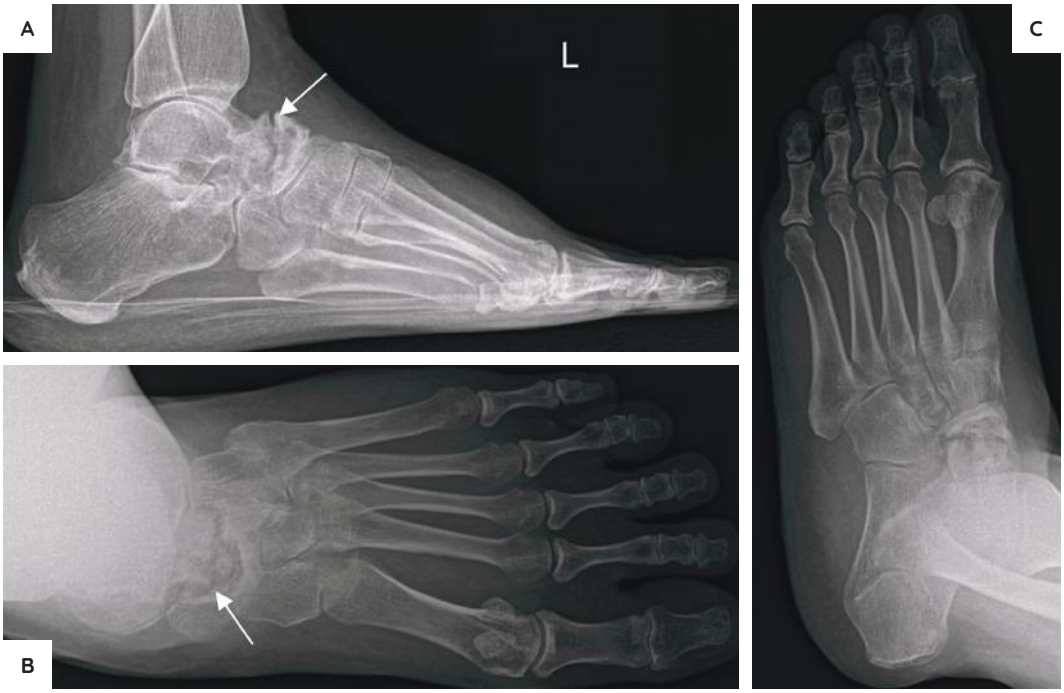

Figure 2. Preoperative radiographs [lateral view **(A)**, anterioposterior view **(B)**, oblique view **(C)**] of the left foot 'showing cortical irregularities with sclerotic changes *(white arrows)* of the talus and navicular bones with apparent narrowing of the talonavicular joint.

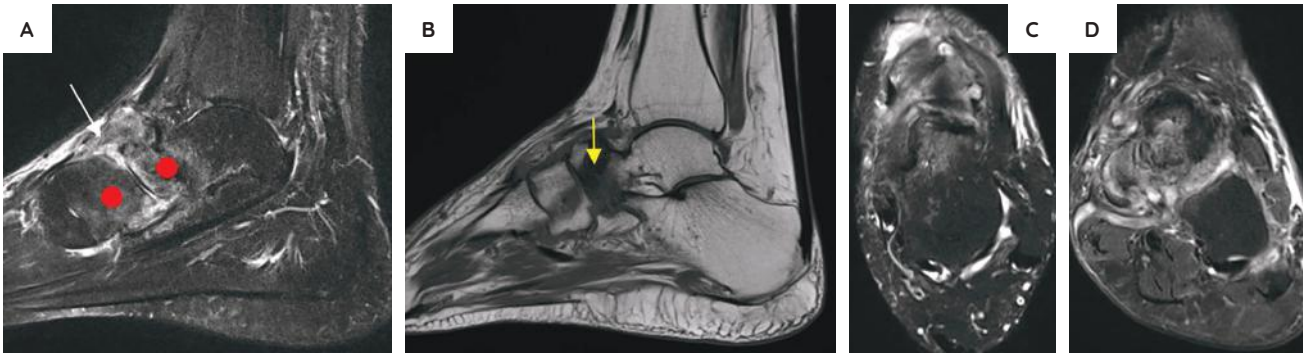

Figure 3. Magnetic resonance imaging of the left foot. T2-weighted sagittal image **(A)** demonstrating diffuse joint effusion *(white arrow)* and marrow edema *(red dots)*; T1-weighted sagittal image **(B)** demonstrating cortical destruction *(yellow arrow)*; T2-weighted axial **(C)** and coronal **(D)** images further demonstrating the talar head and navicular abnormalities.

DISCUSSION

Extrapulmonary, extraspinal tuberculosis is an uncommon presentation of tuberculosis, with an even more uncommon presentation in the foot, with a reported incidence of 3% among bone tuberculosis cases.[8] The tarsal joints and calcaneus are the two most common lesion sites, but navicular and cuneiform tuberculosis are extremely rare.[9] The insidious course and non-specific presentation make diagnosis and detection difficult, often at a more advanced stage.[10]

Upon review of the literature, the authors were able to identify only a total of three cases of isolated osseous tuberculosis involving the talonavicular joint (Table 1). Of these, the majority were females, while the ages ranged from as young as nine to as old as 43 years.

Diagnosis of osteoarticular tuberculosis of the foot and ankle is relatively difficult compared with other presentations of extrapulmonary tuberculosis, such as in the spine and hips. The delay in diagnosis is often due to difficulties in isolating the organism and differentiating the disease from other diseases that TB can mimic, such as osteoarthritis, pyogenic osteomyelitis, fungal osteomyelitis, or bone tumor.[11,12] In our literature review, all cases presented with chronic pain of at least four months, with associated swelling and limited range of motion due to pain. Clinical presentations of talonavicular TB were similarly insidious and non-specific.

Hematologic tests such as erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) are non-specific but commonly used to monitor response to treatment. In a study of extrapulmonary TB, 15.5% and 26.8% presented with

normal CRP and ESR levels, respectively.[13] In other studies, two of three cases show a slight elevation of ESR and CRP. Our patient presented with normal values.

Preoperative imaging, such as radiographs, demonstrated signs of osteopenia, erosive changes of the bone and joint, and soft tissue swelling. These findings are consistent with chronic or ongoing bone infection; however, these findings are not specific to tuberculosis. MRI can reveal marrow edema, joint effusion, and bone or cartilage destruction on T1 and T2 weighted images, as seen in our case, which are suggestive of inflammation, but are not specific to tuberculosis.[9]

Our diagnosis was made based on the histopathologic report from samples taken during debridement. In the literature review, all cases confirmed the diagnosis of tuberculosis through histopathologic findings consistent with tuberculosis and yielded positive cultures of Mycobacterium tuberculosis. Histopathology and demonstration of Acid-Fast Bacilli (AFB) either by Ziehl-Nielsen staining or culture is the gold standard in diagnosing musculoskeletal tuberculosis.[14] MTB-PCR assays, like the Xpert MTB/RIF and Xpert Ultra, show faster yield with high specificity (95–100%) comparable with culture and AFB staining, but variable sensitivity (75–85%).[15] Diagnosis confirmed via culture or MTB-PCR should be established before initiating anti-tuberculous therapy.[16]

Antituberculous therapy (ATT) remains the mainstay of treatment of bone tuberculosis, and should be initiated upon diagnosis.[8,9,11] Literature presents varying regimens and

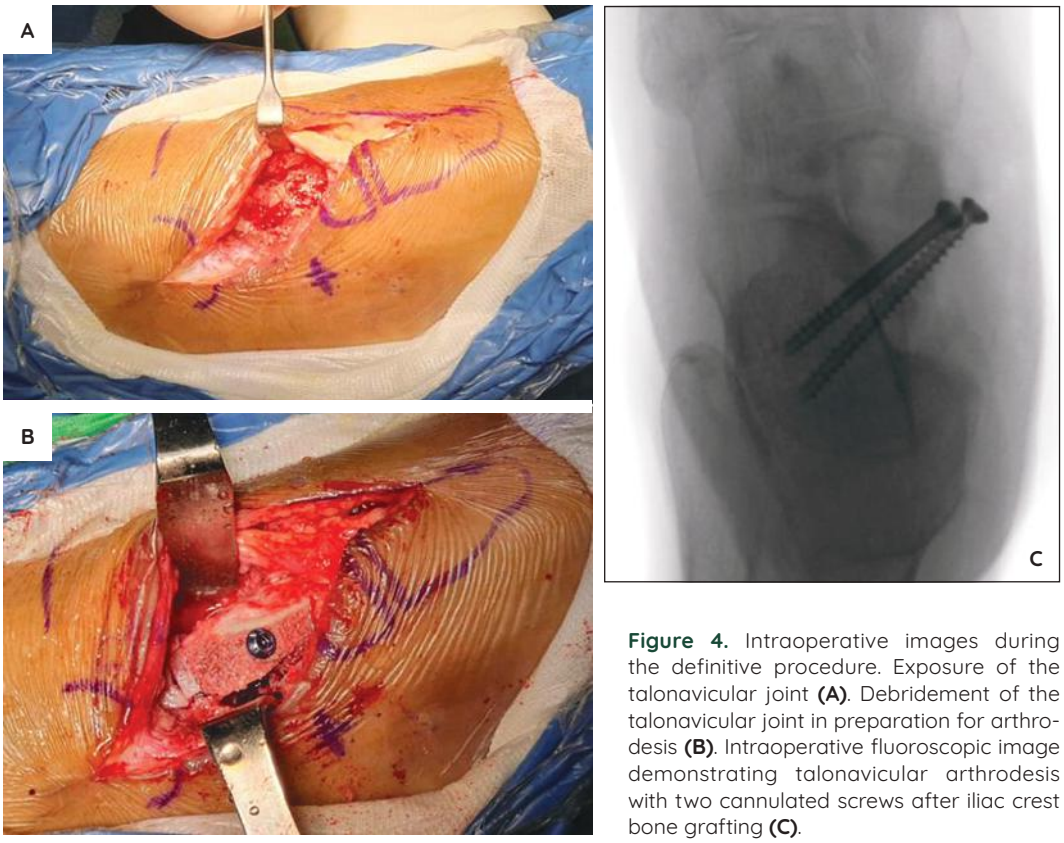

Figure 4. Intraoperative images during the definitive procedure. Exposure of the talonavicular joint **(A)**. Debridement of the talonavicular joint in preparation for arthrodesis **(B)**. Intraoperative fluoroscopic image demonstrating talonavicular arthrodesis with two cannulated screws after iliac crest bone grafting **(C)**.

Table 1. Summary of literature of talonavicular joint tuberculosis

Author / Year Published	Demographic	Presentation	Duration of symptoms	Tests	Radiographs	Final Diagnosis	Surgery	ATT
Present Study	41F	Pain, swelling	6 years	Normal ESR and CRP	Cortical irregularities with sclerotic changes	Positive biopsy and MTB-PCR	Sequestrectomy, antibiotic bone cement, bone grafting	HRZE 2 months, HRE 2 months, HR 4 months
Faizan 2017	9M	Swelling, pain, limited ROM	6 months	Elevated ESR, CRP	Diffuse osteopenia, marginal erosion, soft tissue prominence	Needle biopsy; positive culture	None	HRZE 4 months, HR 1 year
Kapetanakis[12] 2018	43F	Swelling and pain, limited ROM	4 months	-	Osteitis and arthritis	Positive culture, bone biopsy	None	HRZE 2 months, HR 4 months
Brew 2010	41F	Pain, swelling, tenderness, limited ROM	7 months	Elevated ESR	Periarticular osteopenia, narrow TN joint	Open biopsy, positive culture	None	RE 12 months

TN, talonavicular joint; ATT, antituberculous therapy; H, isoniazid; R, rifampicin; Z, pyrazinamide; E, ethambutol; S, streptomycin

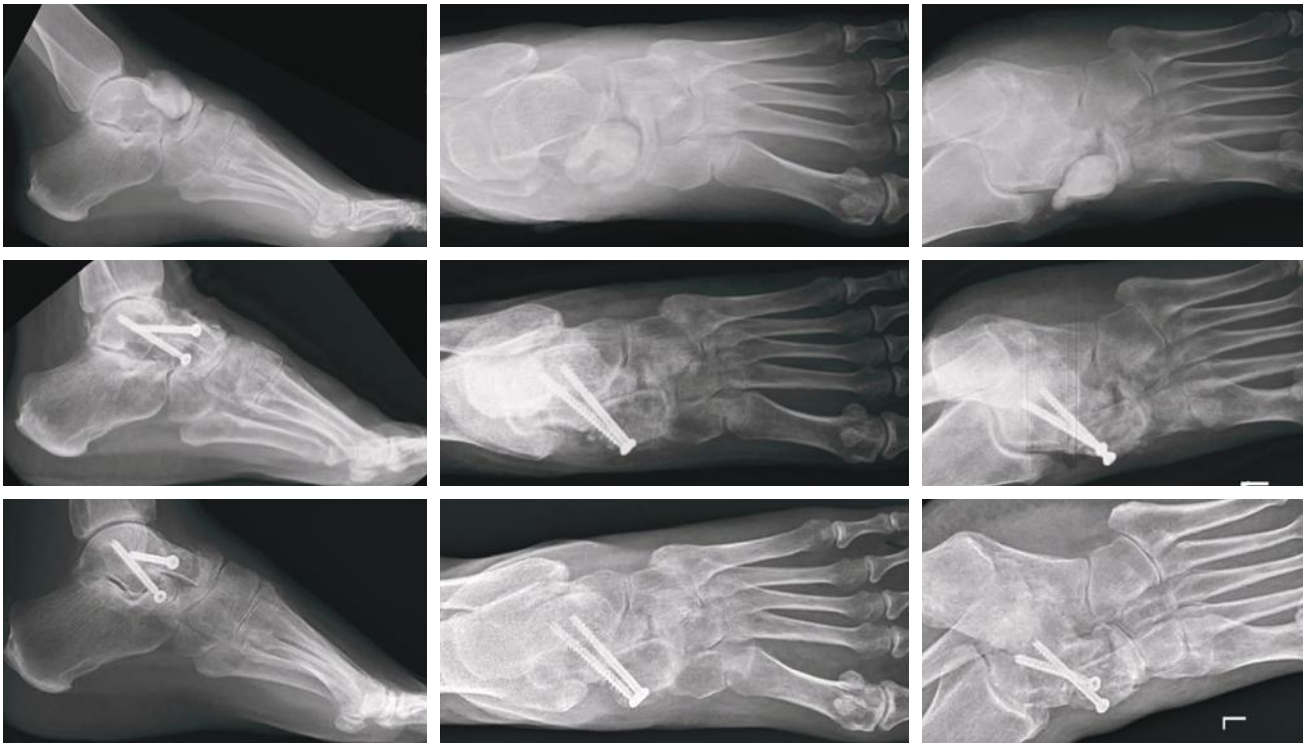

Figure 5. Comparative radiographs of the affected foot in lateral *(left)*, anteroposterior *(center)*, and oblique *(right)* views. **Top row:** Radiographs after the index surgery demonstrating persistent talonavicular joint destruction. **Middle row:** Immediate post-operative radiographs following definitive talonavicular arthrodesis with screw fixation. **Bottom row:** Radiographs at 4-month follow-up demonstrating maintained alignment, stable hardware, and progressive osseous fusion across the arthrodesis site.

durations of anti-TB medications, with three of six studies employing an initial high intensity phase with isoniazid (H), rifampicin (R), ethambutol (E), and pyrazinamide (Z) for two to four months, and a maintenance phase with isoniazid and rifampicin for six to 18 months. Related literature recommended extended treatment with ATT for bone and musculoskeletal TB.[17] In the Philippine setting, the disease treatment regimen for newly diagnosed extrapulmonary TB involving bones and joints consists of two months HRZE and ten months of HR.[16]

The decision for surgery depends on the severity of clinical and radiographic presentation. Resection and curettage of sequestered bone can be done for non-healing lesions.[11] Local infection control and immediate mechanical stability can be achieved by placing a temporary antibiotic-laden cement spacer.[18] Surgery could take the form of a biopsy when the diagnosis is uncertain, debridement for severe cases or poor response to therapy, or resection with or without arthrodesis for deformity or arthritis.[19] The decision to do arthrodesis is dependent upon the extent of bony destruction and instability.[18]

CONCLUSION

Tuberculosis of the talonavicular joint is a rare presentation of a prevalent infectious disease in the Philippines. The difficulty in diagnosis is attributed to its insidious onset and non-specific presentation, which can result in treatment delay and disease progression. Although uncommon, tuberculosis should always be a differential in cases of chronic ankle and foot pain.

