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Retrograde Intramedullary Headless Cannulated Screw Fixation for Unstable Metacarpal Fractures: A Longitudinal Case Series Study

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Abstract

Background: Metacarpal fractures account for a substantial portion of upper extremity skeletal trauma. Traditional percutaneous stabilization techniques, such as Kirschner wires, often require prolonged rigid external immobilization, predisposing patients to joint stiffness and chronic tendon adhesions. Retrograde intramedullary headless cannulated screws represent a minimally invasive alternative designed to deliver absolute mechanical and rotational stability.

Objective: To evaluate the clinical, radiographic, and functional outcomes of adult patients presenting with unstable extra-articular metacarpal fractures managed via retrograde intramedullary headless cannulated screw fixation.

Materials and Methods: An observational, descriptive, and retrospective longitudinal case series study was executed at the Department of Hand and Upper Limb Reconstructive Surgery of the Hospital Militar Universitario 'Dr. Carlos Arvelo', Caracas, Venezuela. A cohort of 25 adult patients (aged 20 to 60 years) treated between January 2024 and March 2025 was systematically evaluated.

Results: The study group showed a clear male predominance (84%, n=21) with a mean age of 32.4 years. The fifth metacarpal was the most frequently injured anatomical site (56%, n=14), with diaphyseal fractures accounting for 75% (n=19) of the sample. Complete radiographic bone consolidation was achieved in 100% (n=25) of the cohort, with a mean consolidation time of 6.2 weeks. Functional assessment at the final 12-week follow-up revealed an excellent mean total active range of motion (TAM) of 265°, with no reported cases of osteosynthesis material displacement, extensor tendon traction, or deep infection.

Conclusion: Retrograde intramedullary headless cannulated screw fixation constitutes a highly efficient, safe, and reproducible surgical choice for unstable extra-articular metacarpal fractures. It offers exceptional mechanical stability, avoids the need for external immobilization, and guarantees prompt, reliable functional restoration.

Keywords: *Metacarpal fractures; Intramedullary screws; Headless cannulated screw; Functional recovery; Early mobilization; Hand traumatology.*

Introduction

Metacarpal fractures are among the most frequently encountered traumatic skeletal injuries in the upper limb, representing approximately 18% to 44% of all hand fractures [1,2]. These injuries display a peak incidence within young adult males aged between 18 and 34 years, an highly active working population demographic, which translates into a substantial socio-economic, personal, and occupational impact [1,3]. The fifth metacarpal represents the most commonly affected skeletal site, particularly in its subcapital neck region, primarily sustained through high-energy direct impact, axial loading, or direct trauma during physical altercations (the classic 'punch injury'), work-related accidents, or competitive athletic activities [1,4].

The core clinical challenge in managing unstable metacarpal fractures lies in preventing structural malalignment. Inadequate anatomical reduction or biomechanically insufficient internal hardware stabilization frequently induces secondary deformities, including shortening, severe apex-dorsal angulation, or rotational malunions [3,5]. These structural alterations disrupt the delicate intrinsic-extrinsic muscular equilibrium of the hand, leading to compromised grip strength, restricted digital range of motion, and persistent functional deficits [1,6]. Surgical intervention is universally indicated when conservative closed management cannot secure stability, specifically in fractures presenting with a diaphyseal or subcapital displacement greater than 2 mm, apex-dorsal angulation exceeding acceptable parameters, or structural shortening greater than 5 mm [1,3].

While various internal fixation modalities exist, substantial controversy persists regarding the optimal surgical approach that achieves rigid biomechanical stability while minimizing regional soft-tissue disruption. Traditional percutaneous Kirschner wire (K-wire) fixation, though inexpensive and technically simple, lacks adequate rotational control and inherently mandates prolonged external splint immobilization [5]. This prolonged immobilization frequently induces secondary joint stiffness, pin-tract infections, and extensor tendon adhesions [5,7]. Conversely, open reduction and internal fixation (ORIF) with low-profile mini-plates and screws provides rigid structural stability but requires aggressive dorsal periosteal stripping, expanding the risk of extensor apparatus scarring and subsequent tendon tethering [3]. Consequently, minimally invasive alternatives have emerged to overcome these complications.

