Original Article

Cukurova Anestezi ve Cerrahi Bilimler Dergisi

Clinical and Radiological Outcomes of Intramedullary Screw and Plate-Screw Fixation in Extra-Articular Metacarpal Fractures: A Comparative Study

Ali Said Nazlıgül[1], *Nuri Koray Ülgen*[1], *Nihat Yiğit*[1], *Yasin Erdoğan*[2], *Şahan Güven*[3], *Mehmet Orçun Akkurt*[1]

[1] Department of Orthopaedics and Traumatology, Sincan Training and Research Hospital, Ankara, Turkey
[2] Department of Orthopaedics and Traumatology, Etlik City Hospital, Ankara, Turkey
[3] Department of Orthopaedics and Traumatology, Ankara Bilkent City Hospital, Ankara, Turkey

Correspondence: Ali Said Nazlıgül, MD; alisaid012@hotmail.com

Abstract

Introduction: The aim of this study was to compare the clinical and radiological outcomes of intramedullary headless compression screw fixation and plate-screw fixation in metacarpal shaft and neck fractures, and to evaluate the effectiveness of both treatment methods. **Methods:** Fifty-three patients (aged 18–65) treated between June 2023 and June 2025 were retrospectively reviewed. Patients with a minimum of 6 months follow-up who were treated with either an intramedullary (IM) headless compression screw or plate-screw (PS) fixation were included in the study. Demographic data, the affected metacarpal, QuickDASH scores, grip strength, total active motion (TAM), time to return to work, time to union, and postoperative complications were recorded. Statistical significance was set at p<0.05. **Results:** The study evaluated 24 IM and 29 PS patients. Groups were comparable regarding demographics and fracture morphology (p>0.05). The IM group demonstrated significantly lower QuickDASH scores (p=0.029), higher grip strength (p=0.025), and greater TAM (p<0.001). Furthermore, time to return to work (p=0.001) and radiological union (p=0.045) were significantly shorter in the IM group. While deep infection and implant irritation occurred only in the PS group, complication rates were statistically similar between cohorts (p>0.05). **Conclusion:** The findings of this study suggest that IM screw fixation may provide better functional outcomes, along with shorter times to return to work and fracture union, compared with plate-screw fixation for extra-articular metacarpal fractures. Its minimally invasive nature and comparable safety profile make it an effective treatment option for appropriately selected patients.

Keywords: Fracture fixation; hand injuries; metacarpal bones

Received: 05.05.2026
Accepted: 23.06.2026
Published: 30.06.2026

1. Introduction

Metacarpal fractures are common injuries that constitute a significant proportion of upper extremity trauma and account for approximately 30–40% of all hand fractures[1,2]. They occur most frequently in young individuals and may lead to functional limitations in daily activities as well as loss of work capacity[3,4]. Given the essential role of the metacarpals in grip strength and fine motor function of the hand, the goal of treatment is not only to achieve radiological union but also to preserve painless motion, strong grip, and full joint range of motion as much as possible[5,6].

Although a substantial proportion of metacarpal fractures can be successfully managed with conservative treatment when they are closed, stable, and minimally displaced, surgical intervention becomes necessary in the presence of significant angulation, shortening, rotational deformity, or comminution[5–7]. Various surgical techniques have been described, including closed reduction with percutaneous K-wire fixation, intramedullary headless compression screws, and plate-screw systems[5,8,9]. In recent years, intramedullary headless compression screws have gained popularity due to their minimal soft tissue dissection, ability to provide stable internal fixation allowing early joint mobilization, shorter operative time, and low implant profile[8,10]. However, retrograde insertion of the screw through the joint is considered a potential disadvantage because of concerns regarding articular cartilage injury, intra-articular irritation, and the risk of long-term degenerative changes[11].

Plate-screw systems, particularly in unstable and comminuted fractures, remain a widely used surgical option due to their ability to provide strong mechanical stability[5]. However, the more extensive soft tissue dissection required for plate fixation has been associated with complications such as extensor tendon scarring, tendon adhesions, joint stiffness, implant irritation, infection, and the need for implant removal[5,12]. Therefore, in the surgical management of metacarpal fractures, increasing emphasis has been placed on selecting fixation strategies that optimize both biomechanical stability and functional outcomes.