ETHICAL CONSIDERATIONS

Patient consent was obtained before manuscript submission.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

DMC: Conceptualization, Methodology, Software, Validation, Formal Analysis, Investigation, Resources, Data Curation, Writing – original draft preparation, Writing – review and editing, Visualization, Project administration, Funding acquisition; **LEA:** Conceptualization, Methodology, Fornal analysis, Writing – review and editing, Visualization, **HMC:** Conceptualization, Methodology, Writing – review and editing, Visualization, Supervision, Project administration; **JRP:** Writing – review and editing, Visualization, Supervision.

DATA AVAILABILITY STATEMENT

No datasets were generated or analyzed for this research.

AUTHOR DISCLOSURE

The authors declared no conflict of interest.

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CASE REPORT

Early Outcomes of Staged Combined Halo-Pelvic Traction and All-Posterior Kyphectomy for Severe Kyphotic Deformity

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ABSTRACT

Severe kyphotic deformity is one of the sequelae of tuberculosis of the spine. When left untreated, patients may develop restrictive lung and heart disease and even neurologic deficits. Surgery is complex and risky, especially in young children. Halo-pelvic traction is a technique reported to decrease complexity, blood loss, operative times, and complication rates of definitive fixation of severe deformities; however, the technique has not been used locally.

This is a case report on a 6-year-old with severe kyphotic deformity secondary to tuberculosis of the spine. The aim was to provide novel insights into the design and application of the halo-pelvic traction construct, combined with an all-posterior surgical technique to achieve deformity correction.

The halo-pelvic traction was able to achieve 26 degrees (35.13%) correction over 35 days with an average daily angular correction of 0.72 degrees per day and daily lengthening at 1.52 mm per day. The patient was able to ambulate with assistance at two weeks and ambulate without assistance at three weeks on the traction construct. At six weeks, vertebral column resection and definitive fixation through an all-posterior approach were done with final angular correction of 49 degrees (66.21%). The halo-pelvic construct was maintained as an adjunct to fixation and was maintained until fusion.

The combined two-staged approach of halo-pelvic traction and vertebral column resection through an all-posterior approach has proven to be effective in this pediatric patient with severe kyphotic deformity.

Keywords. kyphosis, spine, tuberculosis, halo-pelvic traction, traction, external fixators, child

INTRODUCTION

The spine is the most commonly affected site in skeletal tuberculosis, accounting for approximately 50% of cases.[1] When left untreated, tuberculosis eventually destroys anterior vertebral bodies, leading to kyphosis. As many as 40% of kyphotic deformities in children worsen over time. In children, growth potential also increases the risk for progression of the deformity due to the crankshaft phenomenon.[2]

Severe kyphotic deformity in very young patients presents a significant challenge. When neglected, the deformity may limit thoracic cavity volume and diaphragmatic excursion, resulting in compromised ventilation. Patients may also develop right ventricular hypertrophy and failure as a consequence of long-standing hypoxemia and pulmonary hypertension.[3] Neurologic deficits can present in up to 41% of patients with tuberculosis of the spine in severe deformities.[4] Symptoms may manifest initially as pain, numbness, and a subtle change in gait, and later progress to quadriplegia and loss of bowel and bladder control.[2]

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A multi-drug treatment regimen under direct supervision remains the standard of care in treating tuberculosis. Surgery is performed on patients with kyphosis more than 60 degrees and in pediatric patients with "spine-at-risk signs."[2,5]

Management of severe kyphotic deformities can be complex and risky, especially in young children. In children, instrumentation is possible but challenging. Vertebral bodies remain mostly cartilaginous until secondary ossification begins at puberty. The pedicles are small, and the potential length of screws may be short, limiting purchase.[6] Cases that require long posterior fusion are also at risk of the crank-shaft phenomenon due to the remaining growth potential.[7]

Recent techniques focus on a single-staged approach for acute correction. However, this approach entails complex osteotomies and acute deformity correction while working around an exposed spinal cord. This is accompanied by the risk of neurological, vascular, and pulmonary complications in up to 40% of patients.[8] Several traction techniques have been developed to promote gradual improvement in the deformity before definitive fixation and reduce complications, complexity, blood loss, and operative time.[9-15] With gradual correction of the deformity, the spinal cord, its blood supply, and other soft tissues are able to adapt.

The halo-pelvic traction and halo-gravity traction are techniques described in the literature. While both techniques are able to correct deformities and decrease complications, a recent study by Zhou determined that halo-pelvic traction was able to achieve more deformity correction over a shorter duration and decrease the need for a three-column osteotomy while having no significant difference in complication rates compared to halo-gravity traction.[14]

There are limited studies on its use in young children. Thus, this case report aimed to describe the development of the construct, the surgical technique, and the short-term radiological and clinical outcomes of halo-pelvic traction in the management of severe kyphotic deformity from spine tuberculosis in a 6-year-old.

CASE

We present the case of a 6-year-old boy (height 89.5cm, weight 13.2 kg (Z < -3, WHO), BMI 16.5 kg/m^2) with a four-year history of gradually progressing back and chest deformity (Figure 1). One year before consultation at the orthopedic outpatient department, the patient had a cough and fever and was diagnosed as a case of presumptive tuberculosis, but he was not started on anti-Koch's therapy. He developed an

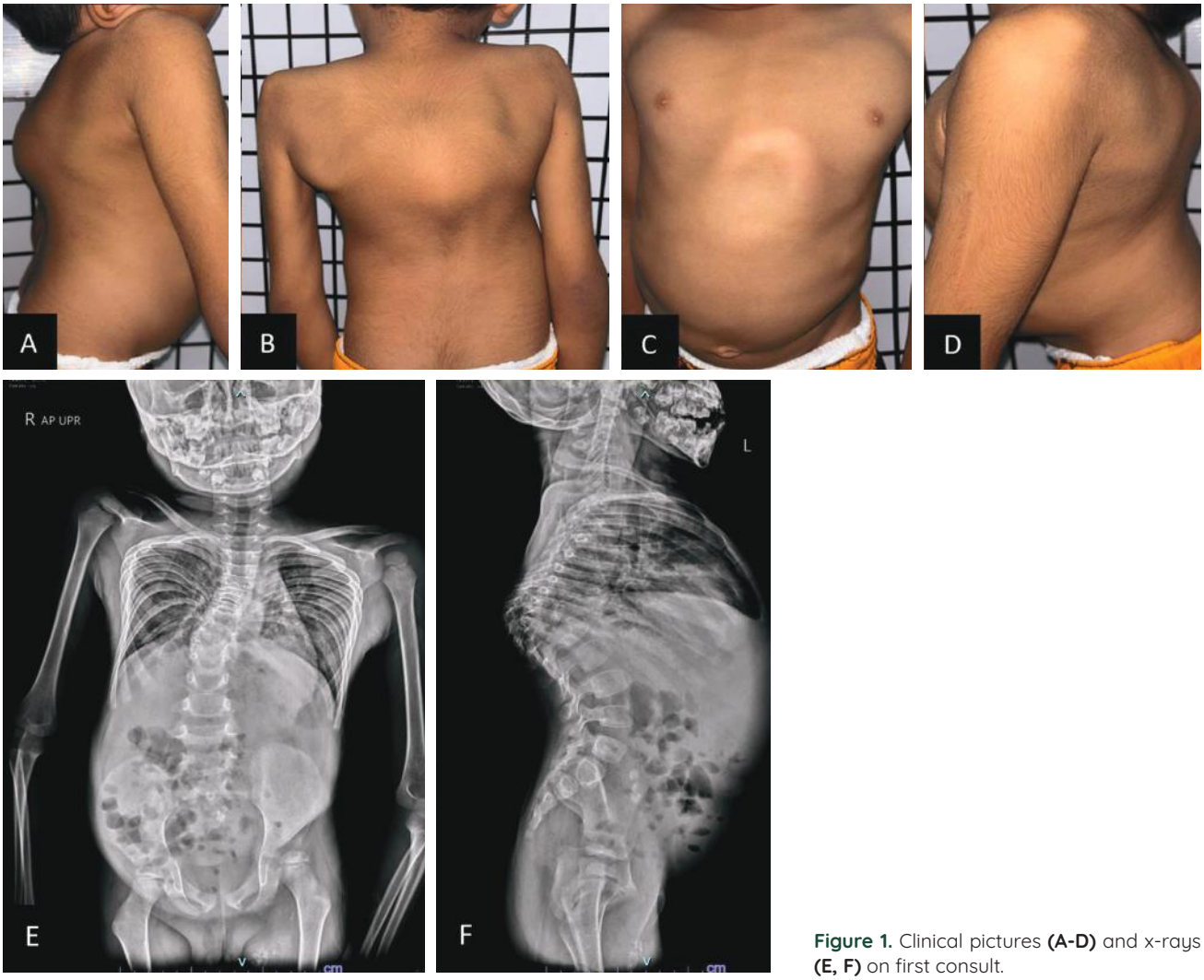

Figure 1. Clinical pictures **(A-D)** and x-rays **(E, F)** on first consult.

Figure 2. Halo-pelvic traction construct assembled prior to surgery.

abscess on the left proximal thigh and underwent incision and drainage. He was then started on anti-Koch's regimen and was referred to our service for a severe kyphotic deformity at the thoracolumbar junction. The patient had no sensory and motor deficits, was normoreflexive, and ambulatory without aid. He had 74 degrees of kyphosis at the thoracolumbar junction, which improved to 53 degrees while lying supine. He had no available MRI. Infection parameters done at three months of anti-Koch's therapy (CBC, ESR, and CRP) were within normal values. Nutritional parameters (albumin, calcium, and vitamin D) were also within normal values. During spirometry, he had difficulty sustaining breaths due to poor respiratory effort.

The halo-pelvic traction construct was designed by one of our co-authors (GCB) (Figure 2). This consisted of a halo ring measuring 18 cm in diameter, a pelvic ring and a dummy ring both measuring 26 cm in diameter, and connecting rods. Pins were used to fix the halo ring to the cranium and ilium. The dummy ring at the level of the xiphoid process was floating and served to reduce the vertical offset of the construct to provide better stability while lengthening. The construct was pre-assembled into anterior and posterior halves a few days before surgery for ease of application during the procedure. The construct weighed 2.6 kg, which was 21% of the patient's body weight.

With the patient supine under general anesthesia, the halo ring was applied to the cranium with 8 pins at 6 lbs torque. The pin configuration was adapted from Cetinkaya et al.[15] For the anterior construct, two pins were applied laterally at the supraacetabular level, and two pins were applied 30 degrees from the coronal plane at the anterior superior iliac spine (ASIS). These were attached to the halo ring with connecting rods. The patient was then flipped prone. For the posterior construct, two pins were applied 20 degrees from the midline at the posterior superior iliac spine (PSIS) and attached to the halo ring with connecting rods (Figure 3). Immediately after application of the construct, the kyphotic angle was measured at 68 degrees. No acute correction was done at this stage.

One day after application of the halo-pelvic traction, the patient reported good pain control and was able to sit up (Figure 4). Distraction was initiated on day two, initially at a rate of 3 mm per day. However, the patient was unable to

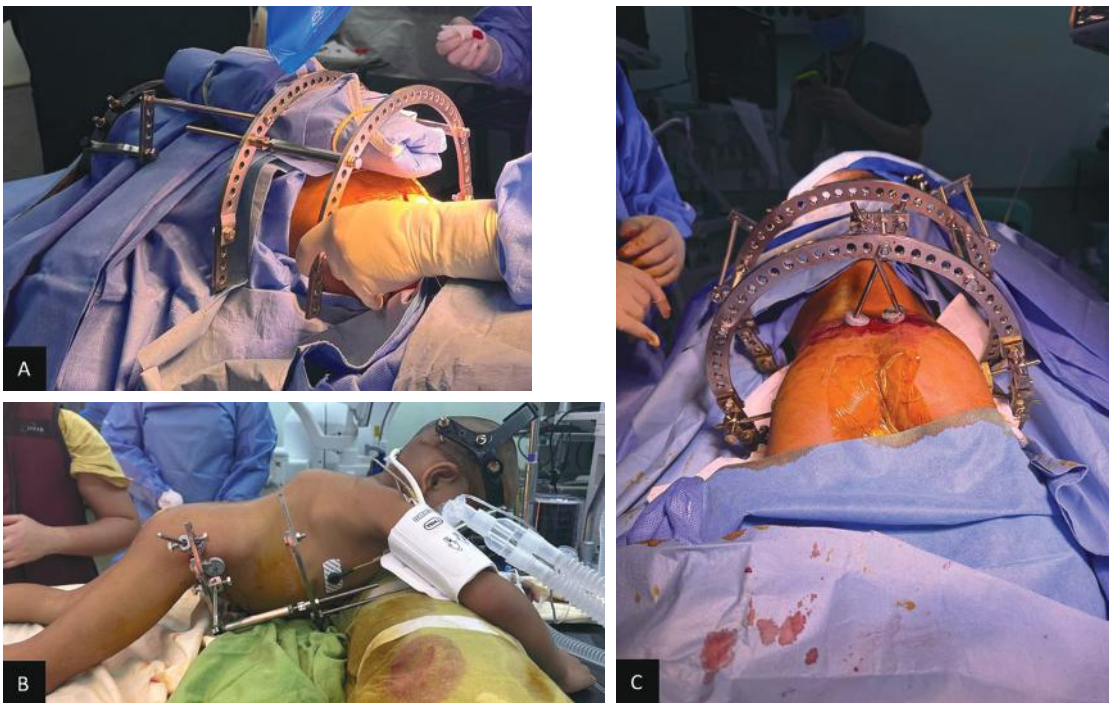

Figure 3. The anterior construct was connected to the halo ring. Pins were inserted at the supraacetabular area and anterior superior iliac spine **(A)**. The patient in prone position with multiple pillows for padding **(B)**. The posterior construct was connected to the halo ring and pins inserted at the posterior superior iliac spine **(C)**.

Figure 4. Patient was able to sit up one day after application of the halo-pelvic traction **(A-C)**. Patient lying down in bed **(D)**.

tolerate distraction due to pain in the pelvis, hence the rate of distraction was decreased to 1.5 mm per day.