The clinical implementation of retrograde intramedullary headless cannulated screws (HCS) represents a meaningful paradigm shift in upper extremity traumatology. This technique utilizes the biomechanical benefits of an intraosseous load-sharing construct, achieving rigid interfragmentary compression and absolute rotational control while avoiding extensive soft-tissue dissection [8,9]. By preserving the periosteal blood supply and avoiding the extensor gliding zones, this method permits immediate post-surgical active rehabilitation [7]. This investigation aims to evaluate the clinical, radiographic, and functional outcomes of a longitudinal cohort of 25 patients with unstable extra-articular metacarpal fractures managed via this retrograde intramedullary approach at a specialized hand surgery center.

Materials and Methods

An observational, descriptive, and retrospective longitudinal case series study was executed to evaluate the clinical and radiographic outcomes of unstable metacarpal fractures treated with retrograde internal intramedullary headless cannulated screws. The study protocol was formally evaluated and validated through an institutional clinical consensus meeting at our specialized department, establishing content validity, item clarity, and clinical congruence. The investigation was performed in strict accordance with the ethical tenets of the Declaration of Helsinki. Prior to data collection, written informed consent was explicitly obtained from all patients or their legal guardians.

The study population comprised patients diagnosed with displaced and structurally unstable metacarpal fractures who received medical attention and surgical treatment at the Department of Hand and Upper Limb Reconstructive Surgery of the Hospital Militar Universitario 'Dr. Carlos Arvelo' in Caracas, Venezuela. The study inclusion window spanned from January 2024 to March 2025. A non-probabilistic purposive (intentional) sampling method was utilized, resulting in a final sample of 25 adult patients aged between 20 and 60 years who met all predefined selection criteria.

Inclusion criteria required: 1) Patients who underwent surgical internal stabilization at our department for diaphyseal or subcapital metacarpal fractures using intramedullary headless screws; 2) Fractures presenting with transverse or short oblique fracture lines; 3) Extra-articular, displaced, and structurally unstable metacarpal fractures.

Exclusion criteria comprised: 1) Patients presenting with intra-articular metacarpal fractures or significant articular surface displacement; 2) Patients with skeletally immature or pediatric anatomy; 3) Patients who declined to participate in the long-term clinical follow-up protocol or failed to provide signed informed consent.

The primary data collection technique was direct clinical observation. The analyzed variables included: patient demographics (age and sex), hand dominance, occupation, mechanism of injury, and preoperative imaging findings. Baseline radiographic evaluation was systematically performed using standard anteroposterior (AP) and lateral X-ray views of the affected digit to classify fracture morphology and assess displacement.

Under regional block anesthesia and under fluoroscopic guidance, patients were positioned in the supine position with the affected extremity extended on a radiolucent hand table. Closed reduction of the metacarpal fracture was initially achieved through manual traction and correction of angular or rotational deformities. A minimal dorsal skin incision was performed at the level of the metacarpophalangeal joint, ensuring meticulous protection of the extensor tendon apparatus. A guide wire was introduced into the intramedullary axis of the metacarpal bone, advancing in a retrograde manner under fluoroscopic control across the fracture site. Following intramedullary reaming over the wire, a headless cannulated screw (diameters ranging from 3.0 mm to 4.0 mm, tailored to the specific medullary canal diameter) was inserted, achieving rigid interfragmentary compression and absolute rotational stability. Final alignment and implant depth were verified via fluoroscopy to ensure the screw remained entirely intraosseous and subsurface to the subchondral bone, preserving joint congruity.

No prolonged post-surgical external immobilization was used, allowing for early active mobilization starting within the first postoperative week to prevent joint stiffness and tendon adhesions. Longitudinal follow-up evaluations were systematically scheduled at regular intervals. Collected data were initially compiled into a Microsoft Excel 2023 spreadsheet and subsequently exported into the SPSS version 21 statistical software suite for processing. Descriptive statistics were deployed to analyze the data; continuous variables were expressed as means, medians, and standard deviations, while categorical variables were expressed as absolute frequencies and percentages.

Results

The study sample comprised 25 adult patients with unstable extra-articular metacarpal fractures. A pronounced male predominance was observed, accounting for 84% (n = 21) of the cases, while females represented 16% (n = 4). The mean age of the cohort was 32.4 ± 8.6 years (range: 20 to 57 years), concentrating primarily within the highly active working-age population. Regarding hand dominance, the injury affected the dominant hand in 72% (n = 18) of the patients. The most frequent mechanisms of injury were direct trauma or collision during physical altercations (the classic 'punch injury') in 48% (n = 12) of the cases, followed by occupational/work-related accidents in 32% (n = 8), and sports-related trauma in 20% (n = 5).

