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Original Research Article

The Effect of Conservative Versus Operative Management on Functional Outcome in Patients with Metacarpal Fracture

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Abstract

Background: Metacarpal fractures are among the most common skeletal injuries of the upper limb, accounting for 18–44% of all hand fractures, with a significant burden on the working-age population in India. The optimal management—conservative or operative—remains debated, with limited high-quality comparative evidence from Indian tertiary care settings using validated patient-reported outcome measures.

Aim: To evaluate and compare the functional, clinical, and radiological outcomes of conservative versus operative management in patients with metacarpal fractures at a tertiary care teaching hospital in Delhi NCR, India.

Methods: A non-randomised prospective comparative study was conducted at Santosh Medical College and Hospital, Ghaziabad, from 10th January 2024 to 30th June 2025. A total of 96 patients with closed metacarpal fractures were enrolled and managed either conservatively (n=28) or operatively (n=68) based on fracture characteristics and clinical judgment. Outcomes were assessed at baseline, 12 weeks, and 24 weeks using the Michigan Hand Questionnaire (MHQ), Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH), Patient-Rated Wrist and Hand Evaluation (PRWHE), Visual Analogue Scale (VAS) for pain, grip and pincer strength, metacarpophalangeal (MCP) joint flexion, extension lag, and radiological union rates. Statistical analysis employed repeated-measures ANOVA, Student's t-test, Mann–Whitney U test, and Chi-square test using STATA MP-17.

Results: Both groups were comparable at baseline across all demographic and clinical parameters ($p>0.05$). At 24 weeks, both treatment modalities yielded statistically significant and clinically comparable improvements in MHQ scores (84.4±0.92 vs 85.0±0.59), QuickDASH (11.9±1.32 vs 11.4±0.84), PRWHE (8.00±0.97 vs 7.72±0.62), and VAS pain scores (1.21±0.08 vs 1.24±0.05) in conservative and operative groups, respectively. Repeated-measures ANOVA demonstrated highly significant time effects ($p<0.001$) with non-significant group effects ($p>0.05$) for all primary outcomes. Grip strength, pincer strength, MCP flexion, and extension lag improved substantially and in parallel in both groups. Complete fracture union was achieved in all patients (100%) at 24 weeks. Return-to-work times were nearly identical (8.68±2.97 vs 8.63±3.05 weeks; $p=0.850$). The overall complication profile was comparable between groups ($p=0.539$).

Conclusion: Conservative and operative management of metacarpal fractures yield equivalent short- to mid-term functional, radiological, and occupational outcomes when applied with appropriate case selection and structured rehabilitation. Treatment decisions should be individualized based on fracture stability, patient functional demands, and available resources rather than a routine preference for surgery.

Keywords: Metacarpal fracture, conservative management, operative management, functional outcome, Michigan Hand Questionnaire, QuickDASH, PRWHE, K-wire fixation, open reduction internal fixation.
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Introduction

The human hand serves as an indispensable organ of perception, manipulation, and expression, underpinning almost every aspect of occupational and daily life [1]. Among hand injuries, metacarpal fractures are particularly prevalent, accounting for 18–44% of all hand fractures, with the fifth metacarpal being the most frequently involved, representing nearly 20% of all metacarpal injuries [2]. The five metacarpals constitute the structural framework of the palm, transmitting musculoskeletal forces from the digits to the carpus; their anatomical integrity is essential for grip strength, dexterity, and coordinated digital motion [3]. Because of their high incidence, functional significance, and considerable socioeconomic impact, metacarpal fractures continue to be an important focus of contemporary orthopaedic research [4].

Globally, metacarpal fractures occur at an estimated annual incidence of 70–90 per 100,000 population, predominantly affecting males between 20 and 40 years of age who sustain occupational, sports-related, or vehicular injuries [5,6]. In Asian populations, agricultural and industrial mechanisms contribute substantially to the burden [7]. Within India, metacarpal fractures represent nearly half of all hand fracture presentations at tertiary orthopaedic centres, with the fifth metacarpal neck and ring-finger shaft most frequently involved [8,9]. The increasing pace of urbanisation and motorisation has elevated incidence in cities, while the absence of safety protocols in informal industrial sectors sustains high rates in rural settings [10]. Given that most affected individuals are in their economically productive years, even temporary loss of hand function can result in significant occupational disability and financial hardship, making timely and effective management a public-health priority.

