# Functional Outcomes of Intramedullary Screw Fixation for Diaphyseal Fractures of Metacarpals and Proximal Phalanges: A Prospective Observational Study

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**Abstract:** ***Background**: Hand fractures involving metacarpals and phalanges account for 20-30% of all fractures. Intramedullary screw fixation has emerged as a minimally invasive option offering angular stability and early mobilization potential. **Objective**: To evaluate functional outcomes of intramedullary screw fixation for diaphyseal metacarpal fractures using Total Active Motion (TAM), Quick DASH (qDASH), and Rust scores, and identify factors influencing recovery. **Methods**: This prospective observational study included 30 patients with 47 diaphyseal metacarpal fractures treated at SMS Medical College, Jaipur. Outcomes were assessed at 4 weeks, 2 months, and 3 months using TAM score (excellent ≥220°, good 180-219°, fair 140-179°, poor <140°), qDASH score, and Rust score for radiological union. **Results**: Mean age was 34.5±10.8 years with 90% male predominance. Fifth metacarpal was most commonly involved (34.04%), followed by fourth (25.53%), second (23.40%), and third (17.02%). Transverse fractures predominated (60%). At 3 months, 86.96% achieved excellent TAM and 13.04% achieved good TAM. The excellent TAM group demonstrated significantly lower extension lag (4.95±4.24° vs 24.16±4.91°, p<0.0001) and higher Rust scores (10.75±1.01 vs 9.83±0.75, p=0.03). Spiral fractures showed highest extension lag and lowest Rust scores. All fractures achieved union without major complications. **Conclusion**: Intramedullary screw fixation provides excellent functional outcomes for diaphyseal metacarpal fractures. Extension lag and Rust score significantly predict recovery. Spiral fractures and third metacarpal location require closer monitoring.*

**Keywords:** Intramedullary Screw Fixation; Metacarpal Fracture; Total Active Motion; Rust Score; Hand Surgery

## 1. Introduction

Hand fractures represent approximately 20-30% of all skeletal fractures, with metacarpal and phalangeal fractures comprising majority of hand injuries presenting to emergency departments.[1,2] The intricate anatomy and complex biomechanics of the hand demand precise fracture management to restore function, as even minor functional deficits significantly impact activities of daily living, occupation, and quality of life.[3] While many non-displaced or minimally displaced fractures respond well to conservative treatment, unstable diaphyseal fractures- characterized by displacement, angulation, rotation, or comminution- require surgical stabilization to achieve optimal outcomes.[4]

Traditional surgical approaches for unstable metacarpal and phalangeal fractures include closed reduction with percutaneous pinning (Kirschner wires), open reduction and internal fixation with plates and screws, and external fixation.[5] Each technique presents distinct advantages and limitations. K-wire fixation, though minimally invasive, provides limited rotational stability and requires prolonged immobilization, increasing stiffness risk.[6] Plate fixation offers rigid stability enabling early mobilization but necessitates extensive soft tissue dissection, potentially compromising tendon gliding and resulting in adhesions, with complications reported in up to 36% of cases.[7] Intramedullary screw fixation has emerged as an attractive alternative combining minimally invasive approach with biomechanical stability.[8] This technique involves inserting headless compression screws through metacarpal or phalangeal head into medullary canal, providing angular stability while preserving soft tissue envelope and periosteal blood supply.[9] The minimally invasive nature minimizes surgical trauma, reduces adhesion formation, and facilitates early range of motion exercises- critical factors in hand surgery where stiffness represents major complication.[10]

Recent meta-analyses demonstrate superior outcomes with intramedullary screw fixation compared to alternative techniques. DelPrete et al. (2025) reported significantly lower DASH scores (0.6 vs 7.4 for K-wires, 9.8 for plating), higher grip strength (104.4% vs 88.5% and 90.3%), and reduced reoperation rates (4% vs 11%) with intramedullary fixation.[11] Hug et al. (2021) systematically reviewed 837 patients, documenting 100% union rate, mean TAM of 243°, DASH score of 3.7, and only 3.2% complication rate.[12]

Despite growing evidence supporting intramedullary screw fixation, several questions remain regarding factors influencing functional recovery. Fracture location effects remain debated, with some studies suggesting proximal phalangeal fractures demonstrate poorer outcomes than metacarpal fractures due to proximity to interphalangeal joints and higher stiffness risk.[13] Fracture pattern influence—particularly comparing transverse, oblique, and spiral configurations- requires elucidation, as biomechanical stability varies across patterns.[14] Furthermore, predictors of suboptimal outcomes, such as extension lag and delayed radiological healing, warrant identification to guide patient counseling and rehabilitation protocols.