The fifth metacarpal was the most frequently injured bone, accounting for 56% (n = 14) of the sample, followed by the fourth metacarpal in 24% (n = 6), the third metacarpal in 12% (n = 3), and the second metacarpal in 8% (n = 2). In terms of fracture topography along the bone axis, diaphyseal shaft fractures predominated with 75% (n = 19) of the total, while subcapital (neck) fractures constituted 25% (n = 6). Radiographic fracture line analysis revealed that 68% (n = 17) were transverse patterns and 32% (n = 8) were short oblique lines (Table 1). A representative example of a displaced fourth metacarpal shaft fracture screening profile and its baseline status can be observed in [Figure 1].

Rigid stabilization using retrograde intramedullary headless cannulated screws permitted immediate post-surgical rehabilitation. Technical intraoperative verification of anatomical reduction, axial tracking, and complete subsurface hardware compression within the bony canal was systematically performed using dual-plane fluoroscopy [Figure 2]. Structural radiographic bone consolidation (defined by cortical bridging callus and disappearance of the fracture line) was successfully achieved in 100% (n = 25) of the patients, with a mean consolidation time of 6.2 ± 1.4 weeks (range: 5 to 9 weeks). No cases of delayed union, nonunion, or secondary loss of reduction were reported.

Functional outcomes were highly favorable at the final 12-week follow-up. The mean Total Active Motion (TAM) score achieved was 265° ± 12.5°, indicating excellent functional recovery according to the American Society for Surgery of the Hand (ASSH) criteria.

Objective clinical documentation at the conclusion of follow-up confirmed excellent fist formation, complete extension, and absolute anatomical alignment of the digital axes without residual rotational abnormalities [Figure 3]. Postoperative pain, measured via the Visual Analog Scale (VAS), decreased from a mean preoperative score of 7.8 ± 1.2 to 0.4 ± 0.5 points at week 12. No major complications, such as hardware failure, backing out of the screw, persistent extensor tendon tethering, deep infection, or neurological alterations (with a negative two-point discrimination test), were encountered in this series (Table 2).

Table 1. Clinico-Anatomical Distribution of Metacarpal Fractures (N = 25).

Variable	Sub-category	Frequency (n)	Percentage (%)
Sex	Male	21	84.0%
	Female	4	16.0%
Affected Bone	2nd Metacarpal	2	8.0%
	3rd Metacarpal	3	12.0%
	4th Metacarpal	6	24.0%
	5th Metacarpal	14	56.0%
Anatomical Zone	Subcapital (Neck)	6	25.0%
	Diaphyseal (Shaft)	19	75.0%
Fracture Line	Transverse	17	68.0%
	Short Oblique	8	32.0%

Table 2. Longitudinal Clinical and Functional Outcomes (N = 25).

Outcome Metric	Baseline / Preoperative	Postoperative (Week 4)	Final Follow-up (Week 12)
Radiographic Union (%)	0.0%	40.0% (n=10)	100.0% (n=25)
Mean VAS Pain Score	7.8 ± 1.2	1.8 ± 0.6	0.4 ± 0.5
Mean TAM Arc (Degrees)	—	220° ± 18.4°	265° ± 12.5°
Complications (n)	—	0	0

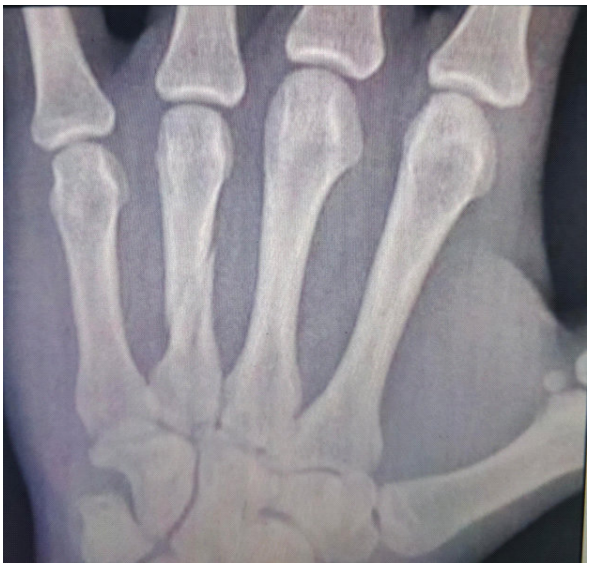

Figure 1. *Anteroposterior X-ray view of the left hand, showing a displaced diaphyseal fracture of the fourth metacarpal.*