The patient remained admitted throughout the course of treatment for monitoring. He received daily body baths with chlorhexidine and daily pin tract care with povidone iodine. In the second week, a superficial pin tract infection developed on the right supraacetabular pin, which resolved after taking antibiotics. He underwent physical therapy for general conditioning, strengthening, deep breathing exercises, and incentive spirometry. Nutritional upbuilding and calcium supplementation were also done. The patient was able to ambulate with minimal assistance at two weeks (Figure 5. A-D) and was able to ambulate without assistance at three weeks (Figure 5. E-G). Serum calcium, albumin, and vitamin D levels were within normal range.

Weekly radiographs were taken to monitor correction, similar to the monitoring interval of Cetinkaya et al (Figure 6). A plain thoracolumbar CT scan done three weeks post-application revealed lysis of vertebral bodies from T5 to L1, with intact posterior structures (Figure 7). At 35 days postop, we measured a kyphotic angle of 48 degrees, angular correction of 0.72 degrees per day, and lengthening of 1.52 mm per day.

Definitive fixation was done at six weeks postoperatively due to plateauing distraction. Intraoperative neuromonitoring (EMG, MEP, and SSEP) and O-arm navigation were utilized (Figures 8 to 10). Through an all-posterior approach, 4.0 mm screws were inserted at T4 and T5 pedicles bilaterally, and 5.0 mm screws were inserted at L1 and L2 pedicles bilaterally. The T6 to T12 nerve roots were sacrificed on the right side for anterior access. To avoid vascular compromise, nerve roots were identified through neuromonitoring to make sure that only nerves were cut and blood vessels were spared. Vertebral column resection was done by removing the remnants of the T6 to T12 vertebral bodies. Scanty caseous material was seen around the remnants of the vertebral bodies and sent for cultures and histopathology. An expandable cage was inserted anteriorly, and bone graft was applied generously prior to closure. There were no changes in the intraoperative neuro-monitoring signals throughout the procedure aside from the irritation after nerve root ligation. After definitive

fixation, the kyphosis angle was measured at 25 degrees. The halo-pelvic construct was maintained as an adjunct to the fixation until fusion.

Postoperative pain was well-controlled with gabapentin and fentanyl patient-controlled anesthesia. He had no new onset weakness or numbness in both lower extremities. He had abdominal pain partially relieved after a bowel movement. He could tolerate high back rest for feeding and was able to tolerate ambulation on day four after definitive surgery (Figure 11). He remained admitted for two more weeks for physical therapy with the goals of general conditioning and gait retraining. Cultures showed no acid-fast bacilli while histopathology revealed fibroosseous tissues with chronic granulomatous inflammation, Langhans-type giant cells, and caseation necrosis.

The patient was seen at the clinic monthly after discharge. He was ambulatory, with no complaints of pain. He developed a superficial pin tract infection at the right hip, which improved with pin tract care and a one-week course of oral antibiotics. X-rays showed no implant loosening or subsidence (Figure 12). At 12 weeks, x-rays showed fusion at the operative site. A CT scan would have been ideal to monitor screw and cage placement. However, as the patient had extensive radiation exposure from the preoperative CT scan and intraoperative O-arm, the team decided to do x-ray monitoring instead.

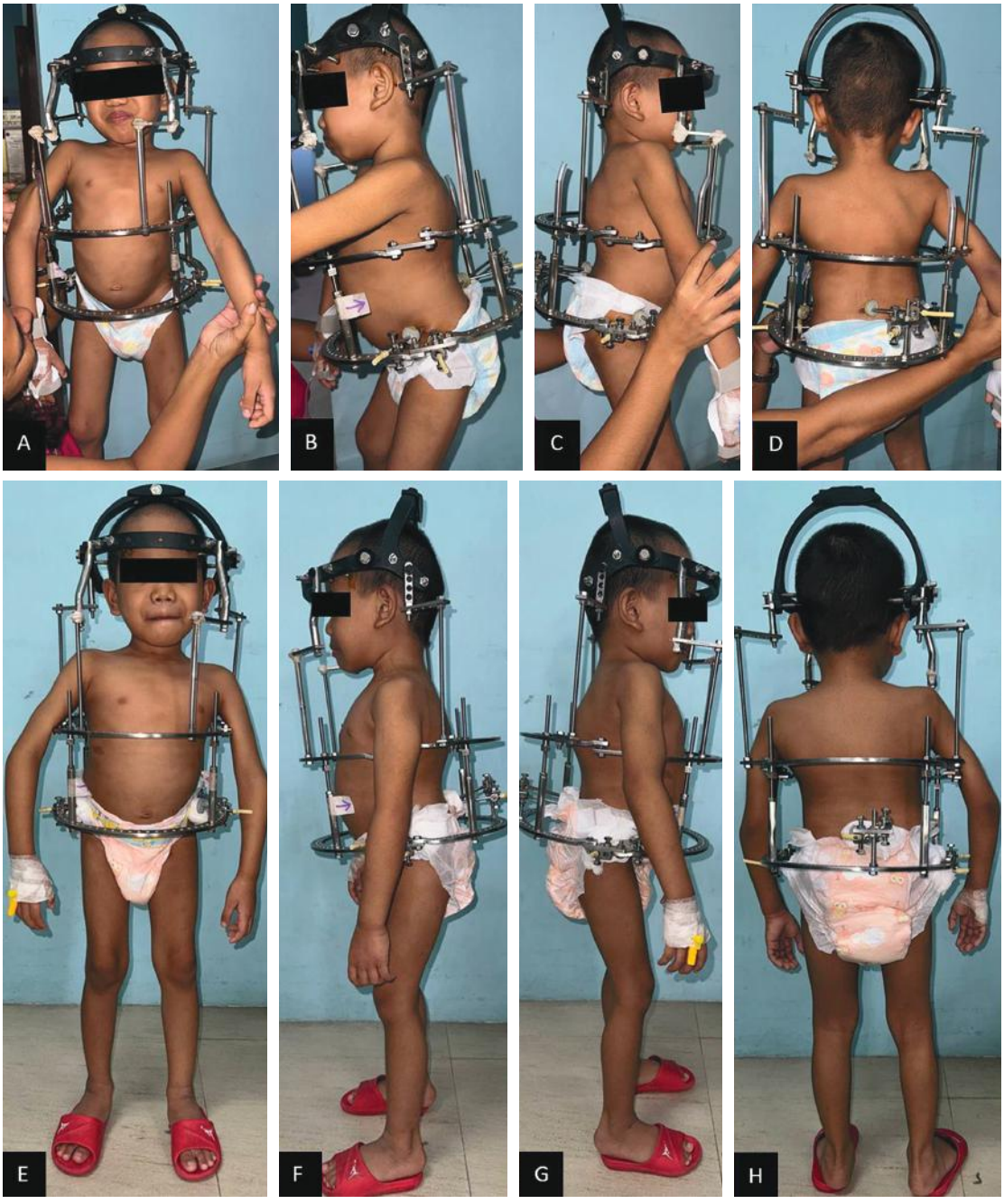

Figure 5. Patient standing on Day 14 **(A-D)** and Day 21 **(E-H)**.

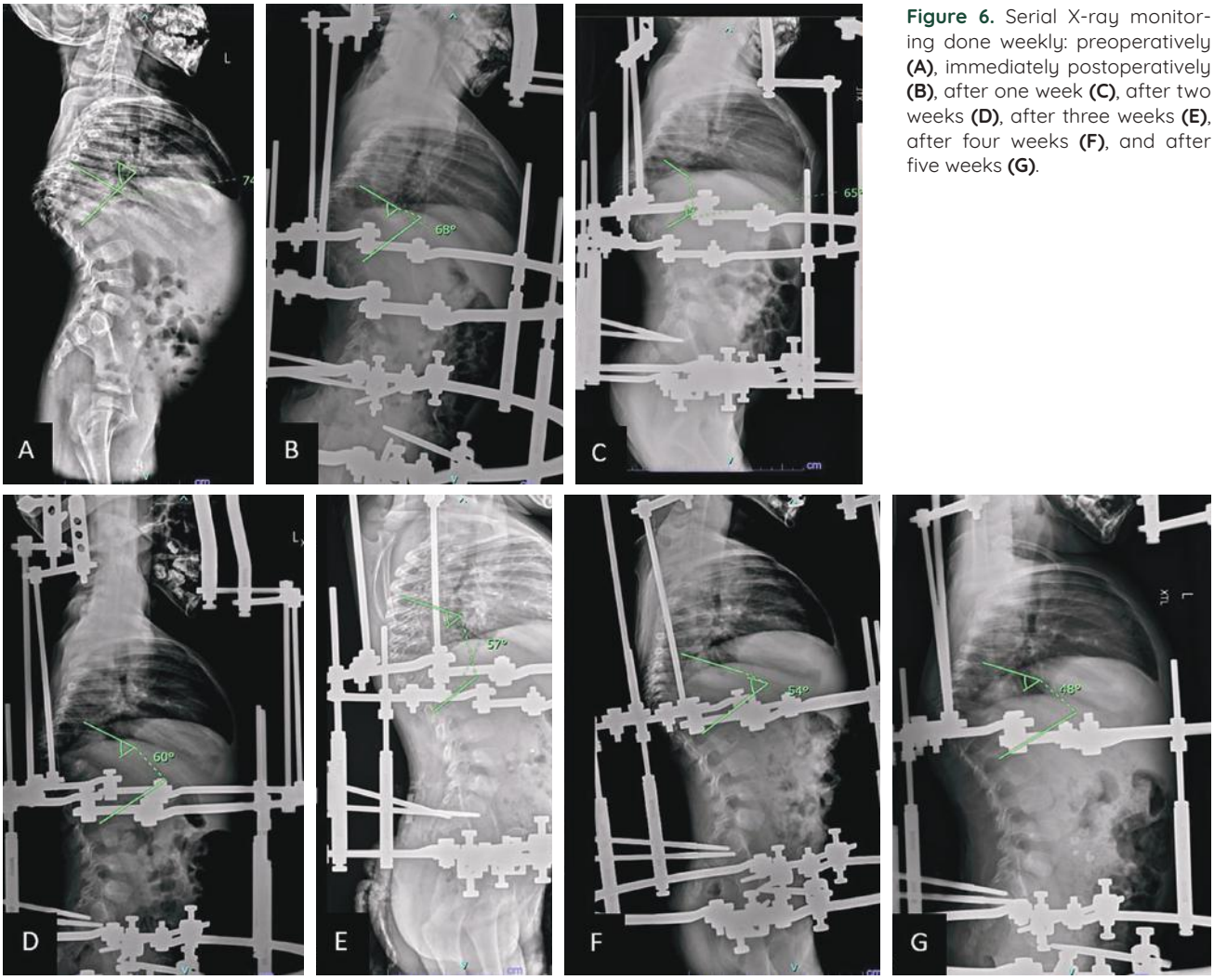

Figure 6. Serial X-ray monitoring done weekly: preoperatively **(A)**, immediately postoperatively **(B)**, after one week **(C)**, after two weeks **(D)**, after three weeks **(E)**, after four weeks **(F)**, and after five weeks **(G)**.

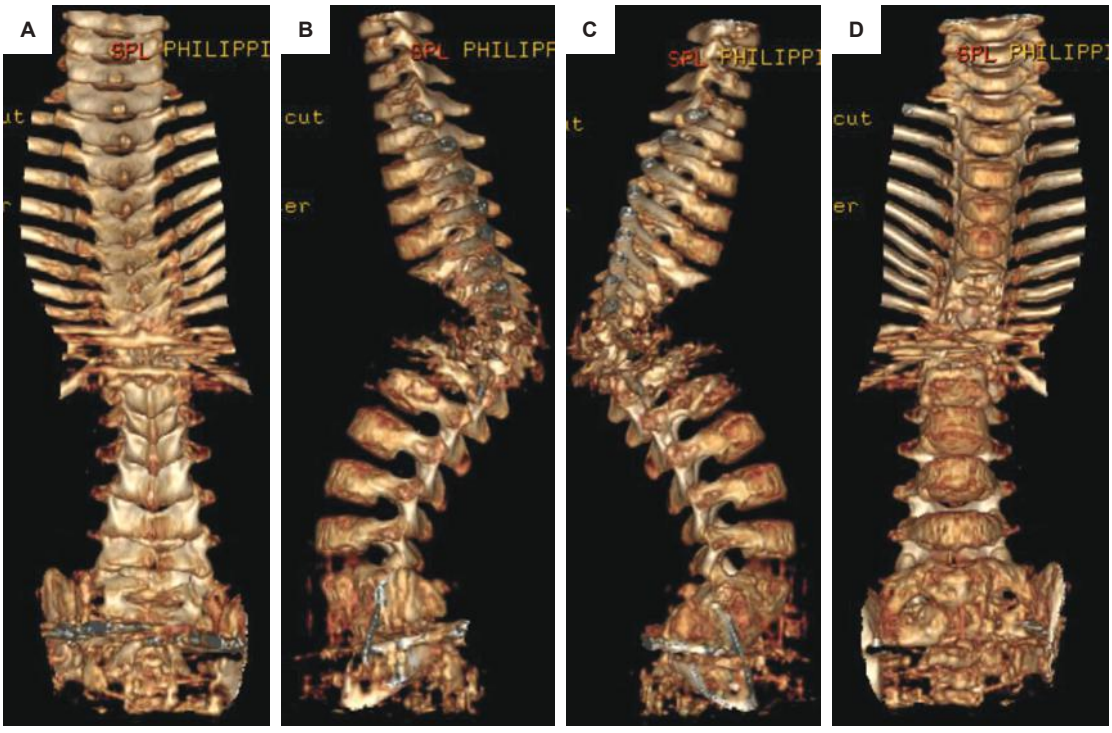

Figure 7. Thoracolumbar CT scan after three weeks **(A-D)**.

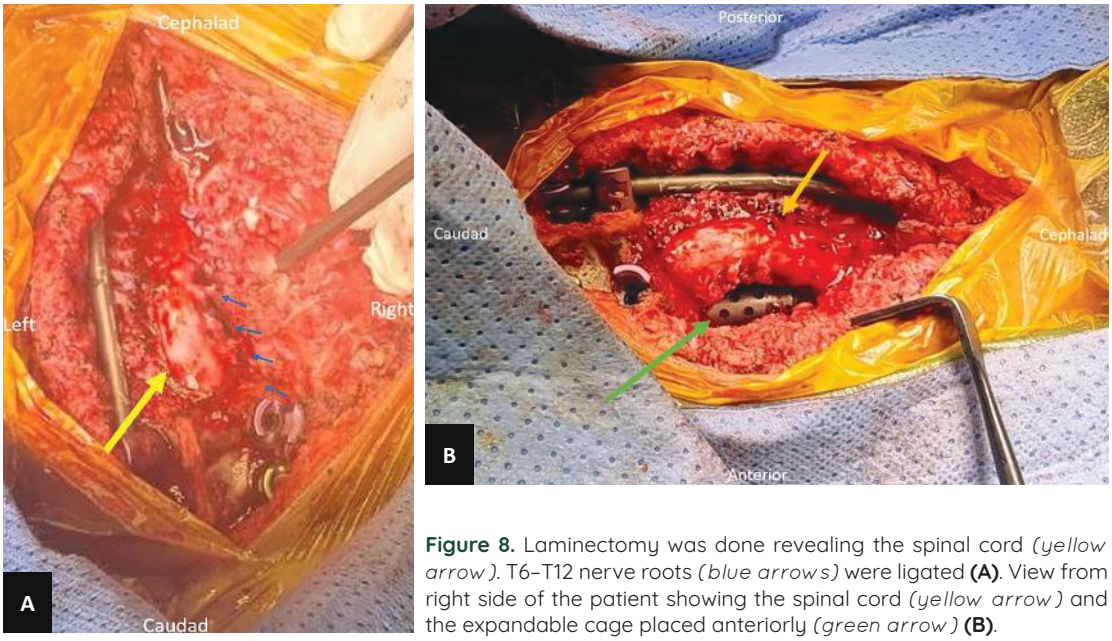

Figure 8. Laminectomy was done revealing the spinal cord *(yellow arrow)*. T6–T12 nerve roots *(blue arrows)* were ligated **(A)**. View from right side of the patient showing the spinal cord *(yellow arrow)* and the expandable cage placed anteriorly *(green arrow)* **(B)**.

