

Functional and Radiological Outcomes of First Metacarpal Fractures Treated with Minimally Invasive Reduction and Osteosynthesis System

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Abstract

Background: First metacarpal base fractures, comprising 4% of hand fractures, pose treatment challenges due to the thumb's functional importance. This study evaluates the functional and radiological outcomes of the Minimally Invasive Reduction and Osteosynthesis System (MIROS) for these fractures.

Methods: A prospective study was conducted on 30 patients with first metacarpal base fractures treated with MIROS at a single institute from June 2022 to October 2024, with a 6-month follow-up. Patients aged ≥ 18 years with closed fractures were included; open fractures were excluded.

Results: Functional outcomes, assessed by the Kapandji score, showed 80% of patients achieving a perfect score of 10 (mean: 9.85 ± 0.46). Radiographic union occurred at a mean of 5.13 ± 1.30 weeks. Extra-articular fractures had the best outcomes, while Rolando fractures showed reduced function.

Conclusion: MIROS demonstrated excellent results, with high functional scores, early mobilization, minimal complications, and faster union compared to traditional fixation techniques. It is a reliable, minimally invasive option for managing first metacarpal base fractures, particularly for extra-articular and Bennett types, although Rolando fractures may require more rigid fixation strategies.

Keywords: Bone Fracture; Closed Fracture Reduction; Metacarpal Bones

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Background

First metacarpal base fractures, accounting for approximately 4% of hand fractures, are significant due to the thumb's critical role in hand function (1). The most common pattern is extra-articular epibasal fracture. These fractures include extra-articular fractures, Bennett fractures (partial intra-articular), or Rolando fractures (complete intra-articular), typically resulting from axial loading on a partially flexed thumb (2). Each fracture type has its own characteristic morphology and response to the treatment. First metacarpal base fractures are difficult to treat. The goals of operative treatment of these fractures include anatomic reduction for the restoration of articular congruity, alignment, and stable fixation to allow early mobilization. The management of first metacarpal base fracture requires the surgeon to take good care of articular reduction, as imperfect reductions and above forces lead to increased joint contact pressures and subsequent predisposition to early arthritis, while excessive angulation may lead to metacarpophalangeal (MCP) joint hyperextension deformity. First metacarpal base fracture treatment modalities range from simple external fixators to intramedullary Kirschner wires (K-wires) and plating. Here, we discuss the clinical outcomes of first metacarpal base fractures after surgical management and fixation with the Minimally Invasive Reduction and Osteosynthesis System (MIROS).

This study aimed to evaluate the postoperative functional and radiological outcome of 35 patients with first metacarpal base fractures treated with MIROS.

Methods

This prospective study included 30 patients with first metacarpal base fractures treated with the MIROS at a single institute from June 2022 to October 2024, with a 6-month follow-up. Inclusion criteria were patients aged ≥ 18 years with closed extra-articular or intra-articular fractures. Exclusion criteria included patients < 18 years or those with open fractures [types I, II, or III per Gustilo-Anderson classification (3)].

Besides, preoperative radiographs of the injured thumb were carried out to assess the size, location, and extension of the articular fragment. Temporary stabilization of the fracture with a thumb spica splint was carried out, and then the patient was posted for surgery. Surgeries were performed under local anesthesia on a standard table with a radiolucent arm board. The operative limb was painted and draped as per the standard protocol.

The surgical aim was anatomic reduction of articular fragments, achieved via indirect reduction using two K-wires per fragment, secured with alpha-beta clamps. Closed reduction involved flexion, abduction, and pronation, verified by an image intensifier. If unsuccessful, a joystick method with a K-wire was used. One K-wire was placed transversely in the distal fragment, fixed to the distal fragment or second metacarpal base. A second K-wire was inserted transversely into the metacarpal shaft, bent 90 degrees, and clamped with an alpha-beta clamp (Figure 1).

Postoperative radiographs guided immediate mobilization (Figure 2).

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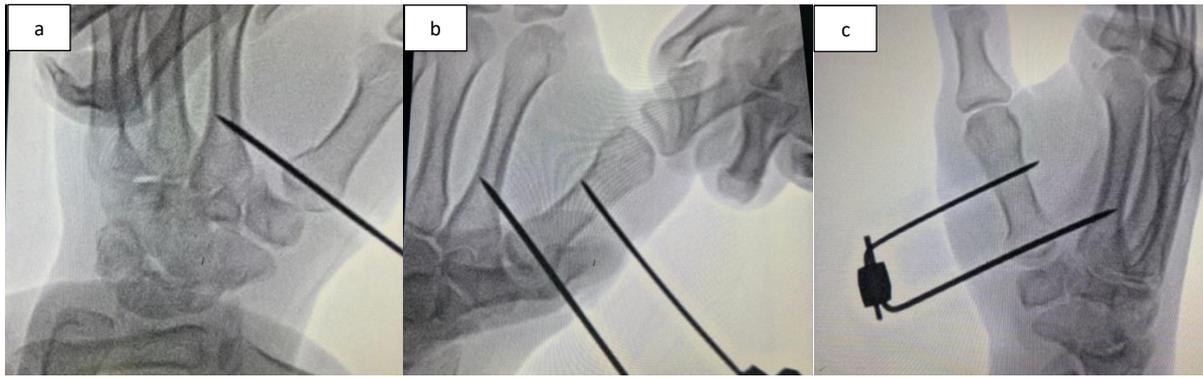