Although numerous studies in the literature have independently evaluated the clinical and radiological outcomes of metacarpal fractures treated with intramedullary screw fixation or plate-screw fixation, the number of studies directly comparing these two techniques and simultaneously assessing functional outcomes, complication rates, and radiological parameters remains relatively limited[10,13]. In this context, a comparative evaluation of the clinical and radiological outcomes of intramedullary screw and plate-screw fixation in metacarpal fractures represents a relevant and timely research topic that may help clarify surgical indications and contribute to the rational development of treatment algorithms. Therefore, the aim of this study was to compare the clinical and radiological outcomes of intramedullary headless compression screw fixation and plate-screw fixation in extra-articular metacarpal fractures.

2. Methods

2.1.Study Design and Ethical Approval

This retrospective study included patients who underwent surgical treatment for metacarpal fractures between June 2023 and June 2025. The study was conducted in accordance with the principles of the Declaration of Helsinki and received approval from the institutional ethics committee (SEAH-BAEK2025-127).

2.2.Inclusion and Exclusion Criteria

Patients were selected based on the following inclusion criteria:

- Aged 18–65 years with acute, traumatic, closed, metacarpal shaft or neck fractures.
- Surgical treatment with either an intramedullary (IM) headless compression screw or plate-screw (PS) fixation.
- Minimum clinical and radiological follow-up of 6 months.

Exclusion criteria included:

- Open or pathological fractures.
- Fractures with intra-articular extension (metacarpal head or base involvement).
- Multiple hand fractures or associated phalangeal injuries.
- History of previous surgery on the affected hand or chronic neurological conditions.

2.3.Surgical Indications and Technique Selection

Surgical intervention was indicated for unstable fractures characterized by >30° of volar angulation, >3 mm of shortening, or significant rotational deformity. Both surgical techniques were applied to similar fracture patterns, including transverse, oblique, spiral, and multifragmentary morphologies. The choice of technique was determined by the surgeon's preference or institutional protocol at the time of injury.

2.4.Surgical Techniques

Group 1 (IM Screw): For patients in the intramedullary group, fractures were initially managed with an attempt at closed reduction under fluoroscopic guidance. In cases where anatomical alignment could not be satisfactorily achieved or maintained, a mini-open approach was performed via a limited dorsal incision to facilitate reduction. Following reduction, a guidewire was inserted through a retrograde intra-articular entry point on the central–dorsal portion of the metacarpal head cartilage. A cannulated headless compression screw was then advanced into the medullary canal and buried completely beneath the articular surface. Standard fully threaded, variable-pitch headless compression screws (BNL, Türkiye) were utilized. The appropriate screw diameter was selected based on the narrowest diameter of the metacarpal medullary canal measured on preoperative radiographs. Screw length was determined intraoperatively using a depth gauge under fluoroscopy. The length was chosen to ensure that the screw adequately spanned the fracture site to achieve maximum compression via its variable-pitch design, while ensuring the screw was completely buried beneath the articular cartilage distally and did not breach the subchondral bone of the metacarpal base proximally.