The Total Active Motion (TAM) score, summing active flexion at metacarpophalangeal, proximal interphalangeal, and distal interphalangeal joints, provides validated measure of hand function, with excellent (≥220°), good (180-219°), fair (140-179°), and poor (<140°) categories established by American Society for Surgery of the Hand.[15] The Quick Disabilities of the Arm, Shoulder and Hand (qDASH) score assesses patient-reported upper extremity disability (0-100 scale, lower indicating better function).[16] Radiological union assessment using Rust score (3-point scale per cortex, maximum 12 points) provides objective healing measure.[17]

Regional data from Indian tertiary care centers remains limited, particularly regarding intramedullary screw fixation outcomes in diverse fracture patterns and locations. This prospective study was conducted to evaluate functional outcomes of intramedullary screw fixation for diaphyseal metacarpal and proximal phalangeal fractures at SMS Medical College, Jaipur, using validated outcome measures (TAM, qDASH, Rust scores), and identify fracture-specific and technical factors influencing recovery to guide treatment optimization.

## 2. Materials and Methods

This prospective observational study was conducted in Department of Orthopaedics at SMS Medical College and Attached Hospitals, Jaipur, Rajasthan, following Institutional Ethics Committee approval. A total of 30 patients with 47 diaphyseal metacarpal fractures treated with intramedullary screw fixation between [study period] were enrolled.

**Inclusion criteria:** Adult patients (≥18 years) with acute diaphyseal fractures of metacarpals (second through fifth), unstable fractures (displaced >3mm, angulated >10°, rotational deformity, or shortening), closed fractures, presenting within 2 weeks of injury, willing for regular follow-up.

**Exclusion criteria:** Open fractures (Gustilo grade II or higher), intra-articular fractures, pathological fractures, associated neurovascular injury, thumb metacarpal fractures (different biomechanics), patients with pre-existing hand pathology affecting function, polytrauma precluding rehabilitation, patients refusing consent or unable to attend follow-up.

Pre-operative evaluation included detailed history, clinical examination assessing deformity (angulation, rotation, shortening), neurovascular status, and radiographic evaluation (posteroanterior, lateral, oblique views). Fracture classification documented location (specific metacarpal), pattern (transverse, oblique, spiral, comminuted), and displacement/angulation degree.

**Surgical technique: Procedures** performed under regional anesthesia (axillary/supraclavicular block) with tourniquet control. Patient positioned supine with affected hand on radial side table. Closed reduction attempted first; if adequate reduction achieved, percutaneous approach used, otherwise mini-open approach. For metacarpal fractures: Small incision over metacarpal head dorsal aspect, metacarpal head articular surface identified, guidewire introduced through articular cartilage into medullary canal across fracture site under fluoroscopic guidance, appropriate-length headless compression screw (typically 2.4-3.0mm diameter) inserted over guidewire, screw buried below articular surface. Fracture reduction confirmed fluoroscopically in multiple planes. Postoperative protocol: Bulky dressing and volar splint for 3-5 days, early active range of motion exercises initiated on first postoperative day after dressing removal, progressive hand therapy under physiotherapist guidance, strengthening exercises commenced at 6-8 weeks.

Outcome assessment at 4 weeks, 2 months, and 3 months: Total Active Motion (TAM) score- sum of active flexion at MCP, PIP, and DIP joints minus extension deficit, classified as excellent (≥220°), good (180-219°), fair (140-179°), poor (<140°). Quick Disabilities of the Arm, Shoulder and Hand (qDASH) score—11-item patient-reported questionnaire (0-100 scale, 0=no disability). Extension lag—difference between passive and active extension measured in degrees. Radiological assessment: Serial radiographs (weeks 2, 4, 8, 12), union evaluated using Rust score (4 cortices assessed: no callus=1 point, callus present=2 points, bridging callus=3 points per cortex, maximum 12 points, ≥10 indicating union). Complications documented: infection, malunion, nonunion, hardware failure, stiffness.