Figure 1. a) Close reduction with distal fragment Kirschner wire (K-wire) insertion; b) Proximal fragment K-wire insertion; c) Both wires bent towards each other at 90 degrees and fixed with an alpha-beta clamp

Intravenous (IV) antibiotics were given on the same day, followed by oral antibiotic for 1 week. The course of healing was documented radiologically [anteroposterior (AP) and oblique] and clinically. Complete healing was defined when radiologically complete bone regeneration was seen at the fracture site. Assessment of functional outcome was done using the Kapandji score (4) (Figure 3).

Results

All patients included in this study were above 18 years of age. The youngest was 18 years old and the oldest was 68 years old, with a mean age of 34.57 years [standard deviation (SD): 12.89]. The study population consisted of 30 patients, of whom 20 (66.67%) were men and 10 (33.33%) were women. Injuries involved the right thumb in 17 patients (56.67%) and the left in 13 (43.33%). The most frequently observed fracture pattern was extra-articular, accounting for 17 cases (56.67%). Bennett fractures were seen in 9 patients (30.00%), and Rolando fractures in 4 patients (13.33%). Road traffic accidents (RTAs) were the most common mechanism of injury, noted in 16 patients (53.33%), followed by falls in 8 patients (26.67%) and assault in 6 patients (20.00%).

Age Statistics: The mean age of the participants was 34.57 years, with an SD of 12.89. The age distribution showed that 4 participants (13.33%) were aged 20 years or younger, 16 participants (53.33%) were between 21 and 40 years, 8 participants (26.67%) were between 41 and 60 years, and 2 participants (6.67%) were older than 60 years.

Closed injuries were more common, comprising 26 cases (86.67%). Open injuries were less frequent, with 3 cases (10.00%) classified as grade 1 open fractures and one case (3.33%) as a grade 2 open fracture. The average

operative time was 17.00 ± 4.34 minutes, with a minimum of 10 minutes and a maximum of 25 minutes. Six patients (20.00%) underwent surgery within 10-14 minutes, 14 patients (46.67%) within 15-19 minutes, and 10 patients (33.33%) within 20-24 minutes.

The mean duration before K-wire removal was 33.07 ± 4.11 days. K-wires were removed between 28 to 31 days in 11 patients (36.67%), between 32 to 35 days in 10 patients (33.33%), and between 36 to 40 days in 7 patients (23.33%). Only two patients (6.67%) had K-wires removed after more than 40 days.

Regarding functional outcomes, 28 patients (93.3%) exhibited normal thumb abduction, while 2 patients (6.7%) had terminally restricted abduction. In terms of flexion-extension arc, 26 patients (86.7%) had normal range of motion (ROM), whereas 4 patients (13.3%) experienced terminal restriction.

Functional outcomes varied according to fracture type. All 18 patients with extra-articular fractures demonstrated normal abduction and flexion-extension arc. Among the Bennett fracture cases, 7 out of 8 patients (87.5%) maintained normal function in both movements. In the group with Rolando fractures, 3 out of 4 patients (75%) had normal abduction, but only 1 (25%) had normal flexion-extension.

A strong correlation was observed between flexion-extension status and Kapandji scores. Patients with normal flexion-extension had a higher mean Kapandji score of 9.96 ± 0.19 across 26 cases. In contrast, those with terminally restricted movement had a lower mean score of 8.75 ± 0.50 , noted in 4 cases.

The average time to union was 5.13 ± 1.30 weeks. Union occurred at 4 weeks in 11 patients (36.67%), at 5 weeks in 8 patients (26.67%), at 6 weeks in 7 patients (23.33%), and between 7 and 8 weeks in 4 patients (13.33%).



