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Original Research Article

A prospective and observational study of clinical and functional outcome of meta carpal fracture treated with osteosynthesis using plate

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ABSTRACT

Background: Metacarpal fractures are among the most common hand injuries encountered in orthopaedic practice and can significantly impair hand function if not managed appropriately. Stable fixation with early mobilization is essential for optimal functional recovery, particularly in unstable fracture patterns. Plate osteosynthesis provides rigid fixation and allows early rehabilitation, but its clinical and functional outcomes require systematic evaluation.
Methods: This prospective observational study was conducted in the Department of Orthopaedics at a tertiary care centre over a defined study period. A total of 20 skeletally mature patients with closed metacarpal fractures were included. All patients underwent open reduction and internal fixation using mini-plates and screws. Patients were followed up at regular intervals for a minimum period of three months. Clinical evaluation, radiological assessment of fracture union, postoperative complications, duration of hospital stay, return to work, and functional outcomes were assessed. Functional outcome was evaluated using the Total Active Flexion (TAF) scoring system recommended by the American Society for Surgery of the Hand.
Results: The majority of patients were young to middle-aged adults, with a male predominance. Transverse fractures and shaft-level involvement were the most common fracture characteristics. Radiological union was achieved within 6-7 weeks in 75% of patients. Excellent functional outcomes were observed in 75% of digits 2-5 and in all cases involving the thumb. Overall, 85% of patients achieved satisfactory functional outcomes. Most patients (70%) returned to work within 6-8 weeks. Postoperative complications were minimal, with stiffness observed in 15% of patients and infection in 5%. No cases of non-union, malunion, or implant failure were reported.
Conclusions: Plate osteosynthesis is a safe and effective method for the management of metacarpal fractures, providing stable fixation, early mobilization, and excellent functional outcomes with a low complication rate. Meticulous surgical technique and structured postoperative rehabilitation play a crucial role in achieving optimal results.

Keywords: Metacarpal fractures, Plate osteosynthesis, Open reduction internal fixation, Total active flexion, Functional outcome, Hand fractures

INTRODUCTION

Metacarpal fractures are among the most common injuries of the hand and account for a substantial proportion of the upper limb trauma encountered in orthopaedic practice. The metacarpals play a crucial role in maintaining hand function by providing the structural support, enabling grip strength, and facilitating fine motor activities. Any disruption in their anatomical alignment can significantly impair hand mechanics, leading to functional limitation, deformity, and long-term disability if not managed appropriately.[1] Globally, metacarpal fractures constitute approximately 30-40% of all hand fractures and nearly 10% of all skeletal fractures presenting to emergency

departments.[2] These injuries are particularly prevalent among young, economically productive adults due to their higher exposure to road traffic accidents, occupational hazards, sports injuries, and interpersonal violence. Males are affected more frequently than females, reflecting greater involvement in high-risk activities.[3] Fifth metacarpal fractures, commonly known as "boxer's fractures," represent the most frequently involved metacarpal, followed by fractures of the second and third metacarpals.[4]

In India, metacarpal fractures represent a significant public health concern due to the rising incidence of road traffic accidents, industrial injuries, and assault-related trauma. Indian studies have reported that hand fractures constitute 25-35% of upper limb injuries, with metacarpal fractures forming the majority of these cases.[5] The predominant age group affected ranges from 18 to 40 years, resulting in loss of working days and economic burden on patients and healthcare systems.[6] Falls and road traffic accidents remain the leading mechanisms of injury, followed by direct blows and occupational trauma.[7]

Data from tertiary care centres in Gujarat mirror national trends, with metacarpal fractures forming a substantial proportion of orthopaedic trauma admissions involving the hand. Regional studies have highlighted a predominance of shaft fractures, transverse fracture patterns, and higher incidence on the dominant hand, emphasizing the functional impact of these injuries in daily activities and employment.[8] Delayed presentation and inadequate initial treatment are common challenges in this region, often leading to malunion, stiffness, and compromised hand function.[9]

The management of metacarpal fractures depends on fracture pattern, displacement, rotational deformity, and functional demands of the patient. While conservative treatment may suffice for stable, minimally displaced fractures, unstable fractures often require surgical intervention to restore anatomy and allow early mobilization. Open reduction and internal fixation (ORIF) using plate osteosynthesis has gained popularity due to its ability to provide rigid fixation, maintain length and rotational alignment, and permit early active mobilization, which is essential for optimal functional recovery.[10]