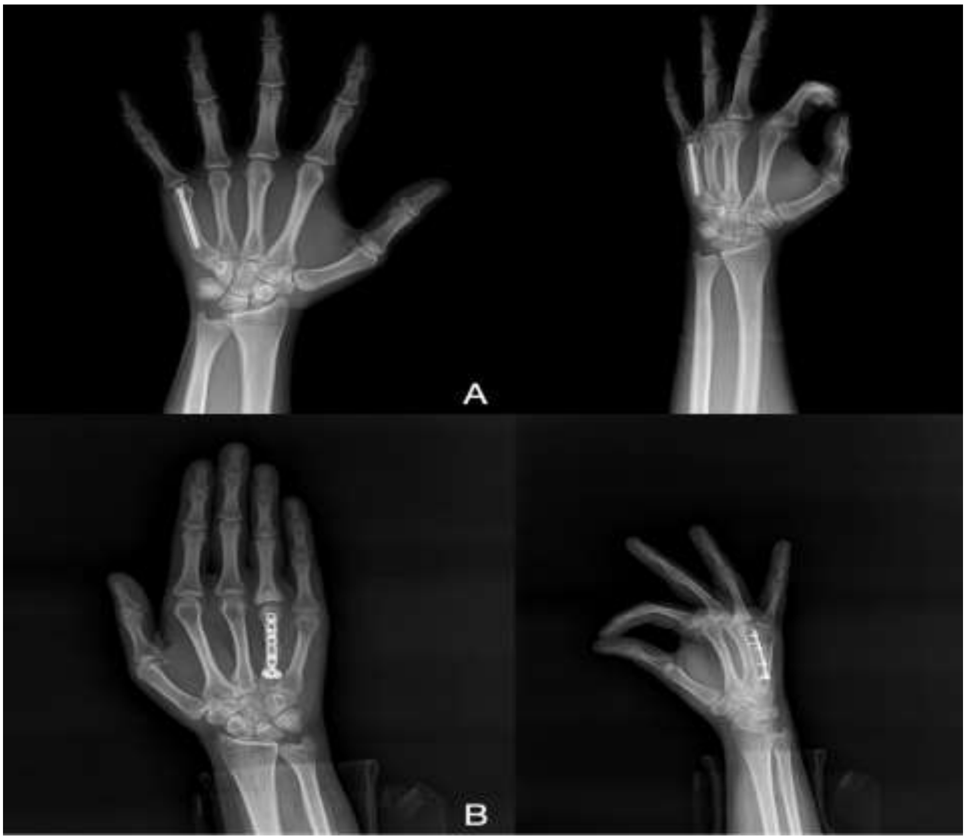

Figure 1. Representative radiological images of the treatment groups.

(A) 6-month postoperative anteroposterior and oblique radiographs of a patient treated with fully threaded intramedullary headless compression screw fixation. (B) 6-month postoperative radiographs of a patient treated with plate-screw fixation, demonstrating complete fracture union.

Group 2 (PS Fixation): A standard dorsal longitudinal incision was utilized to expose the fracture site[14,15]. Open reduction was achieved under direct visualization, ensuring the protection of the extensor tendons. Definitive internal fixation was performed using a low-profile titanium mini-plate and screws (Northmed, Türkiye).

Representative 6-month postoperative radiographs of both treatment groups are shown in Figure 1.

2.5.Postoperative Rehabilitation

To ensure standardization, a uniform postoperative rehabilitation protocol was applied to all patients regardless of the fixation technique. In both the IM and PS groups, the operated hand was immobilized in a functional short-arm dorsal splint for one week postoperatively. Following this one-week period, the splint was removed, and early active range of motion exercises for the fingers and wrist were initiated under the guidance of a hand therapist.

2.6.Outcome Measures and Measurement Protocol

Clinical outcomes were assessed at the 6-month follow-up, which was a standard component of our institution's routine postoperative rehabilitation and monitoring protocol. The recorded measurements were retrospectively extracted from the clinical charts. During these routine visits, measurements were performed by two blinded orthopedic surgeons. Each parameter was measured three times, and the average value was recorded.

• Functional scores: Evaluated using the QuickDASH (Quick Disability of the Arm, Shoulder, and Hand) score.

• Range of motion: Total active motion (TAM) was measured using a manual goniometer.

• Strength: Grip strength was assessed using a Jamar® hand dynamometer.

• Return to Work: Defined as the time (in weeks) elapsed from the date of surgery until the patient completely resumed their pre-injury employment or daily functional activities without restriction. This data was collected based on patient self-reporting during follow-up visits.

• Radiological Assessment: Fracture union was defined as the presence of bridging callus in at least three out of four cortices on anteroposterior and oblique radiographs.