Figure 2. Postoperative mobilization using the clamp from day one



Figure 3. a) Radiological outcomes [a1: Preoperative radiograph; a2: Immediate postoperative radiograph; a3: One-month postoperative radiograph; a4: Final follow-up after Kirschner wire (K-wire) removal]; b) Functional outcomes

The mean Kapandji score was 9.85 ± 0.46 , reflecting overall excellent functional outcomes. A perfect score of 10 was achieved by 24 patients (80%), while 5 patients (16.67%) scored between 9 and 9.5. Only 1 patient (3.33%) recorded a score of 8 (Table 1).

Metric	Value (points)
Mean Kapandji score	9.85 ± 0.46
Kapandji score categories	
Category (points)	Number of cases
10	24 (80.00)
9-9.5	5 (16.67)

Data are presented as mean \pm standard deviation (SD) or number and percent.

Analysis of the relationship between union time and Kapandji score indicates a trend where earlier union is associated with better functional outcomes. Patients who achieved union at 4 weeks had the highest mean Kapandji score (9.91 ± 0.30), reflecting near-perfect thumb function.

Those with union at 5-6 weeks had a slightly lower mean score (9.87 ± 0.35), but still demonstrated excellent outcomes. However, patients whose union occurred between 7 and 8 weeks had the lowest mean Kapandji score (9.50 ± 0.58), suggesting that delayed bone healing was correlated with reduced functional recovery (Table 2).

Union time (week)	Kapandji score	Notes
4	9.91 ± 0.30	Fastest union, near-perfect function
5-6	9.87 ± 0.35	Slightly longer union, still excellent outcomes
7-8	9.50 ± 0.58	Delayed union correlated with lower scores

Data are presented as mean \pm standard deviation (SD).

Discussion

First metacarpal base fractures, including Bennett and Rolando types, are challenging due to their impact on

thumb function. This study evaluates the functional outcomes of patients treated with MIROS, focusing on parameters such as union time, Kapandji score, ROM, and complications. The results are compared with existing literature to assess the efficacy of MIROS.

Men (66.67%) were more affected than women (33.33%), consistent with trauma patterns in active populations. The mean age of 34.57 ± 12.89 years, with 53.33% aged 21-40 years, aligns with higher fracture incidence in young adults due to high-energy trauma. RTAs (53.33%) were the primary cause, followed by falls (26.67%) and assaults (20.00%). Similar trends were reported in studies by De Jonge et al. (5) and Deuschl et al. (6), emphasizing occupational and accidental trauma.

Mean union time was 5.13 weeks (± 1.30), with 36.67% uniting by 4 weeks. This is slightly faster than the results obtained by D. Shah and Gupta, who reported 10-18 weeks with orthogonal dual planting, suggesting that MIROS may promote quicker healing (7).

The mean score was 9.85 ± 0.46 , with 80% achieving a perfect score (10/10). This indicates excellent thumb opposition function, comparable to Greeven et al., where open reduction and internal fixation (ORIF) yielded a mean score of 9.5 (8).

In the present study, patients treated for fractures of the base of the first metacarpal demonstrated excellent functional recovery, with a mean Kapandji opposition score of 9.85 ± 0.46 , radiological union occurring at a mean of 5.13 ± 1.30 weeks, and minimal postoperative stiffness. These results indicate that stable fixation with early mobilization yields predictable and favorable outcomes.

According to D. Shah and Gupta, who evaluated orthogonal dual miniplating for base of first metacarpal fractures, the mean Kapandji score was 9.6, and the mean Disabilities of the Arm, Shoulder and Hand (DASH) score

improved from 61 preoperatively to 7.2 at final follow-up. Radiological union was achieved at a mean of 6 weeks, and grip strength reached approximately 92% of the contralateral side (7). Compared to D. Shah and Gupta study, the present study demonstrates a slightly higher Kapandji score (9.85) and earlier union (5.13 weeks), suggesting comparable or superior functional restoration despite a less invasive fixation strategy.

In the study by Brüske et al., functional assessment following operative management of Bennett and Rolando fractures showed that patients achieving anatomical reduction had pinch strength between 80-90 percent of the uninjured hand and grip strength around 85-95 percent, while those with residual displacement showed significantly inferior outcomes and higher rates of stiffness (9). In comparison, the present study showed near-normal thumb motion in 93.3% of patients, with only 6.7% exhibiting terminal restriction, supporting Brüske et al. conclusion that maintenance of reduction is critical for optimal function (9).

According to Greeven et al., in their systematic review comparing ORIF and closed reduction with percutaneous fixation for Bennett fractures, the pooled rate of post-traumatic arthrosis was 57.5% in ORIF versus 26.1% in closed reduction and internal fixation (CRIF), while mean surgical time was 71.9 minutes for ORIF and 30.2 minutes for percutaneous fixation. Functional impairment was low and comparable in both groups (1.4% ORIF vs. 1.8% CRIF) (8). In contrast, the present study reported a mean operative time of only 17 minutes, with 80% of patients achieving a perfect Kapandji score of 10 and no clinically significant functional impairment at follow-up, indicating procedural efficiency with excellent functional outcomes.