The historical trajectory of metacarpal fracture management traces from simple splinting aimed at bony union to the modern era of evidence-based functional restoration. Initial immobilisation techniques evolved with Kirschner's 1909 introduction of smooth intramedullary wires, which enabled minimally invasive internal stabilisation [11,12]. The mid-twentieth century witnessed the advent of plate-and-screw constructs, offering rigid fixation with improved alignment control [13]. Subsequent refinements—including low-profile locking plates, intramedullary devices, and percutaneous pinning—facilitated earlier rehabilitation while reducing soft-tissue morbidity [14,15]. Nevertheless, for uncomplicated closed fractures, the superiority of operative intervention over well-executed conservative care remains a subject of ongoing debate in contemporary hand surgery literature [16].

The anatomical architecture of the metacarpal—comprising a base articulating with the distal carpal row, a shaft serving as a lever for musculotendinous forces, and a head forming the metacarpophalangeal (MCP) joint—demands meticulous restoration of alignment following injury [17,18]. The dorsal and palmar metacarpal arteries supply these bones, while branches of the median and ulnar nerves provide innervation [19]. Physiologically, the metacarpals act as dynamic levers for the intrinsic and extrinsic hand musculature, maintaining the transverse and longitudinal arches of the hand essential for power grip and precision pinch [20]. Even minor rotational malalignment—as little as five degrees—can translate to 1.5 cm of digital overlap during fist formation, severely compromising dexterity and functional grip [21].

Injury mechanisms are diverse and include direct axial impact producing fifth-metacarpal neck fractures ("boxer's fracture"), indirect torsional forces generating spiral shaft patterns, and crush injuries causing comminution [22,23,24]. The direction of force determines fracture morphology: torsional loading produces spiral patterns, while axial compression leads to impaction or comminution [25]. Biological healing follows the classical phases of haematoma formation, inflammatory recruitment, soft and hard callus deposition, and cortical remodelling, with deforming forces from interossei and lumbricals consistently producing apex-dorsal angulation in the hand [26,27,28].

Clinical presentation includes localised swelling, tenderness, deformity, and functional restriction. Standard anteroposterior, oblique, and lateral radiographs constitute the diagnostic cornerstone, while computed tomography is reserved for complex or intra-articular injuries [29,30]. Patient-reported outcome instruments—including the Michigan Hand Questionnaire (MHQ) and Quick Disabilities of the Arm, Shoulder and Hand

(QuickDASH) score—have become standard tools for assessing functional recovery in contemporary orthopaedic research, capturing pain, function, strength, and aesthetic satisfaction in a holistic and patient-centred manner [31]. The AO/OTA 2018 classification system stratifies fractures by anatomical location and morphology, facilitating structured prognostication and treatment planning [32,33].Management strategy is tailored to fracture stability, displacement, configuration, and patient functional demand. Conservative management—comprising closed reduction and immobilisation in a functional splint for three to four weeks, followed by supervised physiotherapy—remains the standard of care for stable, minimally displaced injuries [1,2,3,4]. Operative intervention is reserved for unstable, irreducible, comminuted, or intra-articular fractures, as well as those exhibiting unacceptable rotational malalignment. Percutaneous K-wire fixation offers economic and minimally invasive stabilisation, while plate-and-screw constructs provide rigid fixation with the advantage of early active mobilisation, albeit at the cost of greater soft-tissue dissection, increased risk of stiffness, and higher implant cost [12,15] Despite these well-defined modalities, heterogeneity in treatment practices persists among surgeons reflecting differences in training, institutional resources, and local patient demographics [13,14]. Existing comparative evidence from Indian cohorts is largely retrospective, focuses on radiographic union rather than patient-reported functional outcomes, and lacks longitudinal modelling with validated instruments [25,26]. This critical evidence gap motivated the present prospective comparative study, which aimed to evaluate the effect of conservative versus operative management on functional outcomes in patients with metacarpal fractures at a tertiary care institution in Delhi NCR, India, using a rigorous multi-instrument assessment framework over a 24-week follow-up period.

Material and Methods

Study Design and Setting: This was a non-randomised prospective comparative study conducted in the Department of Orthopaedics, Santosh Medical College and Hospital, Ghaziabad, Delhi NCR, India, from 10th January 2024 to 30th June 2025. The study protocol was approved by the Institutional Ethics Committee (IEC) of Santosh Medical College and Hospital prior to enrolment. Written informed consent was obtained from all participants in English and Hindi, and the study was conducted in accordance with the Declaration of Helsinki.

Study Population: All consecutive patients presenting with closed metacarpal fractures to the outpatient and emergency departments of orthopaedics during the study period were assessed for eligibility. Patients aged 18 years and above with a confirmed closed metacarpal fracture on standard radiography (anteroposterior, oblique, and lateral views), who provided informed written consent, were included.