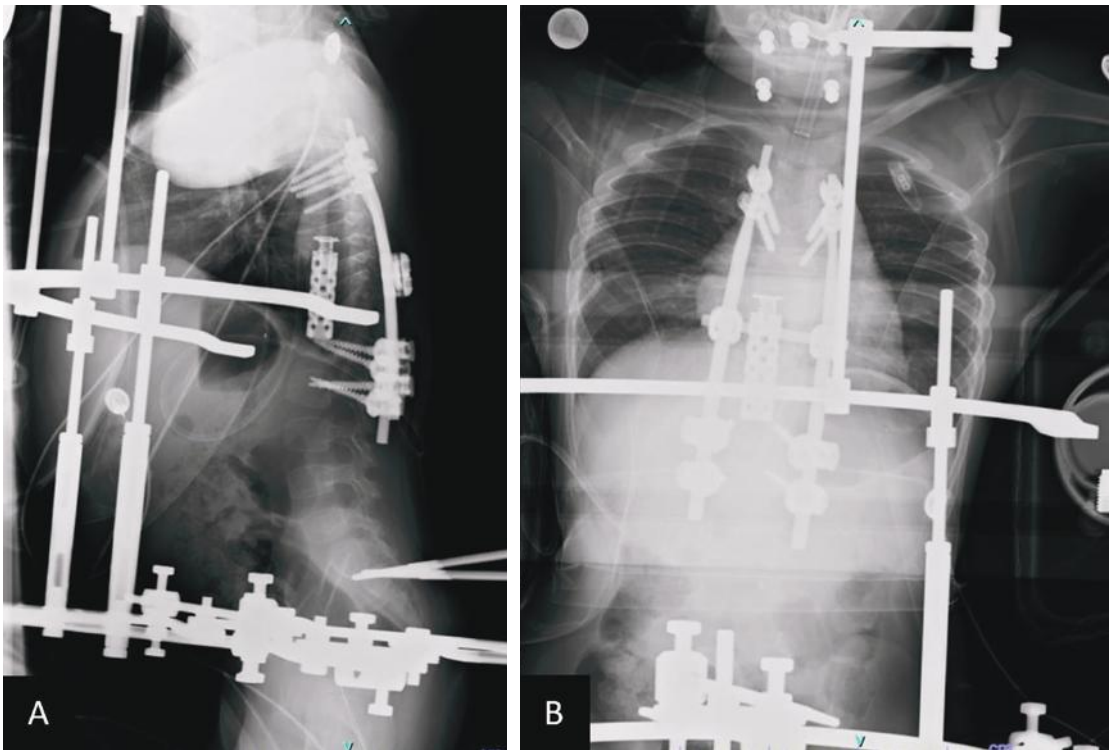

Figure 9. Anteroposterior **(A)** and lateral **(B)** x-rays after definitive fixation.

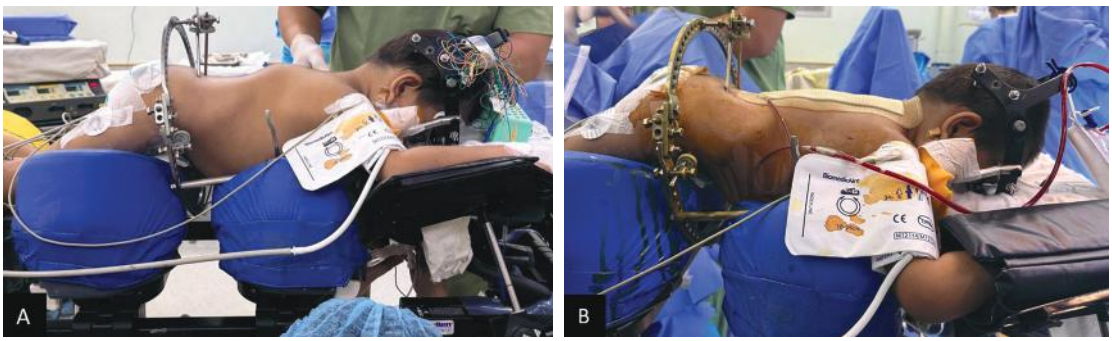

Figure 10. Patient in prone before **(A)** and after definitive fixation **(B)**.

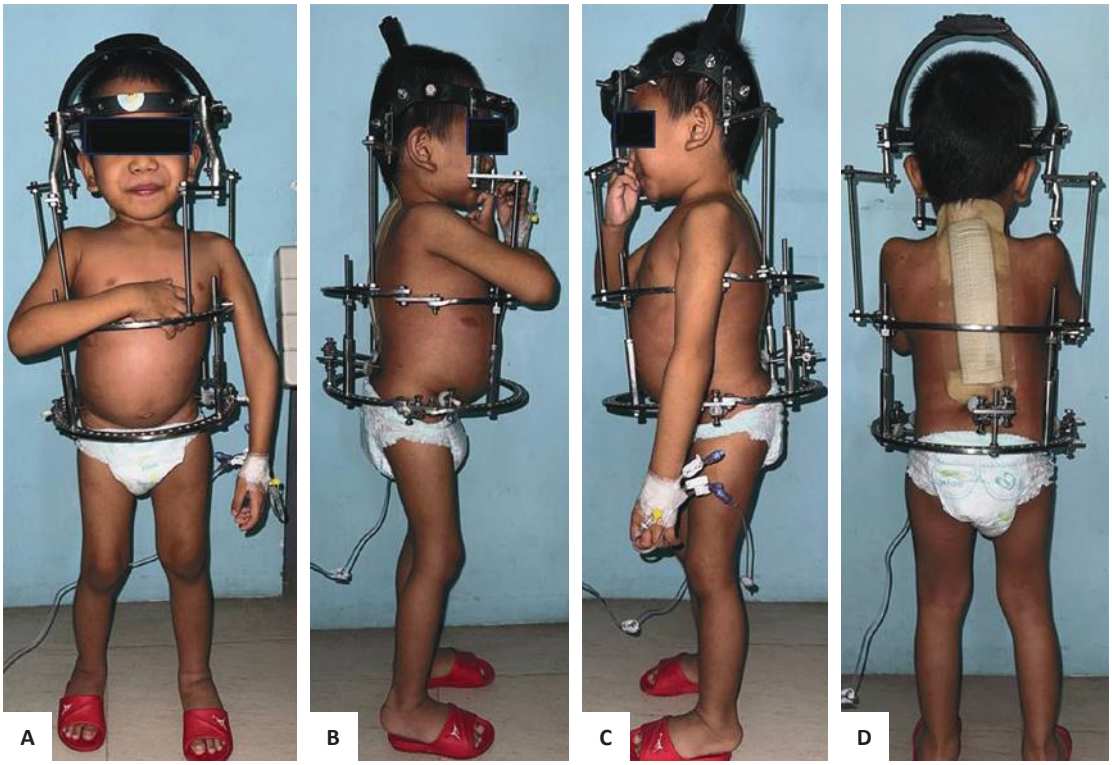

Figure 11. Patient four days after definitive surgery.

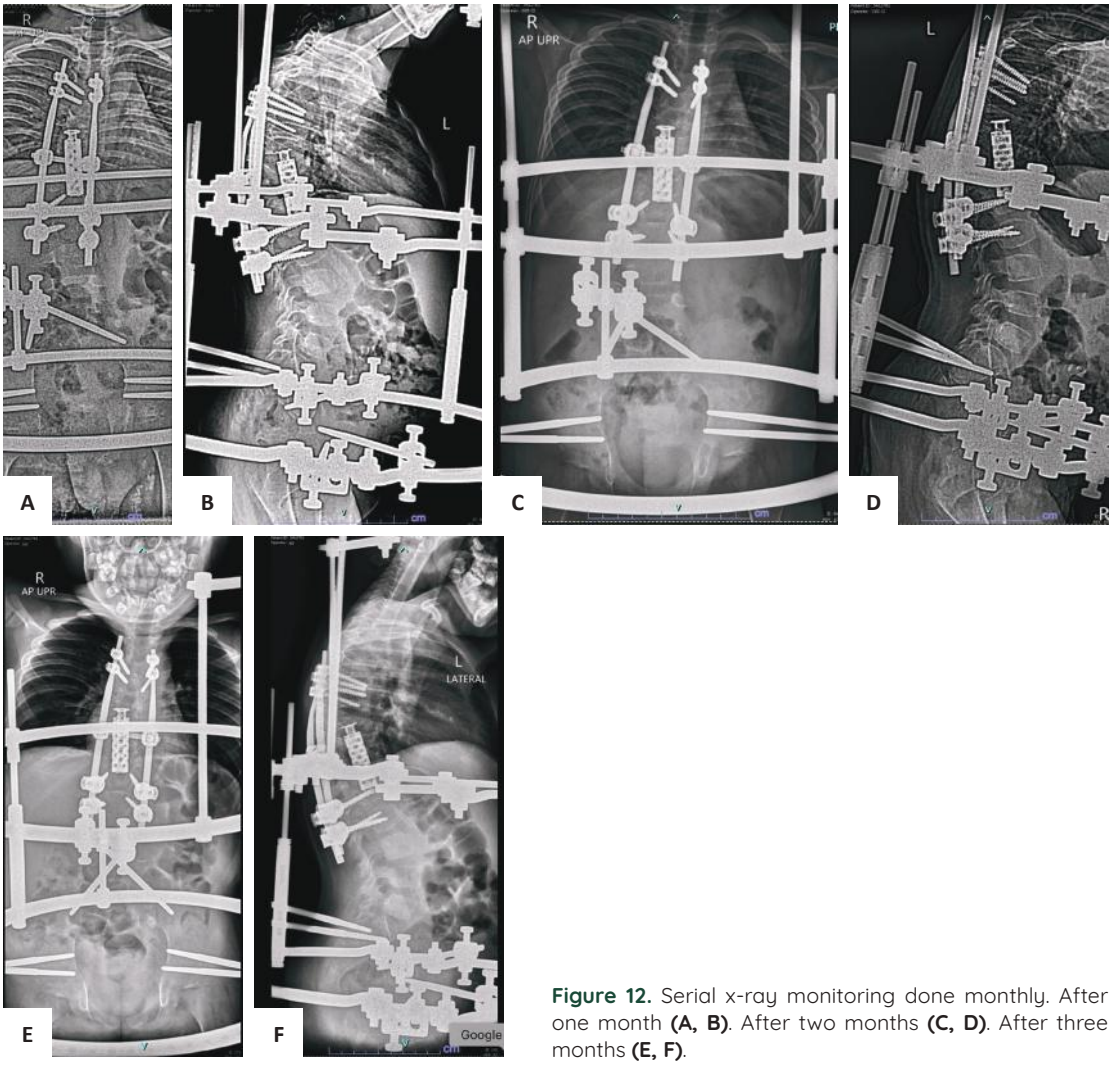

Figure 12. Serial x-ray monitoring done monthly. After one month **(A, B)**. After two months **(C, D)**. After three months **(E, F)**.

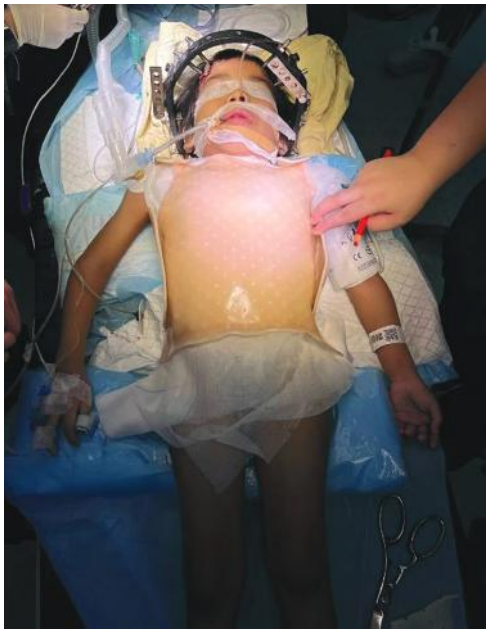

Figure 13. Removal of halo-pelvic traction and application of thermoplast brace.

Fourteen weeks after definitive surgery, the halo pelvic traction was removed in the operating room under sedation, and the patient was shifted to a total contact body jacket made of thermoplast (Figure 13). He remained ambulatory without aid, with no neurologic deficits, at six months after application of halo pelvic traction (Figures 14 and 15).

DISCUSSION

The natural history of spinal tuberculosis in children and adults varies. The pediatric spine is at greater risk for severe destruction and worse deformity due to the residual growth in the uninvolved segments of the spine. Patients present late and with more symptoms (deformity, paraplegia, incontinence, or disseminated bone and organ involvement). Indications for surgery are limited to the "at-risk signs," when ideally this disease could be identified early and treated without surgery. Multilevel involvement is also common and often pathognomonic for spinal tuberculosis, adding to the challenge of limiting fusion levels in children.

Deformity correction in children presents biomechanical and anatomical challenges. Small pedicle sizes, incomplete ossification, and poorer bone density limit fixation options, reduce screw purchase, and risk early loosening. Posterior fixation alone may not provide sufficient stability. The halo-pelvic construct afforded initial sagittal correction, stable bone purchase on the skull and pelvis, gradual distraction, and served as an external augment for the second-stage posterior instrumentation and fusion.

The halo-pelvic traction provides constant distraction at a guided rate as can be tolerated by the patient, while the halo-gravity traction involves intermittent distraction with the patient maintained on a wheelchair for at least 12 hours a day. The halo-pelvic construct has the advantages of consistent traction forces, patient mobilization, and a faster rate of correction as compared to a halo-gravity traction.

The disadvantage of the halo-pelvic construct is similar to that of any external fixation. The size and the weight of the frame may be cumbersome. Our patient was young and presented with low weight and height for age ($Z < -3$). The construct weighed 21% of his weight; he initially complained of its heaviness. This also placed him at risk for pin pullout, pin site infections, falls, and fractures.