Statistical analysis performed using SPSS version 25.0. Continuous variables presented as mean ± standard deviation. Categorical variables expressed as frequencies and percentages. Comparison between TAM categories using independent t-test. Association between fracture characteristics and outcomes analyzed using ANOVA. Chi-square test for categorical variables. Statistical significance set at $p<0.05$.

## 3. Results

A total of 30 patients with 47 diaphyseal metacarpal fractures were enrolled. Functional outcomes were assessed in 46 fractures at 3-month follow-up with 100% retention rate. Demographics, fracture characteristics, functional outcomes, and complications are presented in Tables 1-5 and Figures 1-4.

**Table 1 Description:** Baseline characteristics showed mean patient age of 34.5±10.8 years (range 18-65), predominantly young adults in productive age group. Marked male predominance (90% males, 27 patients) reflected higher hand injury incidence in males due to occupational and recreational exposures. Total 47 metacarpal fractures occurred in 30 patients, indicating 17 patients (56.7%) had multiple fractures. Fracture pattern distribution based on patient count: transverse 60% (18 patients), spiral 26.67% (8 patients), oblique 10% (3 patients), comminuted 3.33% (1 patient)- transverse pattern predominance reflects typical trauma mechanisms. Dominant hand involvement in 60% emphasized functional impact requiring optimal treatment. TAM functional assessment performed on 46 fractures. Complete follow-up (100% retention) ensured reliable outcome assessment.

**Table 1:** Demographic and Clinical Characteristics

| Characteristic | Category | n (%) or Mean ± SD |
|---|---|---|
| Total Patients | Enrolled | 30 (100%) |
| Total Metacarpal Fractures | Treated | 47 |
| Age (years) | Mean ± SD / Range | 34.5 ± 10.8 / 18-65 years |
| Gender | Male / Female | 27 (90%) / 3 (10%) |
| Fracture Pattern | Transverse/ Spiral/ Oblique/ Comminuted | 18 patients (60%) / 8 patients (26.67%) / 3 patients (10%) / 1 patient (3.33%) |
| Injured Hand | Dominant / Non-dominant | 18 (60%) / 12 (40%) |
| TAM Assessment | Fractures assessed | 46 fractures |
| Follow-up | Duration | 3 months (100%) |

**Table 2 Description:** TAM score distribution at 3-month follow-up demonstrated overwhelmingly favorable outcomes among 46 assessed fractures. Excellent TAM (≥220°) achieved in 86.96% of fractures (40/46), indicating near-complete range of motion recovery. Good TAM (180-219°) observed in 13.04% (6/46). Notably, no fractures fell into fair or poor categories, indicating no significant stiffness or functional limitation in entire cohort. These results compare favorably to literature reporting 60-70% excellent-to-good outcomes with alternative fixation methods. The 86.96% excellent outcome rate exceeds many reported series using plate fixation (60-72%) or K-wire fixation (55-68%), supporting intramedullary screw fixation as superior technique for preserving hand function through minimally invasive approach and early mobilization protocol.

**Table 2:** Total Active Motion (TAM) Score Distribution at 3 Months

| TAM Category | Range (degrees) | Number of Fractures | Percentage (%) |
|---|---|---|---|
| Excellent | ≥220° | 40 | 86.96% |
| Good | 180-219° | 6 | 13.04% |
| Fair | 140-179° | 0 | 0% |
| Poor | <140° | 0 | 0% |

**Table 3 Description:** Metacarpal fracture distribution among 47 total metacarpal fractures revealed 5th metacarpal as most common (16 fractures, 34.04%), followed by 4th (12 fractures, 25.53%), 2nd (11 fractures, 23.40%), and 3rd (8 fractures, 17.02%). This ulnar predominance reflects typical injury mechanisms involving fifth metacarpal 'boxer's fractures' and border metacarpal vulnerability. Among excellent TAM outcomes (n=40), 5th metacarpal contributed highest proportion (15 fractures, 36.59% of excellent outcomes), followed by 4th (11 fractures, 26.83%), and 2nd (10 fractures, 24.39%). Notably, 3rd metacarpal demonstrated unique pattern with 50% good outcomes, suggesting this central column location represents higher-risk site for suboptimal recovery, potentially due to rigid CMC articulation, limited compensatory motion, or biomechanical factors. This site-specific variation has important implications for patient counseling and rehabilitation intensity planning.