Patients were excluded if they had open fractures, pathological fractures, bilateral or multiple metacarpal fractures of the same hand, intra-articular fractures with concomitant carpometacarpal joint dislocation, associated neurovascular injury, pregnancy, or significant comorbidities precluding anaesthesia or rehabilitation. Patients who failed to attend scheduled follow-up visits or who withdrew consent were also excluded.

Sample Size and Allocation: Based on previously reported MHQ outcomes in metacarpal fracture cohorts, a minimum sample size of 88 patients was calculated using the standard formula for comparison of two independent means (G*Power 3.1), applying a two-tailed alpha of 0.05 and power of 80%, with an assumed clinically meaningful mean difference of 5 points in MHQ scores, a pooled standard deviation of 10, and a corresponding effect size of Cohen's d = 0.5. The 5-point threshold was adopted as the minimum clinically important difference for the MHQ, consistent with published literature on hand function outcome measurement. Accounting for a 10% attrition rate, a final target of 96 patients was enrolled. This study was designed as a prospective comparative observational study; accordingly, treatment allocation was based on fracture characteristics (stability, displacement, angulation, rotational alignment, and intra-articular involvement) and clinical judgment of the treating orthopaedic surgeon, consistent with current evidence-based practice guidelines, rather than randomisation. Although equal allocation was assumed during sample size calculation, actual recruitment resulted in unequal group sizes (conservative n=28; operative n=68). Statistical analyses were performed using methods robust to unequal group sizes, including repeated-measures ANOVA and non-parametric tests where appropriate, and the overall sample of 96 was considered adequate to detect clinically meaningful differences in primary outcomes.

Conservative Management Protocol: Patients allocated to conservative management underwent closed reduction under regional anaesthesia (haematoma block or wrist block) where indicated, followed by immobilisation in an ulnar, radial, or volar gutter splint or plaster of Paris cast in the intrinsic-plus position (wrist in 30° extension, MCP joints in 70–90° flexion, interphalangeal joints in near-full extension) for three to four weeks. Patients were clinically and radiologically monitored at two, six, twelve, and twenty-four weeks. Supervised hand physiotherapy

incorporating active and passive range-of-motion exercises commenced after splint removal, with graduated strengthening exercises introduced progressively.

Operative Management Protocol. Operative intervention was performed under regional or general anaesthesia. Closed reduction and internal fixation (CRIF) with Kirschner wires (K-wires) was the preferred approach for reducible but unstable fractures, employing either intramedullary, transverse, or crossed-wire configurations. Open reduction and internal fixation (ORIF) using low-profile mini titanium plates and cortical screws was reserved for irreducible, comminuted, or significantly displaced fractures requiring direct visualisation. Dorsal and lateral surgical approaches were employed according to fracture site and configuration. K-wires were retained for three to four weeks and subsequently removed under local anaesthesia. Postoperative immobilisation in a plaster slab was maintained for two to three weeks, followed by supervised progressive physiotherapy from the third postoperative week.

Outcome Assessment: All patients were evaluated at baseline (pre-treatment), 12 weeks, and 24 weeks. Primary outcome measures were patient-reported functional scores: the Michigan Hand Questionnaire (MHQ, score 0–100, higher scores denoting better function), QuickDASH (score 0–100, lower scores denoting less disability), and the Patient-Rated Wrist and Hand Evaluation (PRWHE, score 0–100, lower scores denoting better function). Secondary outcomes included VAS pain score (0–10), grip strength measured by hydraulic hand dynamometer (kg), pincer strength by pinch gauge (kg), MCP joint flexion (goniometry in degrees), MCP extension lag (degrees), radiological fracture union at 12 and 24 weeks on plain radiographs, post-treatment complication profile, and return-to-work time (weeks).

Statistical Analysis: Data were entered into Microsoft Excel and analysed using STATA MP-17. Normality of continuous variables was assessed by Kolmogorov–Smirnov and Shapiro–Wilk tests. Normally distributed data were expressed as mean ± standard deviation (SD) and non-normally distributed data as median with interquartile range (IQR).

Intergroup comparisons of continuous variables were made using Student's independent t-test or Mann–Whitney U test as appropriate, and categorical variables were compared using Chi-square or Fisher's exact tests.

Longitudinal analysis of repeated-measures outcomes (baseline, 12 weeks, 24 weeks) was performed using repeated-measures ANOVA to evaluate main effects of time, group, and time-by-group interaction; this approach is robust to unequal group sizes and was therefore considered appropriate for the present non-randomised design. Effect sizes were expressed as Cohen's d for continuous variables. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 96 patients with metacarpal fractures were enrolled: 28 (29.2%) managed conservatively and 68 (70.8%) managed operatively. All patients completed the 24-week follow-up. Baseline sociodemographic, clinical, and functional parameters were well matched between the two groups.