The patient developed a superficial pin tract infection on the supraacetabular pin on the right side two weeks after application of the construct. Limpaphayom described that 25% of patients with a halo frame developed pin-site infections, for which oral antibiotics would usually be enough.[16] Pin tract care with sulphadiazine or hydrogen peroxide is documented to reduce the incidence of pin site

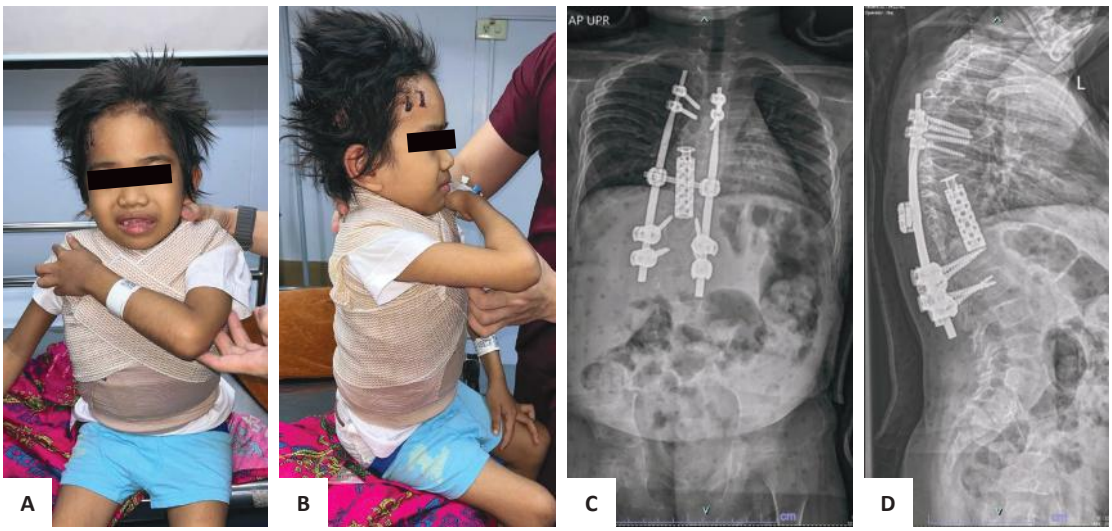

Figure 14. Patient one day after removal of halo-pelvic traction **(A, B)**. X-rays one day after removal of halo-pelvic traction **(C, D)**.

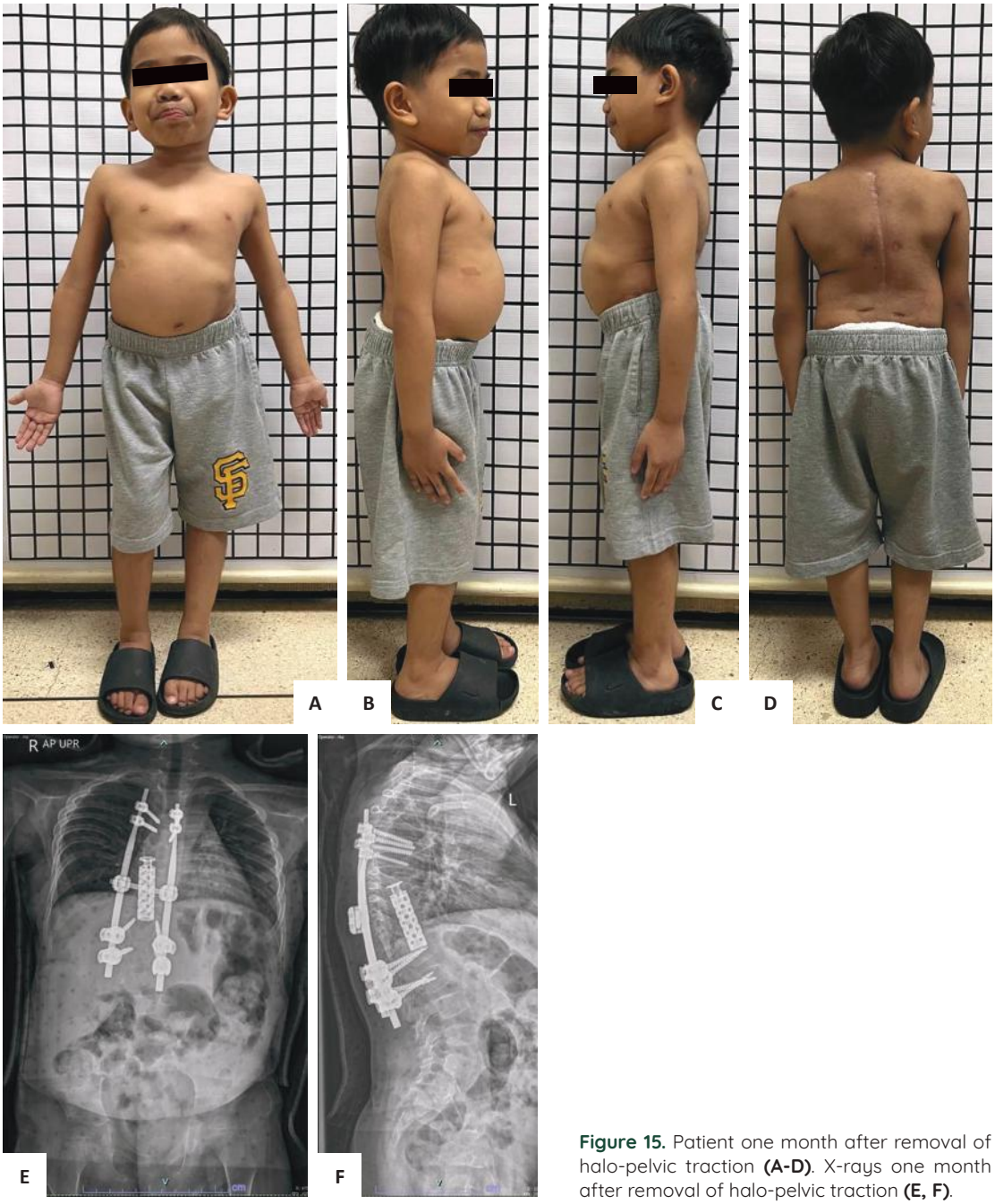

Figure 15. Patient one month after removal of halo-pelvic traction **(A-D)**. X-rays one month after removal of halo-pelvic traction **(E, F)**.

infections and may be considered in future cases.[17] This was proven to be effective in our case, and no recurrence of the pin tract infection was observed.

The initial sagittal correction achieved with the halo-pelvic traction was 26 degrees (35.13%) over six weeks. The correction with the frame seen in our patient was lower than reported by Zhou and lies closer to those in reports using halo-gravity traction in older children, which is around 30–35%.[18,19] Our slowed rate of distraction may have been too conservative because of the lack of literature in our patient's age group, and because we were guided by clinical symptoms (numbness, weakness, and pain), which children may be unable to express accurately. Objective parameters should be studied in a larger population.

The final deformity correction of 66.21% was achieved during the second-stage surgery. Kyphectomy through multilevel vertebral column resection contributed an additional correction of 23 degrees from the initial traction, which was consistent with the average correction of 50–70%.[9,14,15]

We decided to do unilateral multiple pedicle and rib resection to provide a wider fusion bed on the ribs and transverse processes of the involved levels. With this approach, multiple nerve roots were sacrificed to fully visualize and expose the anterior column. There is some evidence that ligation of multiple nerve roots may compromise the vascularity of the spinal cord, which may present as postoperative paraplegia. This may pose an even higher risk than simply ligating the artery of Adamkiewicz. A study has suggested performing

temporary clamping of the nerve roots and monitoring the MEPs and SSEPs for 5–10 minutes before ligation.[20,21] However, preservation of SSEPs is still not a reliable marker of motor function postoperatively. Another study has proposed limiting the nerve root ligation on the right side, farther from the aorta.[21] This, however, does not assuredly prevent catastrophic ligation of the blood supply. A preoperative CT angiogram may be a reasonable precaution to avoid such complications.[21]

The timing of closure of the neurocentral synchondrosis varies by region; the cervical spine closes at around five years old, the lumbar at around 11 years old, and the thoracic spine later at 17 years old. While our main correction was achieved at the thoracic spine, destruction of the T7–L2 vertebral bodies and fusion of ten levels (T4–L2) will have a significant effect on the growth of this area. The growth of each thoracic vertebral body averages 0.7 mm a year in males. With around 10 years of remaining growth, the patient is already expected to be 5 cm shorter than his expected potential height.[22,23] Worsening deformity has been described in cases with scoliosis and progression of apical vertebral rotation post-fusion. In principle, posterior instrumented fusion prevents further growth of the posterior elements but may not prevent anterior growth, and vice versa for anterior fusion. In this case's mainly uniplanar deformity, the possibilities are: (1) overgrowth of the vertebral bodies anteriorly, causing further loss of thoracic kyphosis and/or increased lumbar lordosis, (2) rotational overgrowth of the unfused anterior segments of T4–5 and L1–2, or (3) a combination of the two previous possibilities. Our patient has to be followed up closely for any changes in the unfused segments.

The severity of deformity and the age of the patient were the main factors for considering a relatively tedious procedure. Careful preoperative planning necessitated repetitive radiographs and CT scans due to the construct used. However, with the limited literature, this innovative technique has proven to be effective in the short term. The risk of spontaneous fusion following stripping of the periosteum at the non-fusion levels is still possible. Growing rods or other growth-friendly techniques may be inadequate for definitive fixation.

Since this new technique carries the risk of pin tract infections, the patient had to be confined for close monitoring and observation. Furthermore, the risk of developing new deformities is still possible, and the patient would need to be monitored until adulthood. Current evidence shows no consistent association between repeated diagnostic radiation exposure and risk of developing pediatric cancers.[24]

There are a few comparative studies available on the use of the halo-pelvic traction in young children. Close monitoring of patients and sound clinical judgment helped define our distraction protocol. Our current study shows early clinical and radiographic outcomes. Constant monitoring is needed to assess long-term results and detect possible complications.

CONCLUSION

The combined two-staged approach of halo-pelvic traction and all-posterior vertebral column resection has proven effective in this pediatric patient with severe kyphotic deformity. While protocols on halo-pelvic traction were lacking and the risk of complications for both procedures individually and combined were relatively high, the patient was able to tolerate the procedures. However, while our results are promising in the short term, the patient would need constant monitoring and long-term follow-up to detect and prevent possible complications.

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ETHICAL CONSIDERATIONS

Patient consent forms were obtained before manuscript submission.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

PLFR: Conceptualization, Methodology, Investigation, Resources, Writing – original draft preparation, Writing – review and editing, Visualization; **MRAP:** Conceptualization, Methodology, Investigation, Resources, Writing – original draft preparation, Writing – review and editing, Visualization, Supervision, Project administration; **GCEB:** Conceptualization, Methodology, Investigation, Resources, Writing – original draft preparation, Writing – review and editing, Supervision, Project administration; **FPIN, SAMG:** Conceptualization, Methodology, Investigation, Resources, Writing – review and editing, Supervision, Project administration.

DATA AVAILABILITY STATEMENT

No datasets were generated or analyzed for this research.

AUTHOR DISCLOSURE

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CASE REPORT

Dual Small-Diameter Screw Fixation in Acute Traumatic Slipped Capital Femoral Epiphysis: A Case Report

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ABSTRACT

Slipped capital femoral epiphysis (SCFE) is typically a chronic condition associated with metabolic and biomechanical factors, whereas acute traumatic SCFE in a previously asymptomatic adolescent is uncommon and carries a higher risk of avascular necrosis (AVN). We report the case of a 15-year-old male who presented with acute right hip pain and inability to bear weight following high-energy trauma. Radiographs demonstrated an unstable SCFE with severe displacement and no radiographic features of chronicity. The patient underwent urgent closed reduction and percutaneous fixation using two 4.0 mm cannulated screws, consisting of one partially threaded and one fully threaded screw. Postoperatively, he was managed with staged non-weight-bearing followed by gradual return to full weight-bearing. At 12 months, the patient was asymptomatic with no radiological evidence of AVN or loss of reduction. Functional outcome assessment demonstrated excellent recovery, with a Non-Arthritic Hip Score of 97.5% and high Hip disability and Osteoarthritis Outcome Score values across domains, including pain (98.6), symptoms (98.5), activities of daily living (100), sports and recreation (93.75), and quality of life (100). This case shows a favorable short-term outcome following dual small-diameter screw fixation; however, given the single-case design and limited follow-up, no conclusions regarding implant superiority or reduction in AVN risk can be drawn. Further studies are required to evaluate this technique in unstable SCFE.

Keywords. acute traumatic slipped capital femoral epiphysis, dual screw fixation, hip preservation surgery, unstable slipped capital femoral epiphysis, cannulated screw fixation, adolescent hip trauma

INTRODUCTION

Slipped capital femoral epiphysis (SCFE) is one of the most common adolescent hip disorders and typically presents as a chronic or subacute physeal slip associated with mechanical and metabolic factors. Aprato et al. and Mahran et al. described SCFE as a multifactorial disorder commonly affecting adolescents during periods of rapid growth.[1,2] Acute traumatic SCFE occurring in a previously asymptomatic adolescent is uncommon and may resemble a Salter-Harris type I physeal injury. Sankar et al. and Zaltz et al. reported that unstable slips are associated with a substantially higher risk of avascular necrosis (AVN), likely related to acute disruption of the femoral head blood supply.[3,4]

Management of unstable SCFE remains challenging. While in situ fixation with a single cannulated screw is widely accepted for stable slips, the optimal fixation strategy for acute unstable injuries remains less clearly defined.[5,6] Zaltz et al. reviewed multiple treatment approaches for unstable SCFE, including gentle closed reduction with percutaneous fixation and open reduction techniques, but concluded that evidence supporting one method over another remains limited.[4] Napora et al. reported acceptable outcomes following purposeful closed

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reduction and pinning in unstable SCFE, whereas Kitano et al. identified closed reduction as a potential risk factor for AVN.[7,8] Novais et al. demonstrated favorable short-term outcomes with the modified Dunn procedure in selected unstable slips, though there are still concerns regarding surgical complexity and complications.[9]

Multiple screw fixation has occasionally been described in unstable slips to improve rotational control; however, this approach risks additional physeal injury and lacks long-term evidence. We present a case of acute traumatic unstable SCFE managed with urgent closed reduction and fixation using two small-diameter cannulated screws. The objective of this report was to describe the surgical decision-making, technical considerations, and short-term clinical and radiological outcome of this approach in an uncommon injury pattern.

CASE

A 15-year-old male presented to the emergency department with severe right hip pain and inability to bear weight following a high-energy road traffic accident involving a lateral impact injury. The patient had no prior history of hip or knee pain, limp, restriction of activities, or known endocrine disorders. There were no clinical features suggestive of early puberty or underlying metabolic abnormality. His body mass index was 21 kg/m^2.

On examination, the right lower limb was held in external rotation with painful restriction of hip movements, particularly internal rotation, abduction, and flexion. The patient was unable to ambulate, and the slip was therefore classified as unstable according to the Loder classification system. No distal neurovascular deficit was identified.

Plain radiographs of the pelvis and right hip demonstrated marked posterior and inferior displacement of the femoral epiphysis consistent with slipped capital femoral epiphysis (SCFE) (Figure 1).

Based on Wilson's classification, the slip was categorised as severe, with displacement exceeding 50% of the width of the epiphysis. The Southwick slip angle measured more than 60 degrees. Ultrasonography of the hip demonstrated joint effusion without evidence of metaphyseal remodelling. Radiographs did not show features commonly associated with chronic SCFE, such as rounding of the superior femoral neck, reduction in epiphyseal height, metaphyseal remodelling, or callus formation at the metaphyseal junction.

The absence of prodromal symptoms, combined with the high-energy mechanism of injury and lack of radiographic signs of chronicity, supported the diagnosis of acute traumatic unstable SCFE. However, the possibility of an acute-on-chronic slip could not be excluded in the absence of advanced imaging.

Surgical intervention was performed within 12 hours of presentation. The patient was positioned supine on a radiolucent operating table. Under fluoroscopic guidance, gradual longitudinal traction was applied, followed by gentle controlled internal rotation to correct the externally rotated deformity. To minimize additional injury to the femoral head vascular supply, no forceful manipulation or repeat attempts were performed. Reduction was achieved in a single attempt and confirmed on anteroposterior and lateral fluoroscopic views. Fixation was performed using two 4.0 mm cannulated screws inserted percutaneously. A partially threaded screw was placed centrally across the physis to provide compression and initial stability. This was supplemented with a fully threaded screw inserted in a divergent orientation to improve rotational control while minimizing additional compression across the physis. Care was taken to avoid joint penetration, and both screws achieved secure epiphyseal purchase with four threads crossing the epiphysis.