With respect to fracture subtype, Rolando fractures consistently demonstrated inferior outcomes across studies. D. Shah and Gupta reported delayed union and reduced functional scores in comminuted intra-articular fractures (7), and Greeven et al. emphasized higher complication rates in complex fracture patterns (8). Similarly, in the present study, only 25% of Rolando fractures achieved normal flexion-extension, compared to 100% in extra-articular fractures and 87.5% in Bennett fractures, confirming that comminution negatively affects functional recovery.

Conclusion

This study confirms that MIROS is an effective treatment for first metacarpal base fractures, offering excellent functional outcomes (high Kapandji scores, near-

normal ROM), faster union times compared to ORIF, and low complication rates, especially in closed injuries.

MIROS provides outcomes similar to ORIF without extensive soft tissue disruption, making it a viable alternative for extra-articular and Bennett's fractures. However, Rolando fractures may still require more rigid fixation.

Conflict of Interest

The authors declare no conflict of interest in this study.

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References

1. Stanton JS, Dias JJ, Burke FD. Fractures of the tubular bones of the hand. *J Hand Surg Eur Vol.* 2007;32(6):626-36. doi: [10.1016/j.jhse.2007.06.017](https://doi.org/10.1016/j.jhse.2007.06.017). [PubMed: [17993422](https://pubmed.ncbi.nlm.nih.gov/17993422/)].
2. Brown MT, Rust PA. Fractures of the thumb metacarpal base. *Injury.* 2020;51(11):2421-8. doi: [10.1016/j.injury.2020.07.053](https://doi.org/10.1016/j.injury.2020.07.053). [PubMed: [32741606](https://pubmed.ncbi.nlm.nih.gov/32741606/)].
3. Gustilo RB, Merkow RL, Templeman D. The management of open fractures. *J Bone Joint Surg Am.* 1990;72(2):299-304. [PubMed: [2406275](https://pubmed.ncbi.nlm.nih.gov/2406275/)].
4. Kapandji A. Clinical test of apposition and counter-apposition of the thumb. *Ann Chir Main.* 1986;5(1):67-73. doi: [10.1016/s0753-9053\(86\)80053-9](https://doi.org/10.1016/s0753-9053(86)80053-9). [PubMed: [3963909](https://pubmed.ncbi.nlm.nih.gov/3963909/)].
5. De Jonge JJ, Kingma J, Van Der Lei B, Klasen HJ. Fractures of the metacarpals. A retrospective analysis of incidence and aetiology and a review of the English-language literature. *Injury.* 1994;25(6):365-9. doi: [10.1016/0020-1383\(94\)90127-9](https://doi.org/10.1016/0020-1383(94)90127-9). [PubMed: [8045639](https://pubmed.ncbi.nlm.nih.gov/8045639/)].
6. Deuschl J, Alfort H, Wilcke M. The Epidemiology of Metacarpal Fractures: A Descriptive Study Based on 18,802 Fractures From the Swedish Fracture Register. *J Hand Surg Glob Online.* 2025;7(4):100725. doi: [10.1016/j.jhsg.2025.02.015](https://doi.org/10.1016/j.jhsg.2025.02.015). [PubMed: [40497267](https://pubmed.ncbi.nlm.nih.gov/40497267/)]. [PubMed Central: [PMC12150039](https://pubmed.ncbi.nlm.nih.gov/PMC12150039/)].
7. D. Shah H, Gupta A. Orthogonal dual plating for fracture of base of 1st metacarpal- original study. *Surg Update: Int J Surg Orthop.* 2018;4(4):165-8. doi: [10.17511/ijoso.2018.i04.06](https://doi.org/10.17511/ijoso.2018.i04.06).
8. Greeven APA, Van Groningen J, Schep NWL, Van Lieshout EMM, Verhofstad MHJ. Open reduction and internal fixation versus closed reduction and percutaneous fixation in the treatment of Bennett fractures: A systematic review. *Injury.* 2019;50(8):1470-7. doi: [10.1016/j.injury.2019.06.027](https://doi.org/10.1016/j.injury.2019.06.027). [PubMed: [31288938](https://pubmed.ncbi.nlm.nih.gov/31288938/)].
9. Brüske J, Bednarski M, Niedźwiedź Z, Zyluk A, Grzeszewski S. The results of operative treatment of fractures of the thumb metacarpal base. *Acta Orthop Belg.* 2001;67(4):368-73. [PubMed: [11725569](https://pubmed.ncbi.nlm.nih.gov/11725569/)].