Sociodemographic Profile. Table 1 summarises the sociodemographic profile of the study participants. The mean age of the cohort was in the productive working-age group, with the 18–30 year age group constituting the largest proportion (42.7%), followed by the 31–40 year group (28.1%). Male patients predominated (74.0%). Skilled and unskilled workers together accounted for 62.5% of participants. The lower-middle and upper-lower socioeconomic strata (Kuppuswamy scale) were most represented (68.7%), and urban residents constituted 66.7% of the cohort. No statistically significant differences were observed between groups across any sociodemographic variable (all $p>0.05$), confirming baseline comparability.

Table 1: Sociodemographic Profile of Study Participants by Treatment Group (N = 96)

Variable	Category	Conservative (n=28) n (%)	Operative (n=68) n (%)	Total (N=96) n (%)	p-value (χ^2)
Age group (years)	18–30	13 (46.4)	28 (41.2)	41 (42.7)	0.963
	31–40	7 (25.0)	20 (29.4)	27 (28.1)	
	41–50	5 (17.9)	12 (17.6)	17 (17.7)	
	>50	3 (10.7)	8 (11.8)	11 (11.5)	
Gender	Female	8 (28.6)	17 (25.0)	25 (26.0)	0.717
	Male	20 (71.4)	51 (75.0)	71 (74.0)	
Occupation	Homemaker	4 (14.3)	13 (19.1)	17 (17.7)	0.844
	Skilled	11 (39.3)	28 (41.2)	39 (40.6)	
	Student	7 (25.0)	12 (17.6)	19 (19.8)	

	Unskilled	6 (21.4)	15 (22.1)	21 (21.9)	
Kuppuswamy SES	Lower (V)	1 (3.6)	10 (14.7)	11 (11.5)	0.339
	Lower-middle (III)	10 (35.7)	27 (39.7)	37 (38.5)	
	Upper-lower (IV)	11 (39.3)	18 (26.5)	29 (30.2)	
	Upper-middle (II)	6 (21.4)	13 (19.1)	19 (19.8)	
Residential area	Semi-urban	10 (35.7)	22 (32.4)	32 (33.3)	0.751
	Urban	18 (64.3)	46 (67.6)	64 (66.7)	

Mechanism of Injury. Work-related injuries (37.5%) and road traffic accidents (34.4%) were the two leading mechanisms, followed by sports injuries (13.5%) and falls (10.4%). Assault accounted for 4.2% of cases, exclusively in the operative group.

The distribution of injury mechanisms did not differ significantly between the two treatment groups (χ^2 test, p=0.349), indicating that treatment allocation was governed by fracture characteristics rather than mechanism of injury. Baseline Clinical and Functional Parameters. Baseline functional scores demonstrated excellent comparability between the groups (Table 2). Mean VAS pain scores (7.04±0.79 vs 6.94±0.88), MHQ scores (70.79±3.46 vs 69.85±3.11), QuickDASH scores (34.68±5.67 vs 33.82±6.81), PRWHE scores (71.68±7.40 vs 70.72±9.04), grip strength (12.68±2.68 vs 11.91±2.58 kg), pincer strength (2.51±0.30 vs 2.55±0.31 kg), MCP flexion (56.21±8.48 vs 56.99±9.64°), and MCP extension lag (17.75±2.40 vs 17.59±2.60°) showed no statistically significant differences (all p>0.05), with small effect sizes (Cohen's d <0.3) throughout.

Longitudinal Functional Outcome Analysis. Table 2 presents the repeated-measures ANOVA results for all primary and secondary functional outcomes across the three time points. Both groups demonstrated progressive and statistically significant improvements in all parameters over the 24-week follow-up, with highly significant main effects of time (all p<0.001) but consistently non-significant group main effects and time-by-group interactions, indicating parallel recovery trajectories regardless of treatment modality.