Despite the advantages of plate osteosynthesis, concerns remain regarding technical difficulty, soft tissue handling, extensor tendon irritation, stiffness, and infection. Therefore, systematic evaluation of clinical and functional outcomes following plate fixation of metacarpal fractures is essential to establish its efficacy and safety, particularly in the Indian population where data remain limited. This prospective observational study aims to assess the clinical and functional outcomes of metacarpal fractures treated with plate osteosynthesis using standardized functional scoring systems, thereby contributing valuable evidence to guide surgical decision-making.[11] The present study was undertaken to evaluate the clinical and functional outcomes of metacarpal fractures treated with open reduction and internal fixation using plate osteosynthesis, with the aim of achieving anatomical restoration, early mobilization, and optimal functional recovery of the hand. The objectives of the study were to analyze the various mechanisms, fracture patterns, and surgical techniques involved in plate fixation of metacarpal fractures, to assess postoperative functional outcomes using standardized clinical parameters, and to identify intraoperative and postoperative technical challenges and complications associated with plate osteosynthesis. The justification for conducting this study lies in the increasing incidence of metacarpal fractures in the active and working-age population and the need for stable fixation methods that allow early rehabilitation while minimizing complications such as stiffness, malunion, and functional impairment. By systematically evaluating outcomes following plate fixation, this study seeks to provide evidence-based guidance for surgical decision-making in unstable metacarpal fractures. The findings of this study are expected to contribute to improved treatment protocols, enhance functional outcomes, reduce recovery time, and support the development of standardized management strategies for metacarpal fractures in tertiary care settings.

METHODS

This prospective observational study was conducted in the Department of Orthopaedics at Dhiraj Hospital, S.B.K.S. Medical Institute and Research Centre, Piparia, Waghodia, Vadodara, Gujarat, after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participating patients prior to inclusion in the study. A minimum of 20 adult patients with clinically and radiologically confirmed metacarpal fractures were enrolled using purposive sampling during the study period, which extended from 15th November 2022 until attainment of the sample size or 30th August 2024, whichever occurred earlier.

All skeletally mature patients aged more than 18 years presenting with closed metacarpal fractures and willing to undergo surgical treatment were included in the study. Patients with pathological fractures, compound fractures, crush injuries, those unfit for surgery, individuals below 18 years of age, and patients unwilling to provide written informed consent were excluded. Detailed clinical evaluation was carried out for each patient, including assessment of the mechanism of injury, associated injuries, neurovascular status, and comorbid conditions. Preoperative investigations included routine laboratory tests and radiological evaluation using anteroposterior and oblique radiographs of the affected hand to assess fracture location, angulation, shortening, and comminution. Following preoperative evaluation and optimization, patients were taken up for surgery under regional and/or general anesthesia. Open reduction and internal fixation with plate osteosynthesis was performed under strict aseptic precautions. A tourniquet was applied prior to incision. Surgical approach was selected based on the

involved metacarpal, using dorsal incisions to access the fracture site. The extensor tendons were carefully retracted, and anatomical reduction of fracture fragments was achieved using reduction forceps or temporary Kirschner wire fixation. Interfragmentary lag screws were employed in suitable long oblique or spiral fractures. Plate selection and configuration were determined by the fracture pattern, with straight plates used for shaft fractures and T or L plates for periarticular fractures. Plates were secured with screws ensuring stable fixation and adequate soft tissue coverage. Wounds were thoroughly irrigated and closed without the use of drains, followed by immobilization using a volar below-elbow slab. Postoperatively, the operated limb was elevated for 24 to 48 hours to reduce pain and swelling. Wound inspection was carried out on the second postoperative day, and early active finger mobilization was initiated as tolerated by the patient. Patients were typically discharged between the third and fifth postoperative day and were advised to continue physiotherapy on an outpatient basis. Sutures were removed between the twelfth and fifteenth postoperative day. Follow-up evaluations were scheduled at three weeks, six weeks, eight weeks, and three months postoperatively. Clinical assessment included evaluation of pain, range of motion, and functional recovery, while radiological assessment was performed to assess fracture union, maintenance of reduction, and implant integrity. Functional outcome was assessed at the final follow-up using the Total Active Flexion scoring system recommended by the American Society for Surgery of the Hand.