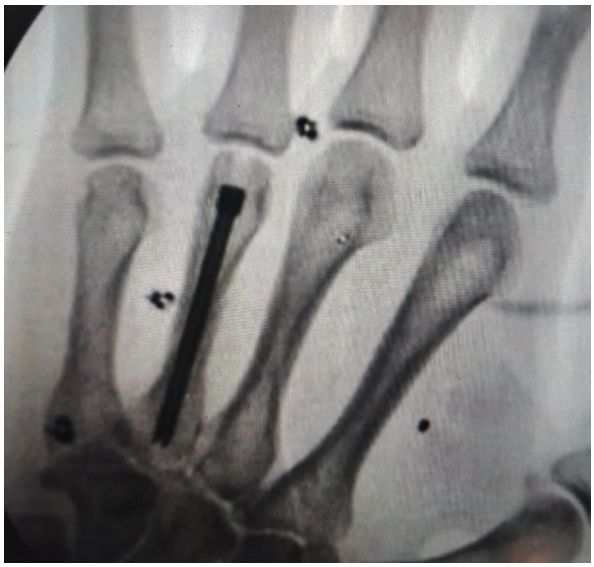

Figure 2. *Intraoperative fluoroscopic views demonstrating retrograde intramedullary headless cannulated screw fixation of the fourth metacarpal fracture.*

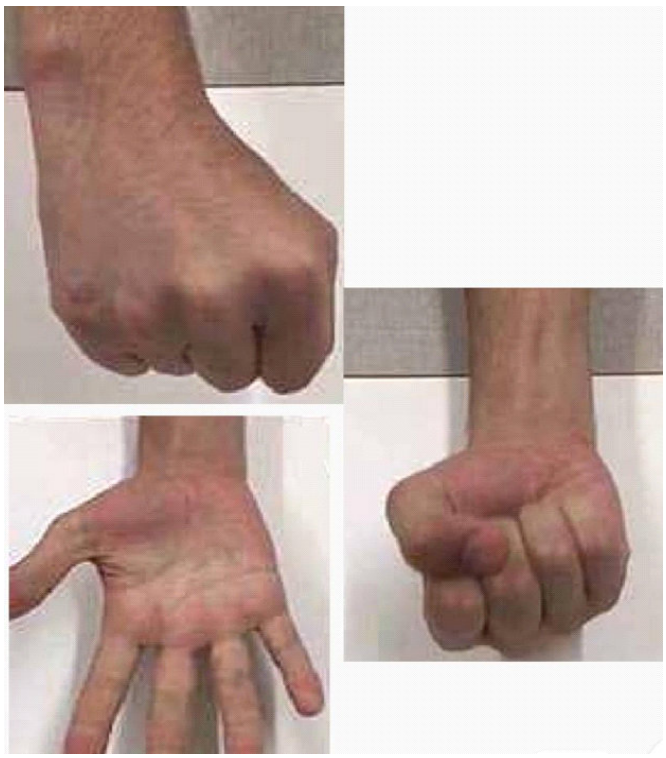

Figure 3. Clinical photographs at the final 12-week postoperative follow-up. The panel demonstrates excellent functional recovery with full digital extension, complete fist formation (Total Active Motion arc of 265°), and absolute restoration of the digital rotational axis without cascade deformity.

Discussion

The surgical management of unstable extra-articular metacarpal fractures continues to evolve toward internal stabilization techniques that minimize morbidity and optimize regional soft-tissue functionality. In our current investigation, internal stabilization using retrograde intramedullary headless cannulated screws led to an outstanding 100% bone consolidation rate and remarkable functional parameters. One of the most critical advantages documented in this study was the ability to completely bypass post-surgical external splint immobilization, allowing for immediate postoperative active physical rehabilitation. This finding strongly correlates with the clinical principles described by Tobert et al. [7], who emphasized that intramedullary bone-splinting eliminates long-term joint immobilization, dramatically reducing secondary stiffness and acceleration toward functional independence.

When contrasted with traditional structural fixation modalities, the retrograde HCS technique offers superior mechanical and soft-tissue advantages. Percutaneous Kirschner wires, historically favored due to simplicity, often fail to deliver sufficient interfragmentary compression or absolute rotational control, resulting in pin-tract infections, thermal bone necrosis, or wire migration [5]. In a comparative clinical trial, Couceiro et al. [5] demonstrated significantly superior long-term Total Active Motion (TAM) scores in patient cohorts undergoing intramedullary screw fixation compared to those managed with traditional K-wires, matching the exceptional recovery curves documented in our current series.