Table 2: Functional Outcome Scores Over Time by Treatment Group (Mean ± SE) — Repeated-Measures ANOVA (N = 96)

Outcome Measure	Timepoint	Conservative (n=28) Mean ± SE	Operative (n=68) Mean ± SE	F (Time) [p-value]	Group p-value
MHQ Score	Baseline	70.8 ± 0.61	69.9 ± 0.39	F=415.86, p<0.001	p=0.963
	12 weeks	79.2 ± 0.80	79.7 ± 0.51		
	24 weeks	84.4 ± 0.92	85.0 ± 0.59		
QuickDASH Score	Baseline	34.7 ± 1.23	33.8 ± 0.79	F=9895.93, p<0.001	p=0.632
	12 weeks	19.9 ± 1.32	19.0 ± 0.84		
	24 weeks	11.9 ± 1.32	11.4 ± 0.84		
PRWHE Score	Baseline	71.68 ± 1.63	70.72 ± 1.04	F=15042.72, p<0.001	p=0.717
	12 weeks	14.32 ± 1.18	13.97 ± 0.76		
	24 weeks	8.00 ± 0.97	7.72 ± 0.62		
VAS Pain Score	Baseline	7.04 ± 0.16	6.94 ± 0.10	F=2087.91, p<0.001	p=0.931
	12 weeks	2.46 ± 0.10	2.51 ± 0.06		
	24 weeks	1.21 ± 0.08	1.24 ± 0.05		
Grip Strength (kg)	Baseline	12.7 ± 0.49	11.9 ± 0.32	F=1119.99, p<0.001	p=0.939
	12 weeks	23.8 ± 0.64	24.0 ± 0.41		
	24 weeks	29.8 ± 0.69	30.1 ± 0.44		
Pincer Strength (kg)	Baseline	2.51 ± 0.06	2.55 ± 0.04	F=1547.04, p<0.001	p=0.462
	12 weeks	4.33 ± 0.08	4.39 ± 0.05		
	24 weeks	5.45 ± 0.09	5.51 ± 0.06		
MCP Flexion (°)	Baseline	56.2 ± 1.76	57.0 ± 1.13	F=56260.93, p<0.001	p=0.659
	12 weeks	76.0 ± 1.77	77.1 ± 1.13		
	24 weeks	86.2 ± 1.78	87.0 ± 1.14		
MCP Extension Lag (°)	Baseline	17.75 ± 0.48	17.59 ± 0.31	F=6585.59, p<0.001	p=0.744
	12 weeks	7.32 ± 0.49	7.19 ± 0.32		
	24 weeks	2.93 ± 0.26	2.75 ± 0.16		

Michigan Hand Questionnaire (MHQ) scores improved from 70.8±0.61 (conservative) and 69.9±0.39 (operative) at baseline to 84.4±0.92 and 85.0±0.59 at 24 weeks, respectively (time effect: $F(2,188)=415.86$, $p<0.001$; group effect: $p=0.963$; interaction: $p=0.255$). QuickDASH scores declined from 34.7±1.23 and 33.8±0.79 at baseline to 11.9±1.32 and 11.4±0.84 at 24 weeks (time effect: $F(2,188)=9895.93$, $p<0.001$; group: $p=0.632$; interaction: $p=0.442$). PRWHE scores fell from 71.68±1.63 and 70.72±1.04 to 8.00±0.97 and 7.72±0.62 at 24 weeks (time effect: $F(2,188)=15042.72$, $p<0.001$; group: $p=0.717$; interaction: $p=0.652$). VAS pain scores declined from 7.04±0.16 and 6.94±0.10 at baseline to 1.21±0.08 and 1.24±0.05 at 24 weeks (time effect: $F(2,188)=2087.91$, $p<0.001$; group: $p=0.931$; interaction: $p=0.716$).

Objective measures of hand function showed equally parallel recovery. Mean grip strength increased from 12.7±0.49 kg and 11.9±0.32 kg at baseline to 29.8±0.69 kg and 30.1±0.44 kg at 24 weeks (time effect: $F(2,188)=1119.99$, $p<0.001$; group: $p=0.939$). Pincer strength rose from 2.51±0.06 kg and 2.55±0.04 kg to 5.45±0.09 kg and 5.51±0.06 kg (time effect: $F(2,188)=1547.04$, $p<0.001$; group: $p=0.462$). MCP flexion improved from 56.2±1.76° and 57.0±1.13° at baseline to 86.2±1.78° and 87.0±1.14° at 24 weeks (time effect: $F(2,188)=56260.93$, $p<0.001$; group: $p=0.659$; interaction: $p=0.053$). MCP extension lag decreased from 17.75±0.48° and 17.59±0.31° to 2.93±0.26° and 2.75±0.16° at 24 weeks (time effect: $F(2,188)=6585.59$, $p<0.001$; group: $p=0.744$; interaction: $p=0.983$).