Postoperatively, the patient remained non-weight-bearing for six weeks, followed by gradual progression to partial and full weight-bearing. Clinical and radiographic follow-up was performed at two weeks, six weeks, three months, six months,

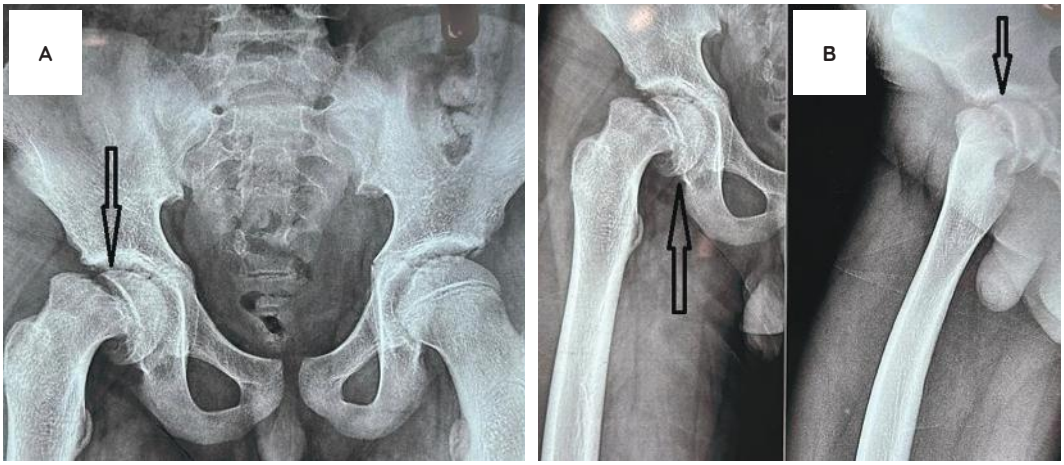

Figure 1. Preoperative anteroposterior and lateral radiographs demonstrating unstable slipped capital femoral epiphysis. Anteroposterior radiograph showing marked displacement of the proximal femoral epiphysis **(A)**. Lateral radiograph demonstrating posterior displacement of the epiphysis **(B)**.

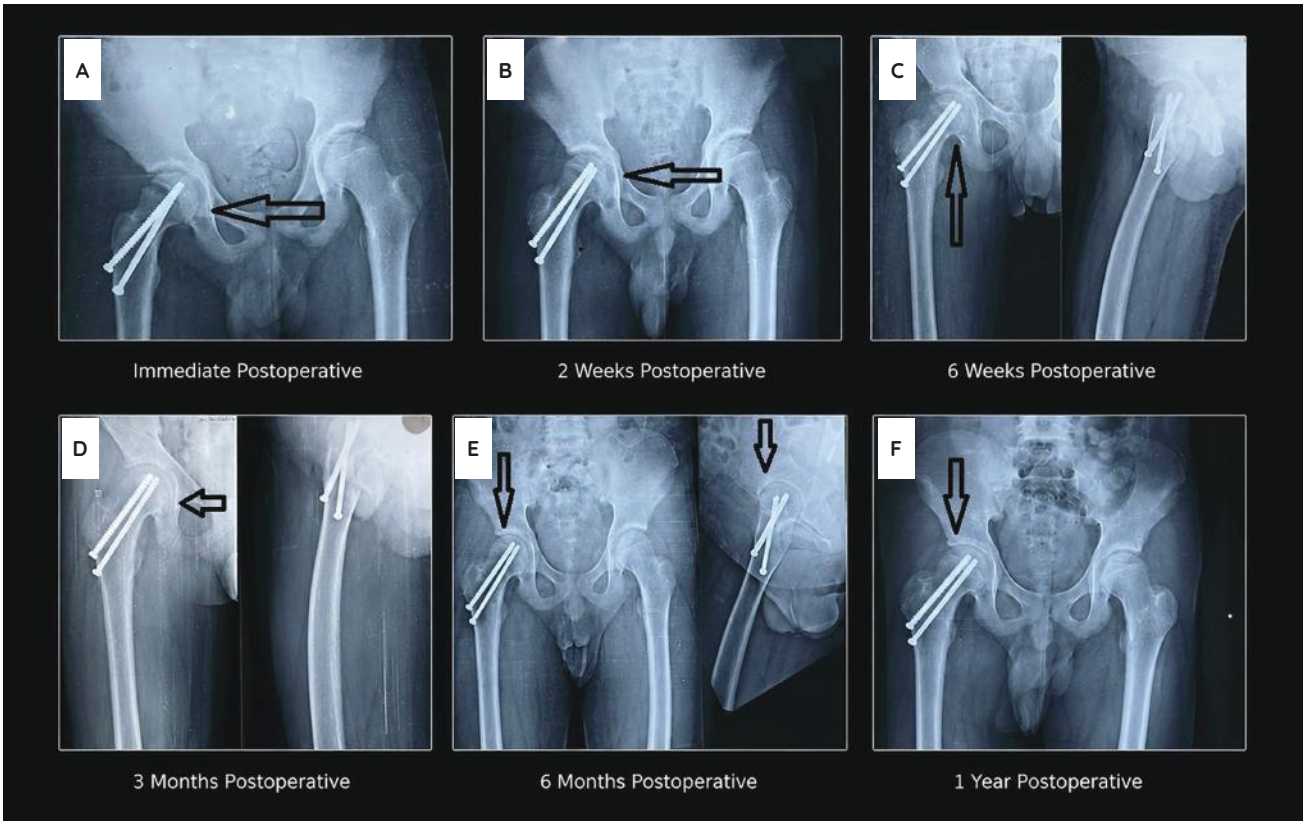

Figure 2. Serial radiographic evaluation of a 15-year-old male with acute traumatic slipped capital femoral epiphysis managed with dual 4.0 mm screw fixation. Immediate postoperative radiographs showing satisfactory closed reduction and placement of dual cannulated screws within the femoral epiphysis without joint penetration **(A)**. Two-week follow-up demonstrating maintained reduction and stable implant position **(B)**. Six-week follow-up showing progressive healing without loss of fixation **(C)**. Three-month follow-up with continued stability and early signs of physeal closure **(D)**. Six-month follow-up radiographs demonstrating maintained alignment and absence of femoral head collapse **(E)**. One-year follow-up showing complete physeal fusion with no radiographic evidence of avascular necrosis or joint space compromise **(F)**.

and one year after surgery. Serial radiographs demonstrated maintained reduction, progressive physeal closure, and no evidence of implant failure, femoral head collapse, or avascular necrosis (Figure 2).

At each follow-up visit, pain, gait pattern, hip range of motion, and functional limitation were assessed. The patient showed progressive improvement without recurrence of hip pain, stiffness, limp, or restriction of daily activities. There was no clinical evidence suggestive of chondrolysis, such as painful progressive loss of hip motion. Follow-up radiographs demonstrated preservation of joint space without narrowing or degenerative changes. At final follow-up, the patient had returned to routine daily activities and non-competitive sports without pain or gait disturbance. Functional assessment demonstrated excellent recovery, with a modified Harris Hip Score (mHHS) of 96 as described by Harris et al. The patient also demonstrated favorable patient-reported outcomes, with a Non-Arthritic Hip Score of 97.5% and high HOOS values across all domains, including pain (98.6), symptoms (98.5), activities of daily living (100), sports and recreation (93.75), and quality of life (100). Clinical examination at final follow-up demonstrated satisfactory active range of motion of the hip with the ability to perform squatting and cross-legged sitting without discomfort (Figure 3).

DISCUSSION

Acute traumatic unstable SCFE represents an uncommon injury pattern that differs from the more frequently encountered acute-on-chronic SCFE. Typical SCFE develops due to gradual physeal weakening related to mechanical, endocrine, and metabolic factors, often with preceding symptoms such as hip pain, thigh pain, knee pain, or limp. In contrast, traumatic SCFE occurs after a significant injury mechanism in a previously asymptomatic adolescent and closely resembles a Salter-Harris type I physeal separation through the proximal femoral physis. Therefore, treatment priorities include restoration of alignment with minimal additional vascular compromise and stable fixation until physeal healing. Management of unstable SCFE remains controversial because no single technique has consistently demonstrated superior outcomes across all patient groups.[4,6] Closed reduction with percutaneous fixation continues to be used by many surgeons because it avoids the morbidity associated with open procedures, although concern persists regarding further compromise of femoral head vascularity during manipulation.[7,8] In the present case, acceptable alignment was achieved with gentle reduction in a single attempt, avoiding the need for surgical dislocation or open reduction.

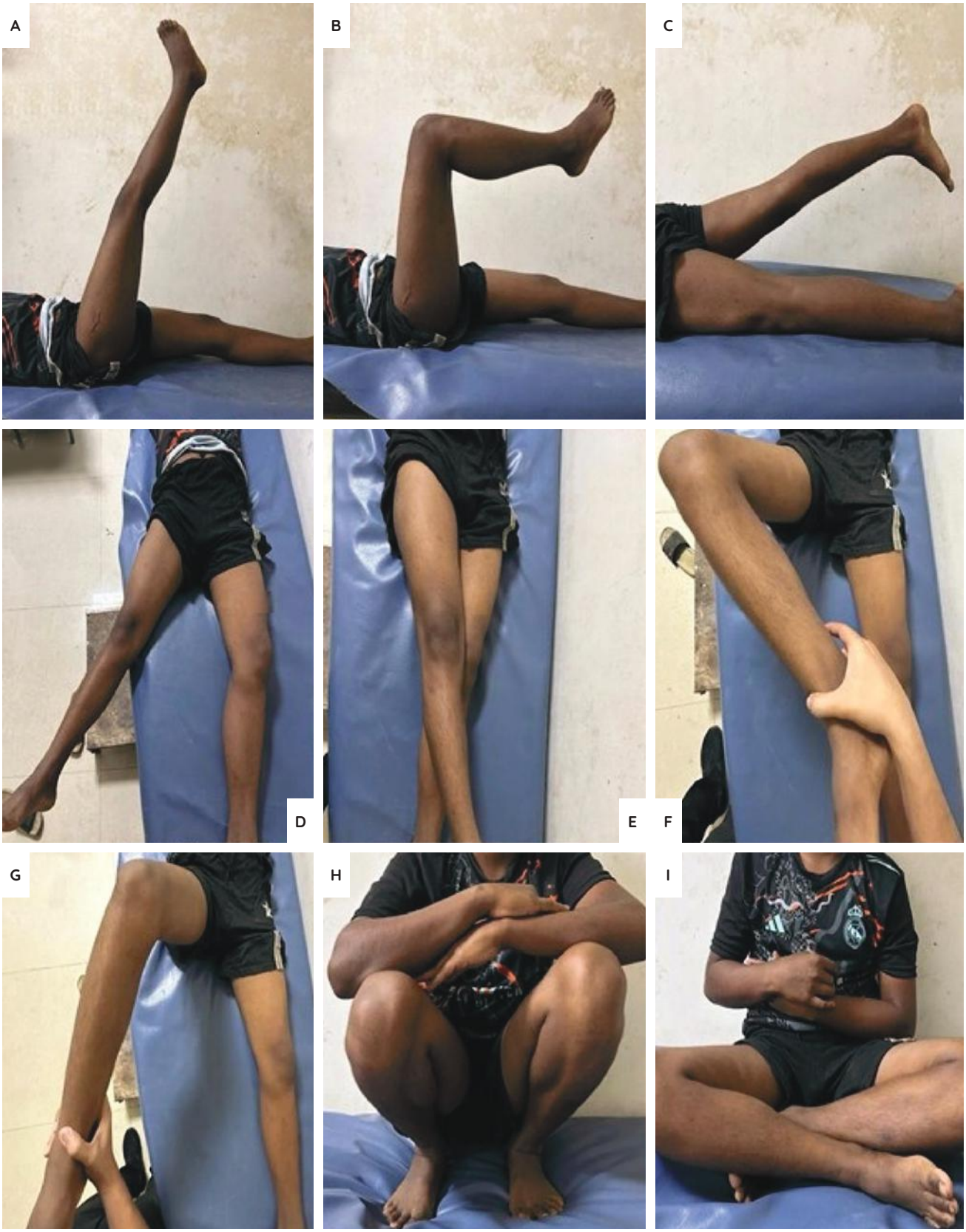

Figure 3. Clinical outcome at 12-month follow-up demonstrating functional recovery of the right hip following urgent closed reduction and percutaneous fixation with two 4.0 mm cannulated screws for acute traumatic unstable slipped capital femoral epiphysis. Demonstration of active straight leg raise with good hip flexor strength **(A)**, active hip flexion to approximately 90° in the supine position **(B)**, active straight leg raise with the knee extended, demonstrating maintained hip flexion and quadriceps function **(C)**, active hip abduction in the supine position, showing satisfactory abductor function **(D)**, neutral lower limb alignment with full knee extension in the supine position **(E)**, passive hip internal rotation demonstrating satisfactory postoperative range of motion **(F)**, passive hip external rotation demonstrating satisfactory postoperative range of motion **(G)**, ability to perform a full squat without pain or functional limitation **(H)**, and ability to sit cross-legged comfortably, indicating good hip flexion, abduction, and external rotation **(I)**.

The modified Dunn procedure has been advocated for severe unstable slips because it permits direct correction of deformity while preserving femoral head perfusion.[9] Despite favorable short-term results reported in selected series, the procedure remains technically demanding and carries a recognized risk of complications related to surgical dislocation and vascular injury.[2,4] Consequently, less invasive fixation strategies may still be considered when satisfactory reduction can be achieved without forceful manipulation. The decision to use two small-diameter screws in this patient was based on perceived rotational instability after reduction. Biomechanical studies by Pritchett and Perdue and by Leblanc et al. suggested that multiple points of fixation may improve rotational control compared with a single-screw construct.[10,11] However, available evidence remains limited to theoretical models and small clinical reports. Accordingly, this case does not establish superiority of dual-screw fixation or reduction in AVN risk. The technical modification in this case was not the use of multiple fixation points alone, but the use of two smaller-diameter screws to achieve rotational stability while limiting overall implant volume within the femoral epiphysis. This approach was selected based on intraoperative assessment of stability after reduction rather than as a routine alternative to conventional single-screw fixation.

An additional theoretical consideration relates to implant volume within the femoral epiphysis. The combined cross-sectional area of two 4.0 mm screws is smaller than that of a single 7.3 mm screw, resulting in reduced overall implant occupancy within the epiphysis. Whether this difference has any effect on intra-osseous pressure or femoral head perfusion in unstable SCFE remains uncertain, as no vascular or biomechanical assessment was performed in the present case.