Total active flexion was calculated by summing the flexion at the metacarpophalangeal, proximal interphalangeal, and distal interphalangeal joints and subtracting the extensor lag. Outcomes were graded as excellent, good, fair, or poor based on established scoring criteria. Any postoperative complications such as stiffness, infection, implant-related problems, or the need for re-surgery were recorded and analyzed.

RESULTS

A total of 20 patients with metacarpal fractures were included in this prospective observational study. The majority of patients were young and middle-aged adults, with 35% (n=7) belonging to the 18-29-year age group, followed by 25% (n=5) in the 30-39-year group, 20% (n = 4) in the 40-49-year group, 15% (n=3) in the 50-59-year group, and 5% (n=1) aged above 60 years. Males constituted the predominant proportion of the study population (80%, n=16), while females accounted for 20% (n=4). The distribution of injury laterality was equal, with 50% (n=10) involving the right hand and 50% (n=10) involving the left hand. Regarding the mechanism of injury, falls were the most common cause (55%, n=11), followed by road traffic accidents (40%, n=8) and assaults (5%, n=1).

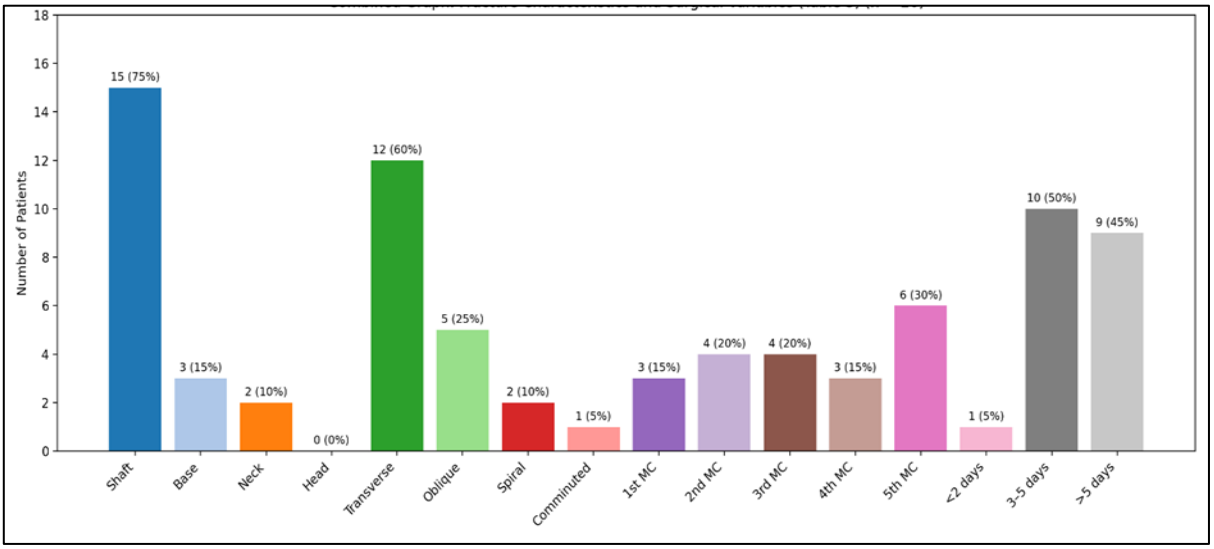

Figure 1: Fracture characteristics and surgical variables. n=20 (100%).

Analysis of fracture characteristics showed that the shaft of the metacarpal was involved in 75% (n=15) of cases, while fractures of the base and neck accounted for 15% (n =3) and 10% (n=2) respectively, with no fractures involving the metacarpal head. The predominant fracture pattern was transverse fractures (60%, n=12), followed by oblique fractures (25%, n=5), spiral fractures (10%, n=2), and comminuted fractures (5%, n=1). The fifth metacarpal was the most frequently involved bone (30%, n=6), followed by the second and third metacarpals (20% each, n=4), while the first and fourth metacarpals were involved in 15% (n=3) of cases each. With respect to surgical timing, fixation was performed within 3-5 days of injury in 50% (n=10) of patients, while 45% (n=9) underwent surgery after more than five days and 5% (n=1) were operated within two days. The duration of hospital stay was 3-5 days in 65% (n=13) of patients, more than six days in 30% (n=6), and less than three days in 5% (n=1).