Radiological, Complication, and Return-to-Work Outcomes. Table 3 summarises the complication profile, radiological outcomes, return-to-work data, and operative details. Radiological union at 12 weeks was achieved in 78.6% of conservatively managed and 79.4% of operatively managed patients, with no significant between-group difference ($p=0.927$). Complete fracture union was achieved in 100% of patients in both groups by 24 weeks. Return-to-work time was comparable between groups (8.68±2.97 vs 8.63±3.05 weeks; Mann–Whitney U, $p=0.850$). The overall complication profile did not differ significantly between groups ($p=0.539$). Joint stiffness was more frequent in the conservative group (21.4% vs 8.8%), while infection was more common in the operative group (11.8% vs 7.1%). Hardware irritation and malunion occurred at similar rates in both groups. Within the operative cohort, CRIF was employed in 70.6% of cases and ORIF in 29.4%; the dorsal approach was used in 66.2% and the lateral approach in 33.8%. K-wire fixation predominated (91.2%), and the complication distribution did not differ significantly by implant type ($p=0.504$).

Table 3: Post-Treatment Complication Profile, Radiological Outcomes, and Surgical Details (N = 96)

Complication / Outcome	Conservative (n=28) n (%)	Operative (n=68) n (%)	Total (N=96) n (%)	p-value (χ^2)
Post-Treatment Complications				
No complication	16 (57.1)	44 (64.7)	60 (62.5)	0.539
Joint stiffness	6 (21.4)	6 (8.8)	12 (12.5)	
Hardware irritation	2 (7.1)	5 (7.4)	7 (7.3)	
Infection	2 (7.1)	8 (11.8)	10 (10.4)	
Malunion	2 (7.1)	5 (7.4)	7 (7.3)	
Radiological Union				
Union at 12 weeks	22 (78.6)	54 (79.4)	76 (79.2)	0.927
Non-union at 12 weeks	6 (21.4)	14 (20.6)	20 (20.8)	
Union at 24 weeks (complete)	28 (100.0)	68 (100.0)	96 (100.0)	N/A
Return To Work				
Mean return-to-work time (weeks)	8.68 ± 2.97	8.63 ± 3.05	—	0.850
Median return-to-work time (weeks)	7.0	7.5	—	Mann–Whitney U
Surgical Details (Operative Group, n=68)				
Closed reduction & internal fixation (CRIF)	—	48 (70.6)	—	—
Open reduction & internal fixation (ORIF)	—	20 (29.4)	—	—
Dorsal surgical approach	—	45 (66.2)	—	—
Lateral surgical approach	—	23 (33.8)	—	—
K-wire fixation (implant)	—	62 (91.2)	—	p=0.504
Mini-plate fixation (implant)	—	6 (8.8)	—	