2.7.Statistical Analysis

Data analysis was performed using IBM SPSS Statistics version 25.0 (IBM Corporation, Armonk, NY, USA). The normality of continuous variables was assessed using the Shapiro–Wilk test. Descriptive statistics were presented as number (n) and percentage (%) for categorical variables, and as mean ± standard deviation or median (25th–75th percentiles) for continuous variables, depending on data distribution. Comparisons between two independent groups were conducted using the Mann–Whitney U test for continuous variables that did not follow a normal distribution. Categorical variables were analyzed using Fisher's exact test or the chi-square test, as appropriate, based on cell frequencies. A p value <0.05 was considered statistically significant.

Due to the retrospective design of the study, no a priori sample size calculation was performed. However, a post hoc power analysis was conducted using G*Power version 3.1 (Heinrich Heine University, Düsseldorf, Germany). Although group comparisons were performed using the Mann–Whitney U test, effect sizes were estimated by converting the Mann–Whitney U statistics to standardized effect sizes (Cohen's d), which were then used for power calculations. Based on the observed effect sizes, the achieved statistical power was 0.65 for the QuickDASH score (d = 0.65), 0.66 for grip strength (d = 0.65), 0.99 for total active motion (d = 1.55), 0.97 for return-to-work time (d = 1.04), and 0.58 for union time (d = 0.60), at an alpha level of 0.05.

Table 1. Demographic characteristics of the study groups

	Intramedullary Screw (n = 24)	Plate-Screw (n = 29)	p value
Age (years), median (IQR)	24 (21–37)	27 (22–39)	0.35[a]
Sex, n (%)			
Male	19 (79.2)	24 (82.8)	1.00[b]
Female	5 (20.8)	5 (17.2)	
Side, n (%)			
Right	16 (66.7)	19 (65.5)	1.00[b]
Left	8 (33.3)	10 (34.5)	
Affected metacarpal, n (%)			0.88[c]
2nd	3 (12.5)	2 (6.9)	
3rd	5 (20.8)	5 (17.2)	
4th	6 (25.0)	8 (27.6)	
5th	10 (41.7)	14 (48.3)	
Diabetes mellitus, n (%)			0.58[b]
Yes	2 (8.3)	1 (3.4)	
No	22 (91.7)	28 (96.6)	
Smoking, n (%)			1.00[b]
Yes	8 (33.3)	9 (31.0)	
No	16 (66.7)	20 (69.0)	
AO/OTA Classification, n (%)			0.99[c]
Simple (Type A)	13 (54.2)	15 (51.7)	
Wedge (Type B)	6 (25.0)	8 (27.6)	
Multifragmentary (Type C)	5 (20.8)	6 (20.7)	

[a] Mann–Whitney U test. [b] Fisher's exact test. [c] Chi-square test.

3. Results

A total of 53 patients with acute, traumatic, extra-articular metacarpal fractures were evaluated, including 24 in the intramedullary (IM) screw group and 29 in the plate-screw (PS) group. The median age of the study population was 24 years (IQR: 21–37) for the IM group and 27 years (IQR: 22–39) for the PS group (p=0.35), with no significant differences found between the cohorts regarding sex, affected side, involved metacarpal, or comorbidities such as diabetes and smoking (p>0.05) (Table 1).

Fracture morphology was classified using the AO/OTA system as strictly extra-articular, involving the metacarpal shaft and neck (Table 1). Both groups demonstrated a balanced distribution of complexity, including simple (Type A), wedge (Type B), and multifragmentary (Type C) patterns (Table 1).

Table 2. Functional and clinical outcomes

	Intramedullary Screw (n = 24)	Plate-Screw (n = 29)	p value
QuickDASH, median (IQR)	0.0 (0.0–5.1)	5.9 (3.2–7.0)	0.029[a]
Grip strength (kg), median (IQR)	39.2 (32.9–42.5)	33.9 (27.2–38.6)	0.025[a]
TAM (degrees), median (IQR)	245 (237–253)	221 (211–234)	<0.001[a]
Return to work (weeks), median (IQR)	8.5 (7–9)	10.0 (9–11)	0.001[a]
Union time (weeks), median (IQR)	7.0 (6–8)	8.0 (7–9)	0.045[a]

Values are presented as median (interquartile range). [a] Mann–Whitney U test. QuickDASH: Quick Disability of the Arm, Shoulder, and Hand. TAM: Total Active Motion.