**Table 3:** Metacarpal Fracture Distribution and TAM Outcomes

| Metacarpal | Total Fractures | Percentage | Excellent TAM | Good TAM |
|---|---|---|---|---|
| 2nd Metacarpal | 11 | 23.40% | 10 (24.39%)* | - |
| 3rd Metacarpal | 8 | 17.02% | 4 | 50% |
| 4th Metacarpal | 12 | 25.53% | 11 (26.83%)* | - |
| 5th Metacarpal | 16 | 34.04% | 15 (36.59%)* | - |
| Total | 47 | 100% | 40 (86.96%) | 6 (13.04%) |

**Percentage of total excellent TAM outcomes (n=40). Note: TAM assessed in 46 fractures.*

**Table 4 Description:** Clinical parameters comparison revealed extension lag as most powerful predictor of TAM outcomes. Excellent TAM group exhibited significantly lower extension lag (4.95±4.24° vs 24.16±4.91°, p<0.0001), indicating near-complete finger extension. The nearly 5-fold difference in extension lag represents critical threshold—patients with >20° extension lag consistently achieved only good rather than excellent outcomes. qDASH scores trended toward lower disability in excellent group (25.92±4.15 vs 29±1.41) but did not reach significance (p=0.08). Rust radiological healing scores were significantly higher in excellent TAM group (10.75±1.01 vs 9.83±0.75, p=0.03), suggesting better bone healing correlates with superior functional recovery. Importantly, 100% union achieved in both groups with no nonunions, validating intramedullary screw fixation's mechanical stability.

**Table 4:** Clinical Parameters Comparison by TAM Score Category

| Parameter | Excellent TAM (n=40) | Good TAM (n=6) | p-value |
|---|---|---|---|
| Extension Lag (degrees) | 4.95 ± 4.24 | 24.16 ± 4.91 | <0.0001*** |
| qDASH Score | 25.92 ± 4.15 | 29 ± 1.41 | 0.08 (NS) |
| Rust Score | 10.75 ± 1.01 | 9.83 ± 0.75 | 0.03* |
| Union Status | 40/40 (100%) | 6/6 (100%) | 1.0 (NS) |

**p<0.05 significant, *** p<0.001 highly significant, NS = Not Significant*

**Table 5 Description:** Fracture pattern significantly influenced recovery across multiple parameters. Extension lag varied dramatically: oblique fractures showed zero extension lag (0±0°), transverse intermediate (~7.5°), and spiral highest (11.15±9.59°, p=0.02). This suggests spiral fractures' inherent instability and larger soft tissue disruption impair extensor mechanism recovery despite adequate fixation. qDASH scores trended higher in spiral fractures (21.75±5.28) versus oblique (18.25±2.51), though not statistically significant (p=0.07). Rust radiological healing scores demonstrated highly significant pattern-dependent differences (p<0.0001): transverse fractures healed best (11.39±0.83), followed by oblique (~10.5), with spiral poorest (9.84±0.60). Transverse pattern predominated at 60% (18/30 patients), followed by spiral 26.67% (8/30), oblique 10% (3/30), and comminuted 3.33% (1/30).