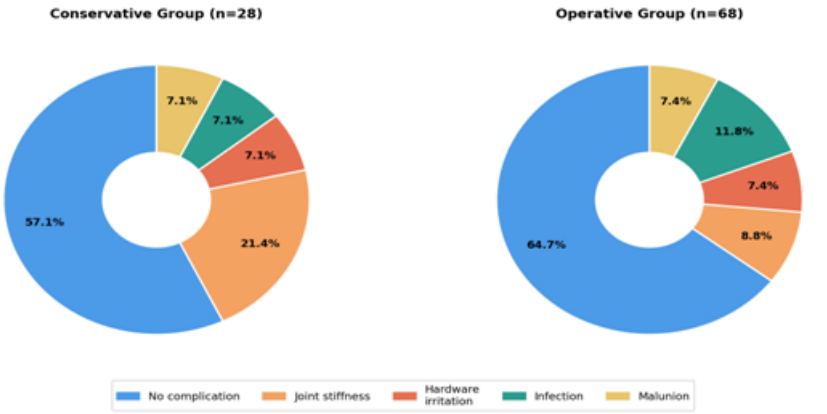


Figure 1: Post-Treatment Complication Profile by Management Group

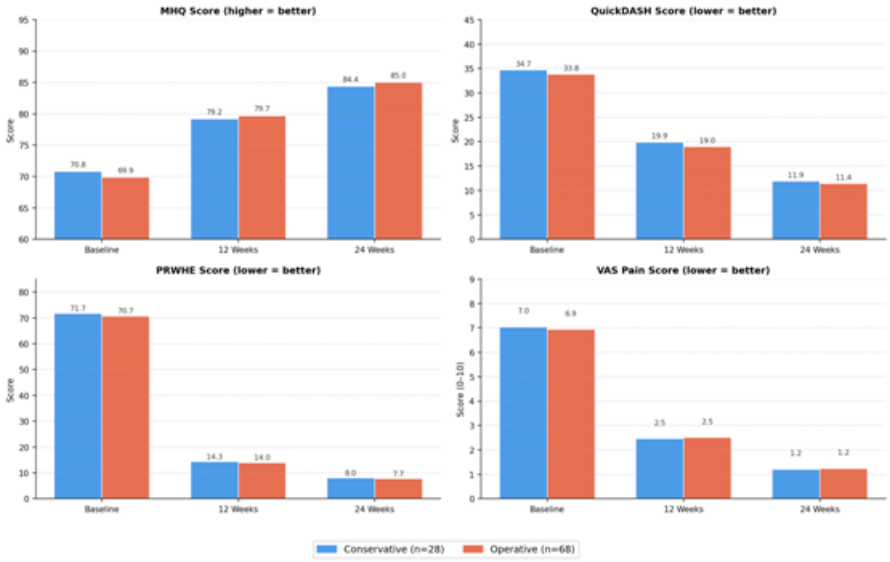


Figure 2: Functional Outcome Scores Over Time by Treatment Group (Mean values; time effects p<0.001; group effects p>0.05)

Discussion

The present prospective comparative study evaluated functional, clinical, and radiological outcomes of conservative versus operative management of metacarpal fractures at a tertiary orthopaedic centre in Delhi NCR, India, over a 24-week follow-up using validated multi-instrument assessment. The principal finding is that both modalities produced statistically significant and clinically comparable improvements in all patient-reported and objective functional parameters, with highly significant time effects and consistently non-significant group effects on repeated-measures analysis, supporting equivalence of outcomes when appropriate case selection and structured rehabilitation are employed.

The sociodemographic profile of the present cohort—predominantly young adult males aged 18–30 years with occupational or road traffic injury mechanisms—is consistent with published Indian data. Sharma et al. reported a large proportion of young males (82.1%) below 30 years of age in their K-wire fixation series, paralleling the 42.7% representation of the 18–30 age group in the current study [34].

Similar demographic patterns were noted by Hirani and Gagal, Chaurasia and Pandey, and Samant et al., all of whom found a predominance of young, economically active males sustaining metacarpal injuries in Indian hospital settings [35,36,37]. The preponderance of skilled and unskilled workers (62.5%) in the present cohort underscores the occupational relevance of metacarpal fractures in the Indian context, a finding corroborated by Gupta et al. and Gupta and Singh, who documented high rates of hand injuries among manual labourers at Indian tertiary centres [38,39]. Baseline sociodemographic equivalence between the two treatment groups (all p>0.05) in the present study ensures that observed differences in outcome, if any, are attributable to treatment effects rather than demographic confounding.

The longitudinal MHQ and QuickDASH trajectories in this study closely align with those reported in comparable Indian and international series. Hirani and Gagal documented comparable MHQ and DASH score improvements in both conservative and operative cohorts when early mobilisation and physiotherapy were incorporated, mirroring the parallel recovery slopes observed in the present repeated-measures analysis [35]. Samant et al. similarly reported comparable functional outcomes between conservative and operative groups without statistically significant intergroup differences [37]. The prospective randomised trial by Peyronson et al. involving displaced finger metacarpal shaft fractures demonstrated equivalent grip strength and DASH outcomes between nonoperative and operative groups at one year, despite marginally better radiographic correction in the operative cohort [40]. Wormald et al., in a systematic review and meta-analysis of extra-articular fifth metacarpal fractures, found no significant differences in patient-reported or radiological outcomes between operative and non-operative management at 12 months, while noting higher adverse-event rates in surgically treated patients [41]. The narrative review by Vikhe et al. suggested potential early functional advantage with rigid fixation, but the present data confirm that any such early advantage does not translate into superior medium-term outcomes as measured by validated instruments at 24 weeks [42]. The equivalent VAS pain reduction observed in both groups throughout follow-up in the present study contrasts with the findings of Lixa et al., who reported greater postoperative pain in surgically treated patients of fifth metacarpal neck fractures despite better radiographic correction [43]. De Haas et al., in a multicentre snapshot study, demonstrated that shorter immobilisation periods were associated with better MHQ outcomes in non-operatively managed fractures, reinforcing the centrality of rehabilitation over modality in pain recovery [44]. Peyronson et al. similarly showed comparable pain trajectories between treatment arms, further supporting the non-modality-dependent nature of pain resolution in metacarpal fractures [40]. In the present study, pain scores declined uniformly to near-minimal levels by 24 weeks in both groups, consistent with the natural healing trajectory of metacarpal fractures when appropriately managed.