Furthermore, while open internal fixation with low-profile mini-plates and screws provides rigid stability, it requires aggressive periosteal stripping and extensive dorsal soft-tissue dissection [3]. This open exposure significantly expands the risk of extensor tendon adhesions, regional scarring, and persistent soft-tissue contraction. As demonstrated by Esteban-Feliu et al. [3], plates are mechanically reliable but carry a higher complication profile regarding hardware prominence and subsequent tendon tethering. Conversely, our minimally invasive retrograde entry technique preserves the crucial surrounding periosteal vascular network and shields the extensor tendon gliding planes, avoiding the need for secondary hardware removal.

From a biomechanical perspective, intramedullary headless screws function as a structural load-sharing device that provides exceptional resistance against bending and torsional forces. Biomechanical loading trials performed by Avery et al. [9] and Labèr et al. [10] confirmed that headless cannulated screws successfully withstand early active motion cycles without mechanical failure. This robust biomechanical foundation matches the complete absence of secondary implant displacement, backing out, or hardware deformation observed throughout our 25-patient longitudinal follow-up.

We acknowledge that this study presents certain limitations, including its retrospective nature, the absence of a direct comparative intervention group, and a relatively concise sample size from a single medical institution. Nonetheless, the absolute bone union rates and outstanding TAM parameters demonstrate that retrograde headless cannulated screws represent a highly effective, safe, and reproducible primary treatment alternative for unstable extra-articular metacarpal fractures, ensuring excellent soft-tissue preservation and early functional restoration.

Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no competing interests.

Financial Disclosure: This research was completely self-funded by the authors. No external grants, commercial funding, or institutional financial support were received.

Ethical Approval: All procedures performed in this study involving human participants were in strict compliance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments. The study protocol was formally reviewed and validated through an institutional clinical consensus meeting at the specialized department.

Informed Consent: Explicit written informed consent was routinely obtained from all individual adult participants or their legal guardians included in the study prior to data extraction.

Authors' Contributions

- **Campanella S:** Contributed to the conceptualization of the study, surgical methodology design, and data acquisition.
- **Chávez M:** Handled data curation, technical validation of regional soft-tissue parameters, and specific literature review.
- **Leal J:** Executed quantitative data analysis, structured the statistical distribution, translated and drafted the manuscript, and managed corresponding editorial communication.
- **Castillo R:** Critically reviewed the manuscript for intellectual content, updated surgical and clinical terminology, and gave final approval for submission.

References

1. Nakashian MN, Pointer L, Owens BD, Wolf JM. Incidence of metacarpal fractures in the US population. Hand (N Y). 2012;7(4):426-430.
2. de Jonge JJ, Kingma J, van der Lei B, Klasen HJ. Fractures of the metacarpals. A retrospective study of 1218 cases. Injury. 2012;25(7):433-436.
3. Esteban-Feliu I, et al. Internal fixation of metacarpal and phalangeal fractures with plates and screws. J Hand Surg Eur Vol. 2018;43(4):385-391.
4. Kollitz KM, Hammert WC, Vedder NB, Huang JI. Metacarpal fractures: treatment and complications. J Am Acad Orthop Surg. 2014;22(9):593-602.
5. Couceiro J, et al. Headless cannulated screws versus Kirschner wires for the treatment of unstable metacarpal fractures: a comparative study. J Hand Surg Am]. 2015;40(2):285-291.
6. Souer RC, et al. Functional outcomes following surgical stabilization of displaced metacarpal shaft fractures. Hand (N Y). 2013;8(2):171-176.
7. Tobert DG, et al. Early active mobilization versus cast immobilization after intramedullary screw fixation of metacarpal fractures. J Hand Surg Am. 2021;46(1):15-22.
8. del Piñal F, et al. Minimally invasive fixation of metacarpal fractures with intramedullary cannulated headless screws. Hand Clin. 2014;30(2):241-250.
9. Avery DM, et al. Biomechanical comparison of internal fixation techniques for metacarpal shaft fractures. J Hand Surg Am. 2017;42(7):521-527.
10. Labèr R, et al. Torsional rigidity and load to failure of headless intramedullary screws in metacarpal neck fractures. J Biomech. 2019;86:112-118.