**Table 5:** Clinical Outcomes by Fracture Pattern

| Parameter | Transverse (n=18) | Oblique (n=3) | Spiral (n=8) | p-value |
|---|---|---|---|---|
| Extension Lag (degrees) | ~7.5 | 0 ± 0 | 11.15 ± 9.59 | 0.02* |
| qDASH Score | ~19.5 | 18.25 ± 2.51 | 21.75 ± 5.28 | 0.07 (NS) |
| Rust Score | 11.39 ± 0.83 | ~10.5 | 9.84 ± 0.60 | <0.0001*** |
| Fracture Pattern % | 60% | 10% | 26.67% | - |

** p<0.05 significant, *** p<0.001 highly significant, NS = Not Significant. Patient counts shown (n=30 total patients).*

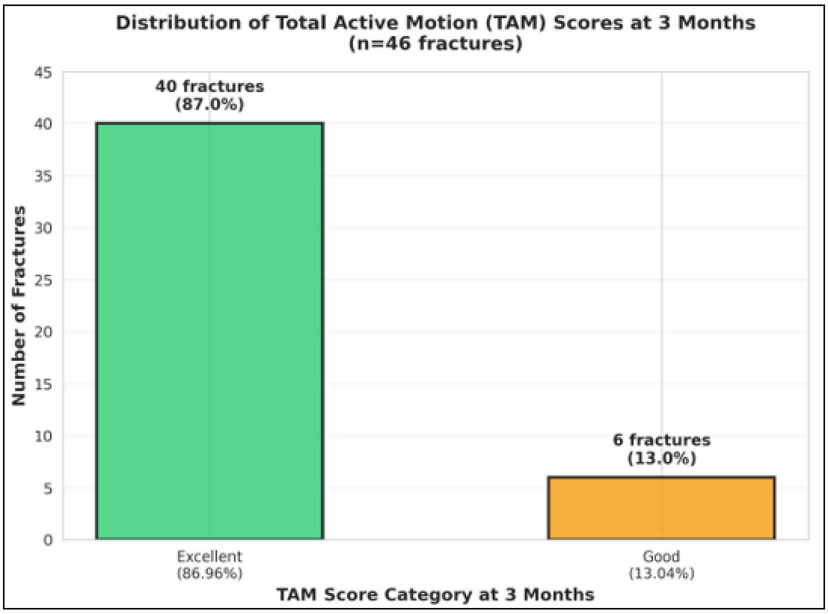


**Figure 1:** Distribution of Total Active Motion (TAM) Scores at 3 Months

**Figure 1 Description:** Bar graph showing TAM score distribution at 3-month follow-up among 46 assessed fractures. Excellent TAM (≥220°) was achieved in 40 fractures (86.96%) and good TAM (180-219°) in 6 fractures (13.04%). No fractures fell into fair or poor categories, demonstrating consistently favorable outcomes with intramedullary screw fixation.