Radiological union was achieved within 6-7 weeks in 75% (n=15) of patients, within 8-9 weeks in 20% (n=4), and beyond nine weeks in 5% (n=1).

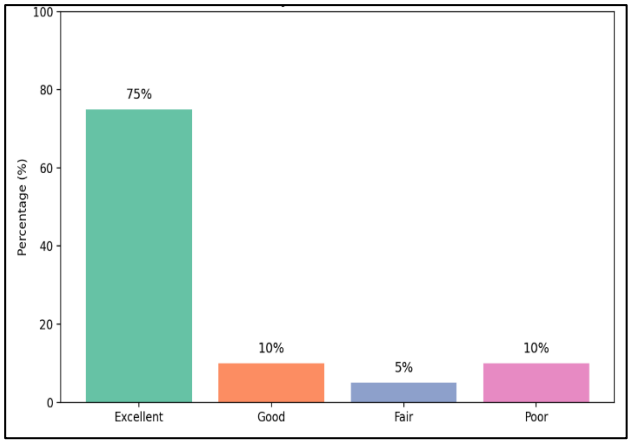

Figure 2: Functional outcome by ASSTH- TAF score at 3 months (n=20) (100%).

Functional outcome assessment using the ASSH–Total Active Flexion (TAF) scoring system demonstrated excellent outcomes in 75% (n=15) of patients, good outcomes in 10% (n=2), fair outcomes in 5% (n=1), and poor outcomes in 10% (n=2), resulting in an overall satisfactory functional outcome in 85% of cases. Early return to work was observed, with 70% (n=14) of patients resuming occupational activities within 6-8 weeks, 20% (n =4) returning within 9-10 weeks, and 10% (n=2) returning after more than eleven weeks. Postoperative complications were minimal, with stiffness observed in 15% (n=3) and surgical site infection in 5% (n=1) of patients. Importantly, no cases of non-union, malunion, or implant failure were recorded during the follow-up period.

The combined multicolour bar graph illustrates the distribution of fracture characteristics and surgical variables among the study participants.

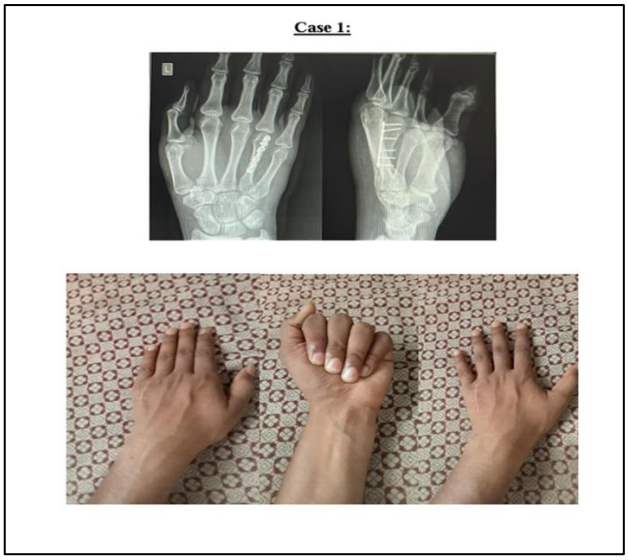

Figure 3: Case 1.

The majority of fractures were located at the shaft of the metacarpal (75%), while fractures involving the base (15%) and neck (10%) were less common, and no fractures of the metacarpal head were observed. With respect to fracture pattern, transverse fractures predominated (60%), followed by oblique fractures (25%), spiral fractures (10%), and comminuted fractures (5%). Analysis of the metacarpal involved revealed that the fifth metacarpal was most frequently affected (30%), followed by the second and third metacarpals (20% each), while fractures of the first and fourth metacarpals accounted for 15% each.

Evaluation of the injury-to-operation interval showed that half of the patients (50%) underwent surgery within 3-5 days of injury, whereas 45% were operated after more than five days, and only 5% received surgical intervention within two days. Overall, the graph demonstrates a predominance of shaft-level, transverse fractures involving the fifth metacarpal, with most patients undergoing surgical fixation within five days of injury.

Table 1: Demographic profile of study participants (n=20).