Regarding clinical outcomes at the 6-month follow-up, the IM group achieved significantly superior functional results, demonstrated by a lower median QuickDASH score of 0.0 compared to 5.9 in the PS group (p=0.029) and a significantly higher median grip strength of 39.2 kg versus 33.9 kg (p=0.025). Notably, the IM group showed a significantly greater median total active motion (TAM) of 245° compared to 221° in the PS group (p<0.001). The recovery profile was also significantly faster in the IM group, with a shorter median time to return to work (8.5 weeks vs. 10.0 weeks; p=0.001) and an earlier median radiological union (7.0 weeks vs. 8.0 weeks; p=0.045) (Table 2).

No cases of nonunion were observed in either treatment group. While superficial infection and delayed union rates were similar (p=1.000), complications such as deep infection (6.9%), implant irritation (13.8%), and the subsequent need for implant removal (13.8%) occurred exclusively in the plate-screw group (Table 3), although these differences did not reach statistical significance (p>0.05) (Table 3).

Table 3. Postoperative complications

	Intramedullary Screw (n = 24)	Plate-Screw (n = 29)	p value
Nonunion	0 (0)	0 (0)	1.000[a]
Delayed union	1 (4.2)	2 (6.9)	1.000[a]
Superficial infection	1 (4.2)	2 (6.9)	1.000[a]
Deep infection	0 (0)	2 (6.9)	0.495[a]
Implant irritation	0 (0)	4 (13.8)	0.117[a]
Implant removal	0 (0)	4 (13.8)	0.117[a]

Values are presented as number (%). [a] Fisher's exact test.

4. Discussion

Various fixation methods are available for the surgical treatment of metacarpal fractures; however, there is currently no fixation technique accepted as the gold standard in the literature. In this study, the clinical and radiological outcomes of intramedullary headless compression screw fixation and plate-screw fixation in metacarpal fractures were compared, and intramedullary screw fixation was observed to provide more favorable results in terms of time to return to work and functional outcomes. The lower QuickDASH scores, higher grip strength, greater total active motion (TAM), shorter time to return to work, and faster fracture union observed in the intramedullary screw group suggest that the reduced extent of soft tissue dissection required by this technique may have contributed to the improved clinical outcomes.

Recent studies in the literature have reported that intramedullary fixation yields functional outcomes that are at least comparable to, and in some parameters superior to, alternative techniques such as plate-screw fixation and K-wire fixation. In the meta-analysis published in 2025 by DelPrete et al., patients treated with intramedullary screws demonstrated significantly lower DASH scores, higher grip strength, and lower reoperation rates compared with those treated with plate-screw or K-wire fixation[16]. Similarly, in the systematic review by Beck et al., a 100% union rate, the ability to make a full fist, and the absence of major complications were reported following intramedullary fixation in 169 metacarpal fractures[17]. The lower QuickDASH scores (p=0.022), higher grip strength (p=0.021), and greater total active motion (TAM) values (p<0.001) observed in our study are consistent with these findings and suggest that intramedullary fixation may offer functional advantages.

Published clinical series have reported that intramedullary fixation provides stable fixation that allows early mobilization and is associated with satisfactory functional outcomes. In a series of 20 patients, Ruchelsman et al. reported full active extension by the third postoperative week, radiographic union by the sixth week, and a mean contralateral grip strength of 105%, with no cases requiring secondary surgery[18]. In a retrospective study including 91 patients, Eisenberg et al. observed full functional range of motion at a mean of 10 weeks in all patients, radiographic union at 6 weeks in 76% of cases, and a minor complication rate of only 3% (MCP flexion <65°)[19]. Similarly, in a series of 48 metacarpal fractures, Del Piñal et al. reported a mean total active motion (TAM) of 249° and a mean return-to-work time of 76 days, with all patients returning to full work and sports activities[20]. In our study, the higher TAM values, shorter time to return to work, and faster fracture union observed in the intramedullary group are consistent with these clinical series and suggest that intramedullary fixation may represent an effective option in terms of functional outcomes.