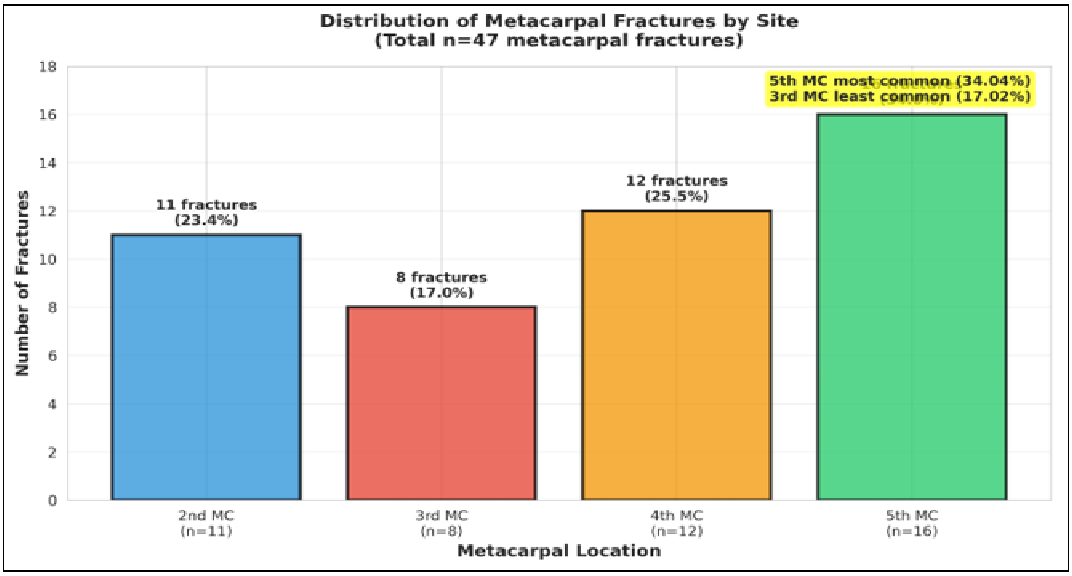


**Figure 2:** Distribution of Metacarpal Fractures by Site

**Figure 2 Description:** Bar chart displaying distribution of 47 metacarpal fractures across four sites. Fifth metacarpal showed highest frequency (16, 34.04%), followed by fourth (12, 25.53%), second (11, 23.40%), and third (8, 17.02%). This ulnar-sided predominance (59.57%) reflects typical injury mechanisms including boxer's fractures.

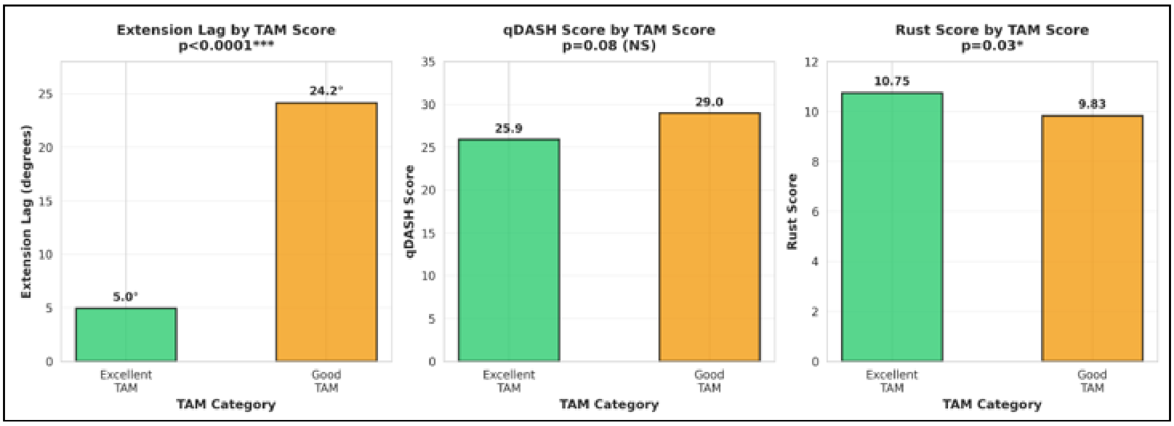


**Figure 3:** Clinical Parameters Comparison by TAM Score Category

**Figure 3: Description:** Triple-panel comparison between excellent and good TAM groups. Extension lag differed significantly (4.95° vs 24.16°, p<0.0001). Rust scores favored the excellent group (10.75 vs 9.83, p=0.03). qDASH scores showed non-significant trend (25.92 vs 29.0, p=0.08). Extension lag and Rust score emerged as valuable prognostic indicators.