Accordingly, this observation should be interpreted as a conceptual consideration rather than evidence of clinical advantage over standard single-screw fixation. Multiple screw fixation also introduces potential disadvantages that must be acknowledged. Additional implants crossing the physis may increase the risk of physeal injury, chondrolysis, hardware conflict, or difficulty during future implant removal procedures. These considerations are particularly relevant in skeletally immature patients, where physeal integrity must be preserved.[1,2]

At one-year follow-up, reduction was maintained, the physis was closed, and there were no radiographic signs of AVN. Functional recovery was favorable, with high NAHS and HOOS values across pain, activity, and quality-of-life domains.[12,13] These patient-reported outcome measures provided a broader assessment of postoperative recovery than the modified Harris Hip Score alone and may be more suitable for adolescent patients undergoing hip preservation procedures.[14]

The timing of surgery is still debated in the literature. Kohno et al. observed a possible association between delayed surgical intervention and the development of AVN after unstable SCFE.[15] Veramuthu et al. reported substantial variation in AVN prevalence across different treatment strategies in their systematic review and meta-analysis.[16] Considerable variation in management preferences among pediatric orthopaedic surgeons further reflects the absence of universally accepted treatment guidelines.[17] In the present case, fixation was performed within 12 hours of injury, which may have contributed to the favorable early outcome. However, this outcome should be interpreted cautiously because complications such as avascular necrosis, femoroacetabular impingement, chondrolysis, and early degenerative changes may develop after longer follow-up periods.

This report has several limitations. It represents a single case with short-term follow-up and no comparison to alternative fixation methods. Dedicated preoperative cross-table lateral radiographs of both hips were not available, limiting detailed bilateral radiographic comparison. Intraoperative images demonstrating the reduction maneuver, guidewire placement, and sequential screw insertion were also unavailable, which limits visual documentation of the surgical technique. Advanced imaging was not performed to assess femoral head perfusion or definitively exclude an acute-on-chronic slip. No biomechanical or vascular evaluation was undertaken, and the observations described here should therefore be interpreted cautiously. Longer follow-up is also necessary to evaluate late complications such as femoroacetabular impingement, deformity progression, and osteoarthritis. Continued surveillance remains important because patients with unilateral SCFE are at risk for subsequent contralateral involvement, particularly in the presence of skeletal or growth-related risk factors.[18-20]

CONCLUSION

Acute traumatic unstable SCFE is an uncommon injury pattern associated with substantial risk of complications, particularly avascular necrosis. In this patient, urgent closed reduction followed by fixation with two small-diameter cannulated screws resulted in maintained reduction, physeal closure, absence of radiographic AVN, and favorable functional recovery at one-year follow-up.

Although dual small-diameter screw fixation provided satisfactory short-term stability in this case, the findings should be interpreted cautiously given the absence of comparative, vascular, and biomechanical evaluations. This report should therefore be regarded as a description of surgical technique and short-term clinical outcome rather than evidence supporting routine use of dual-screw fixation in unstable SCFE.

Further studies with larger patient cohorts and longer follow-up are required to clarify the role of this approach.

ETHICAL CONSIDERATION

Patient's consent was obtained before submission of the manuscript.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

JB: Conceptualization, Methodology, Validation, Formal Analysis, Data Curation, Writing – original draft preparation, Writing – review and editing; **ZI:** Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Writing – review and editing, Supervision; **AD, CRB, MG:** Conceptualization, Methodology, Validation, Data Curation, Writing – review and editing, Supervision.

DATA AVAILABILITY STATEMENT

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AUTHOR DISCLOSURE

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CASE REPORT

Reverse Hemi-Hamate Arthroplasty in Chronic Volar Proximal Interphalangeal Joint Fracture Dislocation: A Case Report

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ABSTRACT

Fracture-dislocations of the proximal interphalangeal joints (PIPJ) are uncommon and complex injuries that are often overlooked. These cases often present with a dorsal dislocation, but a subset of patients present with a volar dislocation and fracture of the dorsal lip of the middle phalanx. In reported cases, functional outcomes are poor following traditional open reduction and internal fixation due to persistent limited range of motion. Hemi-hamate arthroplasty is a relatively new technique introduced in 2002, involving an osteochondral graft to reconstruct the deficient base of the middle phalanx. It affords immediate stability to the joint and earlier range of motion, resulting in less joint stiffness.

A 16-year-old male presented with a three-month history of a volar fracture-dislocation of the left ring finger and had a fixed 60° flexion deformity of the PIPJ and limited range of motion at the distal interphalangeal joint (20–70° range of motion). Patient underwent reverse hemi-hamate arthroplasty (rHHA) using two 1.5 mm cortical screws and was placed in a volar splint for six weeks. At seven months post op, PIPJ and DIPJ active range of motion were 0–90° and 0–75°, respectively. Grip strength was 22% weaker than the unaffected hand (32 kg).

Reverse hemi-hamate arthroplasty is an excellent option for patients with chronic volar PIPJ fracture dislocations with favorable outcomes and return to function while having minimal donor site morbidity.

Keywords. proximal-interphalangeal joint fracture dislocations, hemi-hamate arthroplasty, reconstruction

INTRODUCTION

Fracture-dislocations of the proximal interphalangeal joint (PIPJ) are rare complex injuries that are commonly missed and are challenging to reconstruct, especially when neglected.[1,2] These patients suffer a combination of axial and rotational force that causes PIPJ dislocation and fracture of the base of the middle phalanx.[2,3] Most patients present with a dorsal fracture dislocation (DFD) wherein the volar lip is fractured, but in the rare volar fracture-dislocation (VFD), the dorsal lip instead is fractured.[2,4]

Historically, patients have been treated with external fixation or open reduction and internal fixation. However, poor outcomes hinder the functional status of these patients.[2,5] In 2002, a technique using an osteochondral graft from the hamate was developed to recreate the articulating surface of the middle phalanx with minimal implants and promoted early range of motion to address finger stiffness.[6] To date, there are only a few published articles that describe the use of hemi-hamate arthroplasty (HHA) in DFD, and only

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a handful describe the reverse hemi-hamate arthroplasty (rHHA) in VFD.[2,4]

The objective of this study was to present a case of chronic VFD treated with rHHA, review the outcomes, and contribute data for further study.

CASE

A 16-year-old male presented with left ring finger pain and deformity. He initially suffered a fall on this left ring finger three months prior. He consulted a traditional bone setter who performed manipulation and advised observation. However, due to persistence of pain, he consulted at the outpatient department. On physical examination, he presented with a fixed flexion deformity at the PIPJ and reduced range of motion (ROM) (active 20–70°, passive 0–70°) of the distal interphalangeal joint (PIPJ) (Figures 1 and 2).

The patient underwent reverse hemi-hamate arthroplasty as described by London et al., and volar plate repair.[2]

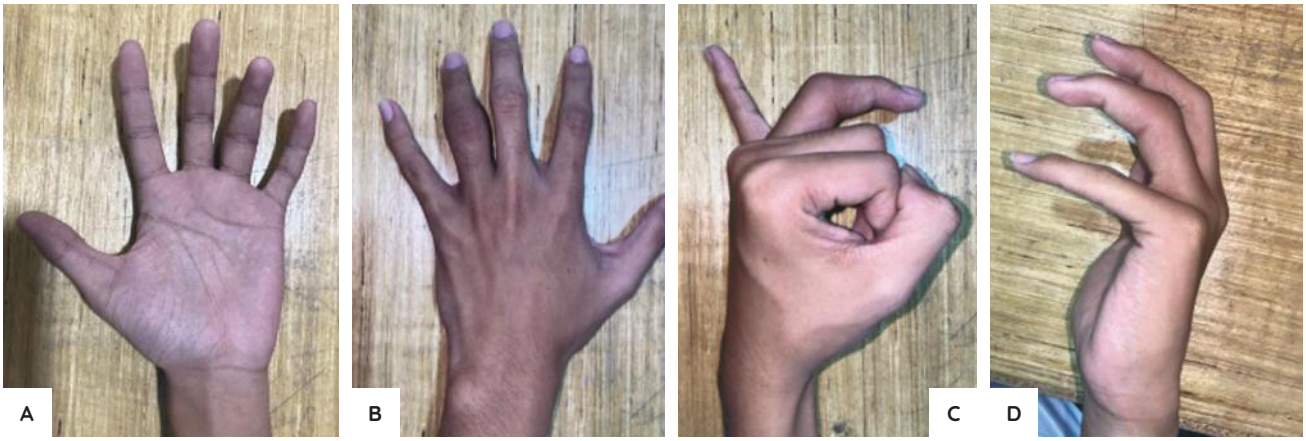

Figure 1. Fixed flexion deformity on the PIPJ of the left ring finger and limited active extension of the DIPJ **(A)**, dorsal view of the left hand **(B)**, attempted active extension demonstrating persistent PIPJ flexion deformity **(C)**, and lateral view showing the fixed flexion deformity **(D)**.

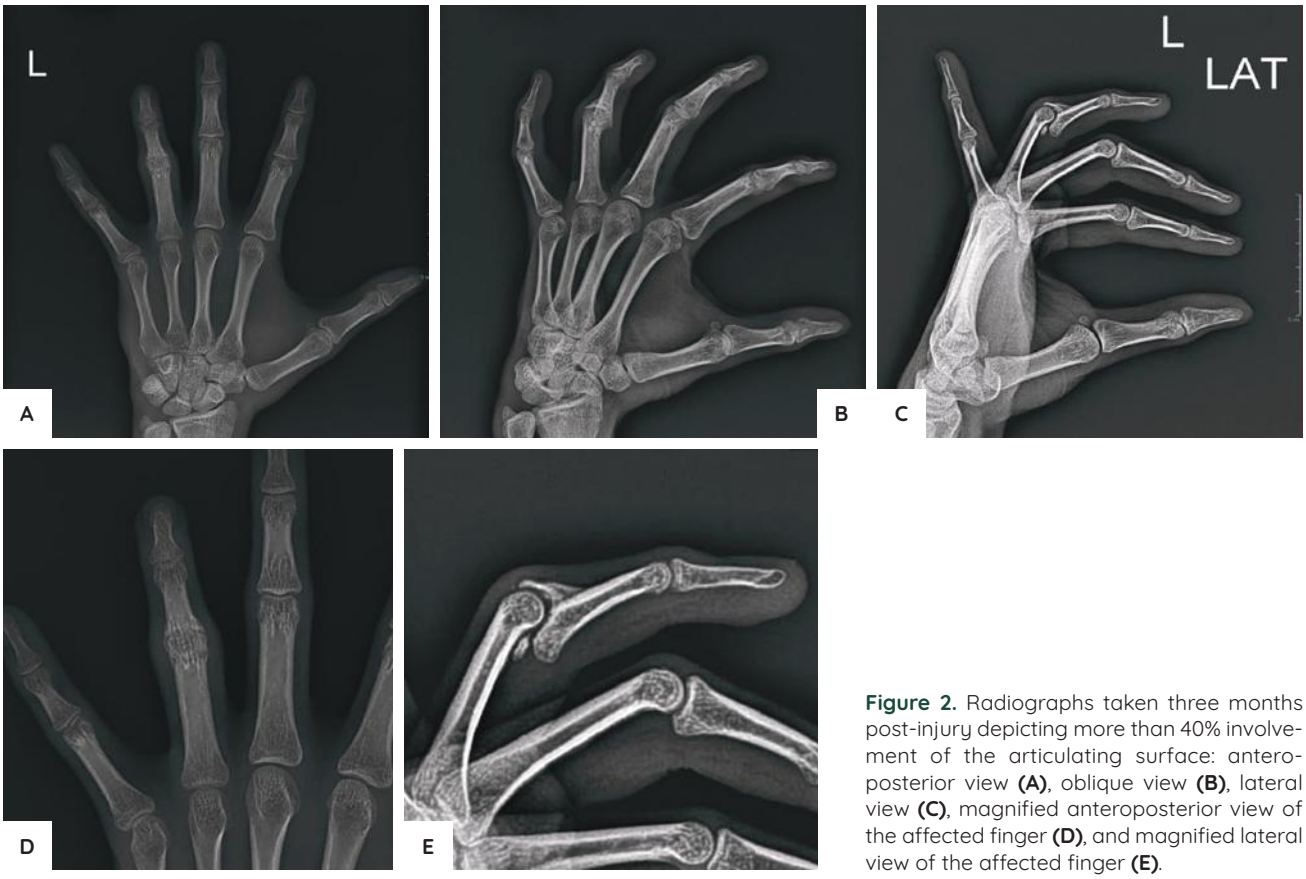

Figure 2. Radiographs taken three months post-injury depicting more than 40% involvement of the articulating surface: anteroposterior view **(A)**, oblique view **(B)**, lateral view **(C)**, magnified anteroposterior view of the affected finger **(D)**, and magnified lateral view of the affected finger **(E)**.

Surgical technique

The PIPJ was accessed using a volar trapezoidal incision and shotgun exposure. The graft recipient site was inspected and prepared. The rHHA differs from HHA since the recipient site is the dorsal base of the middle phalanx; this may require release and later repair of the central slip of the extensor tendon. In the previous case reports,[2,4] the extensor mechanism was preserved either by non-detachment,[2] or reattachment dorsally.[4] In this case, the central slip was not released. The dorsal projection of bone was preserved, and the distal attachment of the central slip was used as a buttress for the graft. Under imaging intensification, the hamate was identified, and a 1 x 1 x 0.8 cm graft was harvested using osteotomes (Figures 3 and 4). The graft was then fixed to the freshened graft site with two 1.5 cm cortical screws, the smallest screw size available (Figure 5).

Post-operatively, a volar splint was applied extending to the ring and small finger in intrinsic plus position to protect our construct and allow passive extension of the PIPJ. Range of motion was delayed for graft incorporation. The splint was discontinued at six weeks, and buddy taping was initiated (Figure 6).

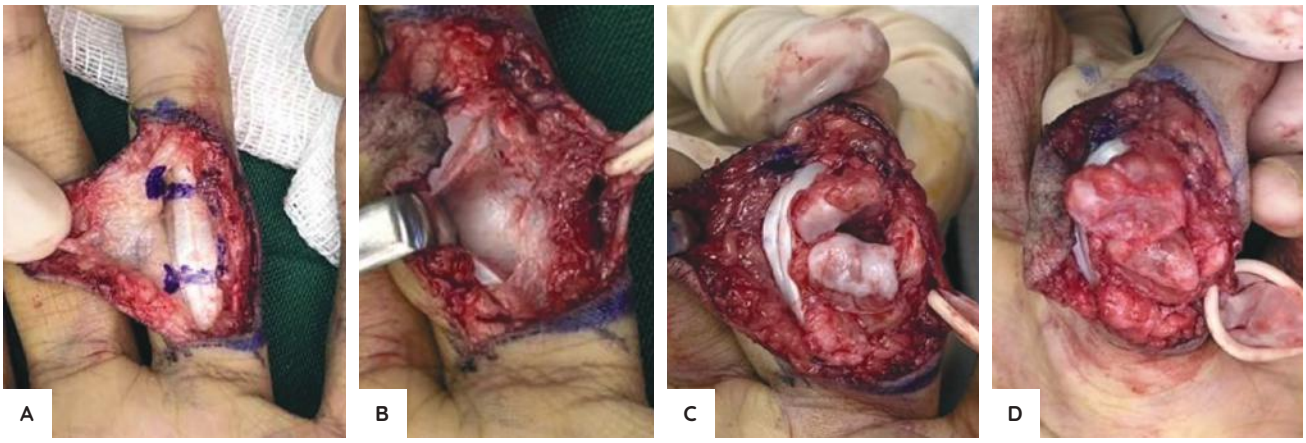

Figure 3. Shows the trapezoidal exposure **(A)**, shotgun exposure of the PIPJ **(B, C)**, and subsequent preparation of the graft recipient site **(D)**.