Variable	Category	Number of patients	Percentage (%)
Age group (years)	18-29	7	35
	30-39	5	25
	40-49	4	20
	50-59	3	15
	>60	1	5
Sex	Male	16	80
	Female	4	20
Side of injury	Right	10	50
	Left	10	50
Mode of injury	Fall	11	55
	Road traffic accident	8	40
	Assault	1	5

Table 2: Clinical and radiological outcomes of metacarpal fractures (n=20).

Outcome parameter	Category	Number of patients	Percentage (%)
Duration of hospital stay (days)	<3	1	5
	3-5	13	65
	>6	6	30
Radiological union (weeks)	6-7	15	75
	8-9	4	20
	>9	1	5
Post-operative complications	Stiffness	3	15
	Infection	1	5
	None	16	80
Return to work (weeks)	6-8	14	70
	9-10	4	20
	>11	2	10

Table 3: Fracture characteristics and surgical objectives covered (n=20).

Study objective variable	Category	Number of cases	Percentage (%)
Fracture location	Shaft	15	75
	Base	3	15
	Neck	2	10
	Head	0	0
Fracture pattern	Transverse	12	60
	Oblique	5	25
	Spiral	2	10
	Comminuted	1	5
Metacarpal involved	1st	3	15
	2nd	4	20
	3rd	4	20
	4th	3	15
	5th	6	30
Injury–operation interval (days)	<2	1	5
	3-5	10	50
	>5	9	45

DISCUSSION

The present study demonstrates that plate osteosynthesis is an effective and reliable modality for management of metacarpal fractures, providing excellent clinical and functional outcomes. A substantial proportion of patients achieved excellent TAF scores, with 75% of digits 2-5 and 100% of thumbs showing excellent functional recovery. Early return to work was observed in most patients, with 70% resuming occupational activities within 6-8 weeks. The overall complication rate was low, with postoperative stiffness observed in 15% cases and surgical site infection in only one patient, while no instances of non-union, malunion, or implant breakage were reported. These findings reinforce importable fixation, early mobilization, and meticulous surgical technique in achieving optimal hand function following metacarpal fractures.[12]

Patient demographics and comparison with literature

In the present study, the mean age of patients was 45 years, with a relatively balanced sex distribution. This demographic profile aligns with the working-age population most commonly affected by hand injuries. Agrawal et al reported a slightly younger mean age of 40 years, whereas Dumont et al and Souer et al reported higher mean ages of 50 and 52 years respectively, with Souer et al noting a female predominance.[13-15] Older age and female predominance in these studies may partly explain their higher rates of complications such as stiffness and non-union, likely due to reduced bone density and slower healing. Mergic et al reported a demographic profile comparable to the present study, suggesting that differences in outcomes are more likely attributable to surgical technique and postoperative rehabilitation rather than patient-related factors alone.[16] The relatively younger and balanced demographic profile in this study may have contributed to the favorable outcomes observed.

Comparison of fracture patterns

The predominant fracture pattern in this study was transverse fractures (60%), followed by oblique (25%), spiral (10%), and comminuted fractures (5%). Dumont et

al reported a lower proportion of transverse fractures (35%) and a higher incidence of spiral fractures (25%), suggesting a different injury mechanism involving rotational forces.[14] Similarly, Souer et al reported a lower transverse fracture incidence (25%) with a higher spiral fracture rate (30%).[15] Agrawal et al observed a predominance of oblique fractures (45%) with fewer transverse fractures (28%), indicating shear-related injury mechanisms.[13] These variations highlight the influence of injury mechanism and patient activity on fracture configuration. The predominance of transverse fractures in the present study suggests a higher incidence of direct impact injuries.

Postoperative complications

The complication profile in this study compares favorably with existing literature. Postoperative stiffness was observed in the 15% of cases, which is comparable to Dumont et al (18%) and Mergic et al (13%), and lower than rates reported by Agrawal et al (21%) and Souer et al (20%).[13-16] The relatively lower stiffness rate in this study may be attributed to early mobilization and the structured physiotherapy protocols. Surgical site infection occurred in 5% of patients, consistent with the rates reported by Souer et al and Dumont et al, while Agrawal et al reported a slightly lower rate and Mergic et al a slightly higher rate.[13-16] Importantly, no cases of non-union, malunion, or implant breakage were observed in this study, in contrast to other studies reporting non-union rates of up to 10% and implant failure rates of 3-5%.[13-15] This highlights the effectiveness of meticulous surgical technique, stable fixation, and careful soft tissue handling.