Grip and pincer strength recovery in this study paralleled the findings of Gülke et al., who demonstrated near-complete grip strength restoration irrespective of rehabilitation modality following surgical fixation, and of Peyronson et al., who reported equivalent grip strength at one year in operatively and non-operatively treated metacarpal shaft fractures [40,45]. Venkatesh and Kerakkanavar reported excellent functional outcomes following low-profile miniplate osteosynthesis with early mobilisation, but the present data confirm that equivalent strength recovery can be achieved with conservative management when supervised physiotherapy is implemented [46]. The finding by Keller et al., in their systematic review, that structured hand rehabilitation programmes significantly improve total active motion and hand function regardless of prior treatment modality, lends further support to the rehabilitation-driven rather than modality-driven functional recovery observed in the present cohort [47].

MCP joint flexion recovery in the present study, approaching 86–87° at 24 weeks in both groups, is consistent with the excellent range-of-motion outcomes (>80% excellent or good) reported by Chaurasia and Pandey for both conservative and operatively managed metacarpal fractures [36]. Although the time-by-group interaction for MCP flexion approached but did not reach statistical significance ($p=0.053$), it did not translate into a clinically meaningful difference in final outcome, consonant with the observations of Gülke et al. and Wormald et al. regarding the comparability of joint motion recovery between management strategies [41,45]. The uniform reduction in MCP extension lag across both groups further reinforces the equivalence of extensor mechanism recovery, with surgical reviews such as Kussmaul et al. noting stiffness as a risk of operative treatment that was effectively mitigated in the present cohort through structured rehabilitation [48]. The radiological finding of a 79.2% union rate at 12 weeks and 100% union at 24 weeks in both treatment groups aligns with the satisfactory healing outcomes reported across the compared literature. Samant et al. documented comparable union rates between conservative and operative groups [37], and Peyronson et al. demonstrated equivalent functional recovery despite marginally superior radiographic alignment in operative cases, implying that radiological perfection does not independently govern functional outcomes [40]. The achievement of universal fracture union by 24 weeks in the present cohort, irrespective of management approach, supports the conclusion that appropriate case selection and adherence to protocol are sufficient to achieve reliable healing without a modality-specific advantage.

The comparable return-to-work times between groups (8.68 vs 8.63 weeks; $p=0.850$) contrast with the longer work absence observed in surgically treated patients in some Western cohorts, as reported by Wormald et al. [41]. This equivalence in occupational reintegration is particularly significant in the Indian context, where the majority of affected patients are manual workers or skilled labourers for whom early return to work has direct

economic implications. The balanced overall complication profile (p=0.539)—with stiffness more frequent in the conservative group (21.4%) and infection more frequent in the operative group (11.8%)—reflects the well-characterised trade-off between modality-specific risks rather than an overall safety advantage for either approach, consistent with the findings of Kussmaul et al. and Chaurasia and Pandey [36,48].

Within the operative cohort, the predominance of minimally invasive K-wire fixation (91.2%) and the absence of a statistically significant association between implant type and complication rate (p=0.504) echo the findings of Sharma et al. and Hirani and Gagal, who reported satisfactory and comparable outcomes with percutaneous fixation when applied judiciously [34,35].

A distinctive strength of the present study is the comprehensive longitudinal framework employing repeated-measures ANOVA across eight functional parameters simultaneously, enabling robust detection of time effects, group effects, and interaction patterns.

The consistent absence of significant time-by-group interactions across all outcomes provides strong internal evidence that functional recovery after metacarpal fractures is predominantly time-dependent and rehabilitation-driven rather than determined by the initial management modality, a conclusion with important implications for resource allocation and clinical decision-making in Indian tertiary care settings.

Conclusion

This prospective comparative study demonstrates that conservative and operative management of metacarpal fractures yield equivalent short- to mid-term functional, radiological, and occupational outcomes when applied according to appropriate clinical indications and supported by structured rehabilitation. Both treatment strategies produced statistically significant and clinically comparable improvements in patient-reported outcomes (MHQ, QuickDASH, PRWHE), pain relief (VAS), objective hand function (grip and pincer strength, MCP flexion, extension lag), and radiological union at 24 weeks, with no clinically meaningful intergroup differences detected on repeated-measures analysis. Complete fracture union was achieved in 100% of patients in both groups, and return-to-work timelines were nearly identical. Complication profiles were acceptable and balanced across modalities.

These findings support a patient-centred, individualised approach to metacarpal fracture management—guided by fracture stability, patient functional demands, occupational requirements, and available resources—rather than a routine preference for operative intervention. Early structured hand rehabilitation should be emphasised as the cornerstone of functional recovery regardless of the chosen treatment modality.

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