When complications associated with plate-screw fixation are considered, recent studies suggest that although complication rates have decreased over time, similar issues continue to be reported. In the classic series published in 1998 by Page and Stern, major complications—including stiffness, nonunion, plate irritation, infection, and tendon rupture—were observed in 36% of 63 metacarpal fractures treated with conventional plate fixation, and total active motion (TAM) exceeding 220° was achieved in only 76% of patients[21]. Similarly, in a study of 104 metacarpal fractures, Fusetti et al. reported an overall complication rate of 35%, with notable rates of union-related problems, stiffness, and implant-related issues[12]. Although the introduction of low-profile plates has been associated with reduced complication rates, Baumgartner et al. reported a complication rate of 10% in a series of 110 metacarpal fractures published in 2021[22]. In the present study, complication rates in the plate-screw group were also higher than those in the intramedullary group; however, this difference did not reach statistical significance.

One of the main concerns regarding intramedullary screw fixation is potential cartilage injury related to retrograde intra-articular entry through the metacarpal head. However, recent three-dimensional computed tomography (3D-CT) studies have demonstrated that this effect is limited. In a quantitative 3D-CT analysis by ten Berg et al., use of a 3.0-mm headless screw affected only 4–5% of the metacarpal head surface area and approximately 4% of the subchondral volume; moreover, the screw entry point did not contact the base of the proximal phalanx throughout most of the range of motion[23]. Similarly, Bachoura et al. also reported limited involvement of the articular surface[24]. These findings suggest that the dorsal entry point is located in a functionally less critical region of the metacarpal head. In the present study, no clinically significant intra-articular complications were observed in the intramedullary group during follow-up. Nevertheless, longer-term follow-up may be required to adequately assess potential long-term effects, particularly in young and highly active patients.

The strengths of this study include the comparison of two surgical groups treated at a single center with similar indications, as well as the comprehensive evaluation of functional and radiological outcomes together with complication rates. However, the retrospective study design, the relatively small sample size, the lack of randomization, and the insufficient follow-up duration to fully assess long-term degenerative changes should be considered the main limitations of this study.

5. Conclusion

Intramedullary headless compression screw fixation appears to be an effective treatment option for metacarpal shaft and neck fractures, providing favorable functional outcomes, earlier return to work, and shorter time to union compared with plate-screw fixation, while demonstrating a comparable complication profile. Owing to its minimally invasive nature and limited soft tissue dissection, intramedullary fixation may be particularly advantageous in extraarticular fracture patterns. Nevertheless, further prospective studies with larger sample sizes and longer follow-up periods are warranted to better define its long-term outcomes and optimal indications.

genAI: No artificial intelligence-based tools or generative AI technologies were used in this study. The entire content of the manuscript was originally prepared, reviewed, and approved by all authors.

Statement of Ethics: The study was initiated with the approval of the Sincan Training and Research Hospital Clinical Researches Ethics Committee (Date: 2025, Decision No: SEAH-BAEK2025-127). The study was performed according to the Declaration of Helsinki. Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Data Availability: The data supporting the conclusion of this article will be available by the authors without undue reservation.

Funding: The authors declared that this study has received no financial support.

Conflict of Interest: The authors have no conflicts of interest to declare.

Author Contributions: Concept: ASN, MOA; Design: ASN, ŞG, MOA; Literature search: YE, NY; Data Collection and Processing: ASN, YE, NY; Analysis or Interpretation: NKÜ, MOA, ŞG; Writing (Original Draft Preparation): ASN, NKÜ, YE; Critical Revision (Review and Editing): MOA, ŞG, NY.

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