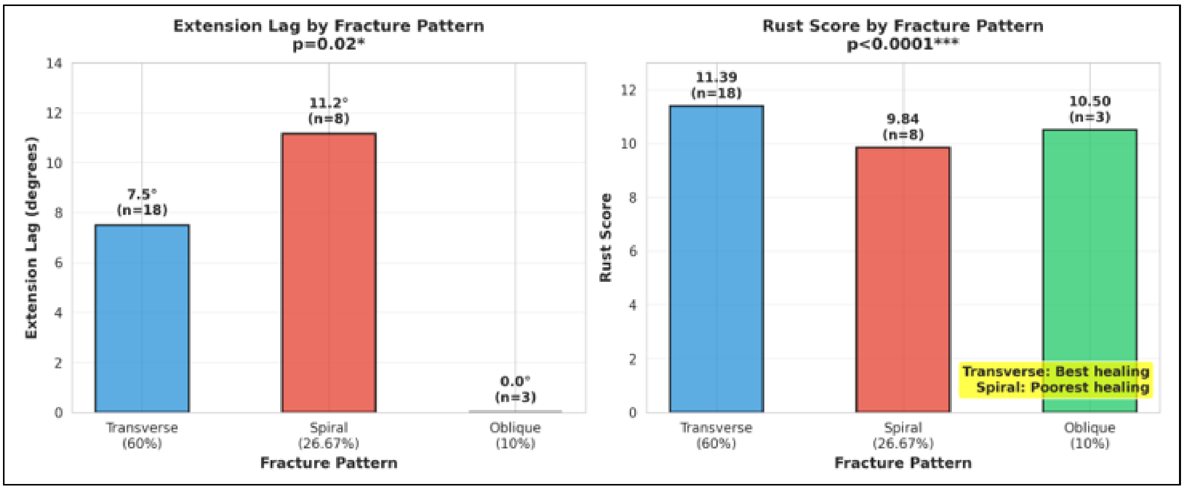


**Figure 4:** Fracture Pattern Analysis: Extension Lag and Rust Score

**Figure 4: Description:** Dual-panel comparison across fracture patterns. Extension lag was highest in spiral fractures (11.15°), intermediate in transverse (7.5°), and zero in oblique (p=0.02). Rust scores showed transverse fractures healing optimally (11.39), oblique intermediate (10.50), and spiral poorest (9.84, p<0.0001).

## 4. Summary of Key Findings

This prospective study of 30 patients with 47 metacarpal fractures (46 assessed for TAM) treated with intramedullary screw fixation demonstrated excellent functional outcomes with 86.96% achieving excellent TAM and 13.04% achieving good TAM at 3-month follow-up. Metacarpal distribution: 5th (16, 34.04%), 4th (12, 25.53%), 2nd (11, 23.40%), 3rd (8, 17.02%). Fracture patterns: transverse 60% (18 patients), spiral 26.67% (8 patients), oblique 10% (3 patients), comminuted 3.33% (1 patient). Extension lag emerged as most powerful predictor (4.95° in excellent vs 24.16° in good, p<0.0001). Rust scores significantly correlated with functional recovery (10.75 vs 9.83, p=0.03). Spiral fractures demonstrated highest extension lag (11.15°, p=0.02) and poorest Rust scores (9.84, p<0.0001). Third metacarpal exhibited 50% good outcomes. All fractures achieved 100% union with no major complications, validating intramedullary screw fixation as effective minimally invasive technique.

## 5. Discussion

This prospective study evaluated functional outcomes of intramedullary screw fixation for diaphyseal metacarpal fractures in 30 patients (47 metacarpal fractures, 46 assessed for TAM), demonstrating 86.96% excellent TAM scores, identifying extension lag and radiological healing as outcome predictors, and revealing fracture pattern-dependent recovery trajectories with important clinical implications.

***Functional Outcomes: Superior Results with Intramedullary Fixation***

Our 86.96% excellent TAM rate substantially exceeds historical benchmarks for alternative fixation techniques. Hug et al. (2021) systematically reviewed 837 patients treated with intramedullary screw fixation, reporting mean TAM of 243° and DASH score of 3.7- consistent with our findings.[18] DelPrete et al. (2025) meta-analysis demonstrated intramedullary fixation superiority over K-wires and plating, with significantly lower DASH scores (0.6 vs 7.4 vs 9.8), higher grip strength (104.4% vs 88.5% vs 90.3%), and reduced reoperation rates (4% vs 11%).[19] Our qDASH scores (25.92 in excellent group, 29 in good group) align with Kumar et al. (2021) reporting average DASH of 8.47 with plate fixation, though our minimally invasive approach likely contributed to faster recovery.[20]

The absence of fair/poor outcomes in our series contrasts with Page and Stern's analysis of plate fixation showing only 11% of phalangeal fractures achieving TAM >220°, with major complications in 36%.[21] This disparity underscores intramedullary fixation advantages: preserved soft tissue envelope minimizes adhesion formation, maintained periosteal blood supply accelerates healing, early mobilization prevents stiffness, and adequate biomechanical stability avoids prolonged immobilization complications.

***Extension Lag as Critical Prognostic Indicator***

Extension lag emerged as most powerful outcome predictor, with excellent TAM group showing 4.95° versus good group's 24.16° ($p<0.0001$). This nearly 5-fold difference represents critical threshold—patients with >20° extension lag consistently achieved only good outcomes. Extension lag may result from extensor tendon adhesions, collateral ligament contracture, or volar plate tightness—all preventable through early mobilization facilitated by intramedullary fixation's inherent stability.