Length of hospital stay and return to work

The average hospital stay in this study was three days, which is shorter than that reported by Dumont et al and Souer et al (four days) and Agrawal et al (five days), and comparable to Mergic et al.[13-16] Shorter hospitalization reflects early mobilization, lower complication rates, and effective postoperative care. Early discharge also reduces healthcare costs and promotes faster rehabilitation. Furthermore, 70% of patients in this study returned to work within 6-8 weeks, indicating rapid functional recovery. Although comparable return-to-work data are not uniformly reported in other studies, the favorable functional outcomes and low complication rates in the present study likely contributed to earlier resumption of daily activities.

Radiological union and functional outcome

Radiological union was achieved within 6-7 weeks in 75% of patients, with delayed union beyond nine weeks seen in only 5%. This compares favorably with studies reporting delayed union and higher non-union rates, particularly in older cohorts.[14,15] Using the ASSH–TAF scoring system, 85% of patients achieved satisfactory functional outcomes, which is comparable to or better than outcomes reported by Dumont et al, Agrawal et al, Souer et al, and Mergic et al.[13-16] The superior functional results in this study underscore the role of rigid fixation and early rehabilitation in restoring hand function.

Comparison with K-wire fixation

When compared with studies evaluating K-wire fixation, plating demonstrated comparable or superior outcomes. Steven et al reported only 61.9% excellent outcomes with K-wire fixation, while Knopp et al reported 81.5% excellent-to-good results.[17,18] Although Bosscha et al reported high success rates with K-wires, prolonged immobilization inherent to K-wire fixation is associated with a higher risk of stiffness.[19] In contrast, plate fixation provides rigid stability, allowing early mobilization and reducing stiffness. While K-wire fixation remains a less invasive and cost-effective option, plating appears to offer better functional recovery in unstable fracture patterns, provided meticulous technique is followed.

Overall, the findings of this study are consistent with existing literature supporting plate osteosynthesis as an effective treatment for unstable metacarpal fractures. The low complication rate, early radiological union, excellent functional outcomes, and rapid return to work observed in this study highlight the advantages of plate fixation when combined with early mobilization and structured rehabilitation. However, the relatively small sample size remains a limitation, and larger prospective studies are recommended to further validate these findings.

Limitations

Despite favourable outcomes, the present study has certain limitations. The sample size was relatively small, which may limit the generalizability of the findings. The study was conducted at a single tertiary care center, and outcomes may vary across different institutions and surgical settings. The follow-up duration was limited to three months, which may not fully capture long-term complications such as late stiffness, implant-related issues, or degenerative changes. Additionally, the absence of a comparative group treated with alternative fixation methods such as K-wire fixation restricts direct comparison of outcomes between different treatment modalities.

CONCLUSION

This prospective observational study demonstrates that plate osteosynthesis is a safe and effective modality for the management of metacarpal fractures, providing stable fixation, early mobilization, and excellent functional outcomes. The majority of patients achieved satisfactory results as assessed by the ASSH–TAF scoring system, with rapid radiological union and early return to work. The low incidence of postoperative complications, absence of non-union, malunion, and implant failure, and short hospital stay further support the effectiveness of plating in appropriately selected cases. Overall, meticulous surgical technique combined with structured postoperative

rehabilitation contributes significantly to optimal functional recovery of the hand following metacarpal fracture fixation with plates.

Recommendations

Based on the findings of this study, plate osteosynthesis is recommended for unstable metacarpal fractures where rigid fixation and early mobilization are required to achieve optimal functional outcomes. Surgeons should emphasize meticulous soft tissue handling, accurate anatomical reduction, and early postoperative physiotherapy to minimize complications such as stiffness. Larger multicentric studies with longer follow-up periods are recommended to further validate these results and assess long-term functional outcomes. Comparative studies evaluating plate fixation versus other treatment modalities, including K-wire fixation, would help establish standardized treatment protocols for metacarpal fractures. Additionally, incorporating patient-reported outcome measures may provide a more comprehensive assessment of functional recovery and quality of life.

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