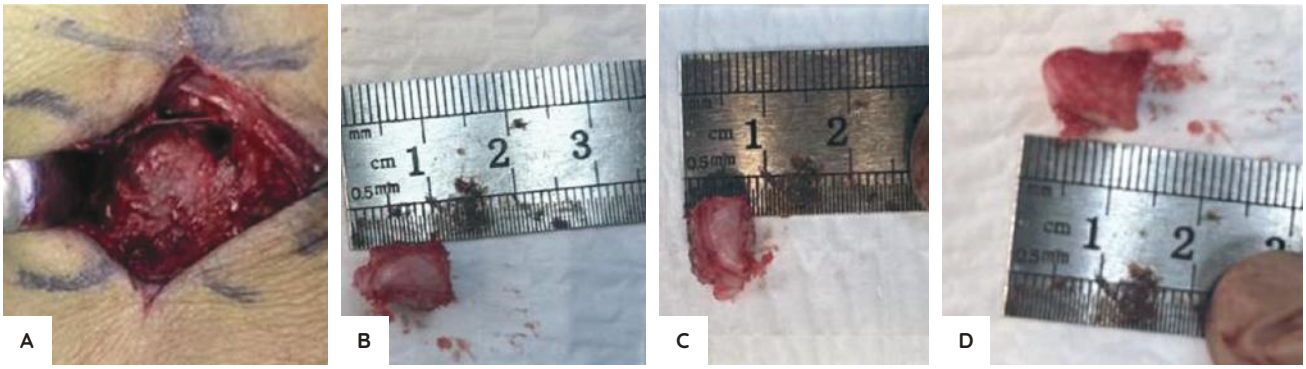

Figure 4. Shows the harvesting of the graft **(A)**, measurement of the graft **(B, C)**, and preparation of the graft **(D)**.

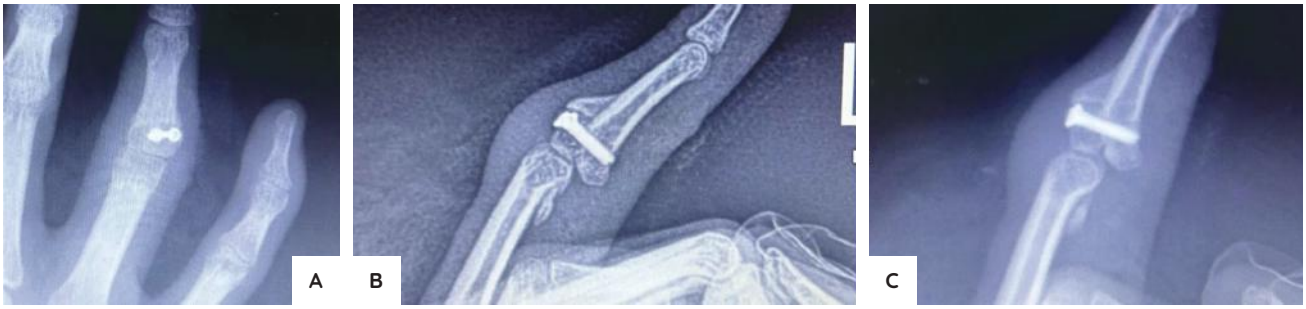

Figure 5. The prepared graft was then secured to the base of the middle phalanx: anteroposterior view **(A)**, lateral view **(B)**, and postoperative lateral view demonstrating graft fixation **(C)**.

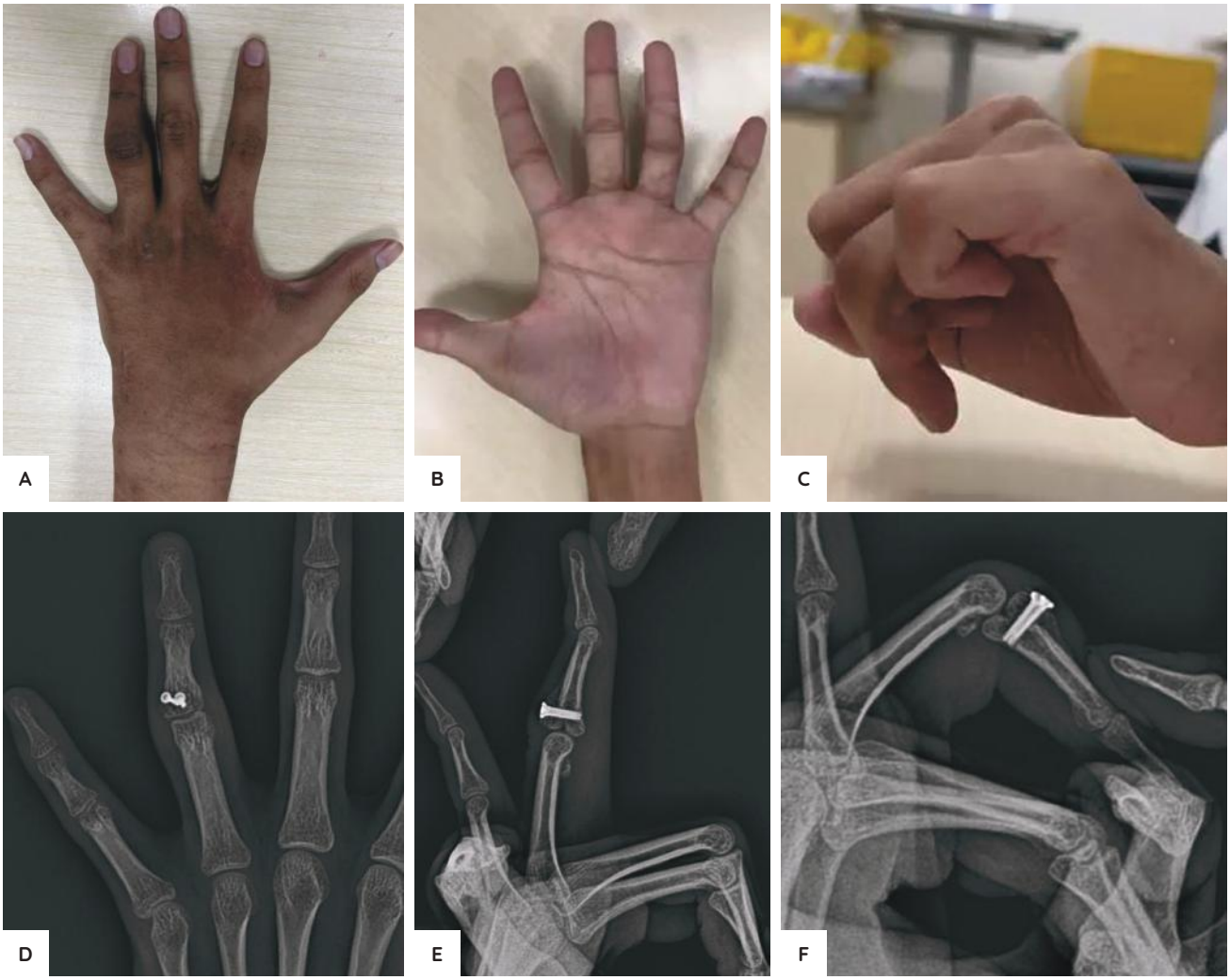

Figure 6. At six weeks postoperatively, wounds were healed. Patient was allowed range of motion as tolerated **(A, B, C)**. X-rays showed partial obliteration of the graft edges, indicating union **(D, E, F)**.

At seven months post op, the patient presented with almost complete resolution of swelling at the PIPJ (Figure 7). Range of motion was 0–90° at the PIPJ and 0–75° at the DIPJ with no extensor lag (Table 1). The good range of motion for the DIPJ was probably due to the stable construct that allowed aggressive range of motion exercises in a motivated patient. The osteochondral graft also shrank in size and was fully incorporated into the middle phalanx, contributing to the improved range of motion. Overall, the patient was satisfied with his functional status with a VAS of 0, FIL-DASH of 10.33, and grip strength 22% weaker than the unaffected hand. The patient had not undergone formal physical rehabilitation but continued to do six-pack hand exercises and stretching of the ring finger.

Table 1. Summary of improvement of range of motion

Follow-up period	PIPJ range of motion active (passive)	DIPJ range of motion active (passive)
Preoperative	Fixed at 60°	20–70° (0–70°)
2 weeks post-op	10–30° (0–45°)	10–20° (10–20°)
3 weeks post-op	10–40° (10–80°)	0–30° (0–30°)
6 weeks post-op	0–90° (0–90°)	0–40° (0–40°)
7 months post-op	0–90° (0–90°)	0–75° (0–75°)

DISCUSSION

Achieving functional range of motion in PIPJ fracture-dislocations has historically been difficult.[7] Our patient's functional outcomes were favorable when compared to existing literature for rHHA. A case report with 10-year follow-up resulted in a ROM of 10–90° of the PIPJ and 20–80° of the DIPJ, but overall patient satisfaction.[2] Another case report with a two-year follow-up resulted in ROM of 10–90° of the PIPJ and 0° of the DIPJ, 100% grip strength compared to the unaffected limb, and overall patient satisfaction.[4]

Low risk of donor site morbidity is another advantage of the hemi-hamate arthroplasty. A systematic review of nine articles with 103 patients reported a low overall morbidity rate of 6.8%; all studies reported pain, with only one patient undergoing revision surgery.[8] Open reduction and internal fixation results in limited PIPJ motion.[5,9,10] Reverse hemi-hamate arthroplasty can be a primary option for patients with

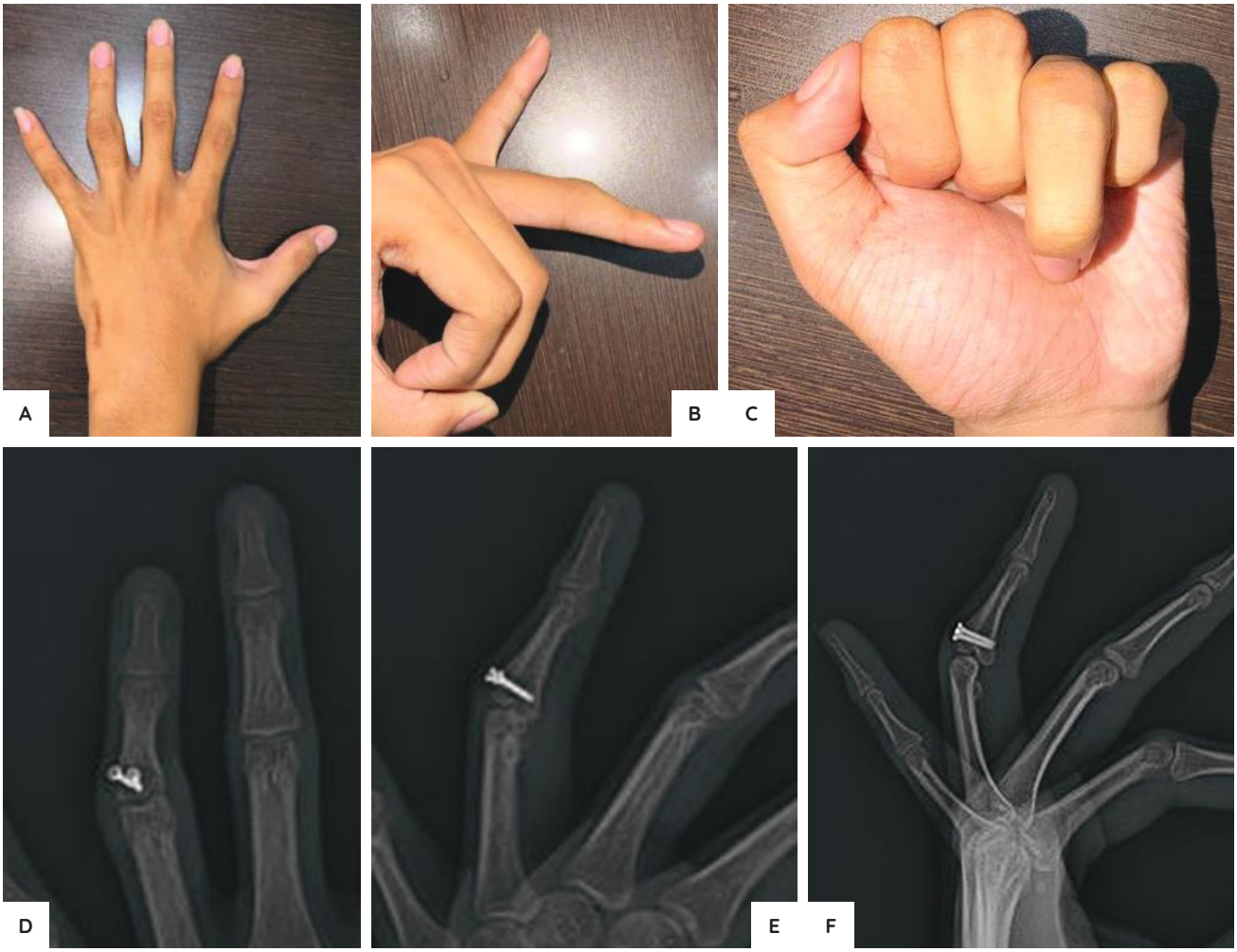

Figure 7. At seven months postoperatively, there was a significant decrease in swelling **(A, B, C)**. The graft was fully incorporated **(D, E, F)**.

comminution of the dorsal lip exceeding 50%, or if fragments are too small to be fixed. The osteochondral graft secured with a low-profile implant allows the patient to have a stable joint for earlier range of motion and therefore less stiffness.

Literature shows different approaches to the reverse hemihamate arthroplasty. One case was approached volarly, as with the usual dorsal fracture dislocation,[2] and the other was approached dorsally.[4] The indication for the dorsal or volar approach lies in the integrity of the central slip mechanism. If the central slip was judged to be intact and attached to the dorsal cortex, a volar approach is used to preserve the central slip. If the central slip was judged to be insufficient,[4] then a dorsal approach is used to also reattach the central slip and reconstruct the extension mechanism. The harvest is similar to the usual hemihamate arthroplasty, but careful trimming is needed to reconstitute the dorsal buttress that was lost in the injury.

CONCLUSION

Reverse hemi-hamate arthroplasty is an effective procedure for chronic volar PIPJ fracture-dislocations. In this case, it provided a stable articular reconstruction that allowed for an excellent functional range of motion (0–90°) and high patient satisfaction with low donor site morbidity despite a three-month delay in treatment. Further studies on outcomes in acutely treated patients should be explored.

ETHICAL CONSIDERATION

Patient consent forms were obtained before manuscript submission.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

ATSCN and MLJL: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data Curation, Writing – original draft preparation, Writing – review and editing, Visualization, Supervision, Project administration; **CECL and EPE:** Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing – original draft preparation, Writing – review and editing, Visualization, Supervision, Project administration.

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.

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None.

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Appropriate footnotes for explanatory purposes or additional information may be placed with proper cross-referencing to the main text, in the following order of usage: *, **, ***

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The manuscript should be written in IMRAD format (Introduction, Methodology, Results and Discussion, Conclusion).

Organize and prepare the manuscript to include the following sections:

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Funding Sources

Funding source/s for the study on which the manuscript is based, to include the writing of the manuscript, should be stated.

Acknowledgments

Contributors to the work who do not fulfill the authorship criteria should be acknowledged.

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Tables should follow references. Each table must be titled and numbered consecutively using Arabic numbers as mentioned in the text. The title should be brief and fully understandable without reference to the text. Each table column and row must have a heading. Tables that indicate the mean should have the corresponding standard deviation. Legends must identify all symbols that appear on the tables and graphs. A maximum of five tables may be included in the manuscript.

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Subject: **SUBMISSION OF MANUSCRIPT FOR PUBLICATION**

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