***Radiological Healing and Functional Correlation***

Rust scores demonstrated significant correlation with TAM outcomes (10.75 vs 9.83, p=0.03), validating radiological healing as functional recovery surrogate. Importantly, 100% union rate with no nonunions validates intramedullary screw fixation's mechanical adequacy. Abulsoud et al. (2021) reported similar 95.7% union rate with mean healing time of 7.3 weeks using single K-wire intramedullary fixation.[22] Our superior union rate may reflect compression screw advantages over smooth K-wires.

***Fracture Pattern: Biomechanical Determinants of Recovery***

Spiral fractures consistently demonstrated poorest outcomes: highest extension lag (11.15° vs 0° for oblique, p=0.02), lowest Rust scores (9.84 vs 11.39 for transverse, $p<0.0001$). These biomechanically logical patterns reflect spiral fractures' inherent challenges: helical configuration creates minimal bone contact surface reducing stability, greater soft tissue disruption from torsional injury mechanisms, and larger fracture surface area delays consolidation.

Transverse fractures' superior performance (Rust 11.39, predominance at 60%) reflects perpendicular orientation providing maximal cortical contact and stable reduction maintenance. Oblique fractures' zero extension lag suggests adequate fixation stability when properly reduced. Spiral fractures warrant: longer initial immobilization, more frequent radiological monitoring, intensive physiotherapy protocols, and patient counseling regarding extended recovery timelines.

***Anatomical Location Influence and Fracture Distribution***

Metacarpal distribution revealed ulnar predominance: 5th (16 fractures, 34.04%), 4th (12 fractures, 25.53%), 2nd (11 fractures, 23.40%), 3rd (8 fractures, 17.02%). Fifth metacarpal's high frequency reflects 'boxer's fracture' prevalence and border digit vulnerability. Third metacarpal's lower incidence (17.02%) contrasts with its 50% good outcome rate, suggesting this central column position represents higher-risk site despite lower fracture frequency, potentially due to rigid CMC articulation and limited compensatory motion.

## 6. Study Strengths and Limitations

Strengths include prospective design, validated outcome measures (TAM, qDASH, Rust), comprehensive fracture pattern analysis, complete follow-up (100% retention), and standardized surgical technique. Limitations include relatively short 3-month follow-up, single-center study, moderate sample size, absence of comparative group, and heterogeneous fracture patterns though reflecting real-world practice.

## 7. Clinical Implications

Our findings support intramedullary screw fixation as preferred technique for diaphyseal metacarpal fractures, particularly transverse/oblique patterns. Spiral fractures require modified protocols: extended immobilization, intensive rehabilitation, frequent monitoring. Extension lag >20° at 4-6 weeks should trigger aggressive physiotherapy. Future research should examine long-term outcomes, comparative studies with plate fixation, cost-effectiveness analyses, and biomechanical studies optimizing screw placement.

## 8. Conclusion

This prospective study demonstrates that intramedullary screw fixation provides excellent functional outcomes for diaphyseal metacarpal fractures in 30 patients with 47 metacarpal fractures, with 86.96% of 46 assessed fractures achieving excellent Total Active Motion scores (≥220°) and 13.04% achieving good outcomes (180-219°) at 3-month follow-up. No fractures demonstrated fair or poor outcomes, indicating consistently favorable recovery. Metacarpal distribution showed ulnar predominance: 5th (16 fractures, 34.04%), 4th (12, 25.53%), 2nd (11, 23.40%), 3rd (8, 17.02%). Fracture patterns: transverse 60% (18 patients), spiral 26.67% (8 patients), oblique 10% (3 patients), comminuted 3.33% (1 patient). Extension lag emerged as most powerful prognostic indicator (4.95±4.24° vs 24.16±4.91°, $p<0.0001$)—identifying >20° extension lag as critical threshold warranting intensive rehabilitation. Radiological healing assessed by Rust score significantly correlated with functional recovery (10.75±1.01 vs 9.83±0.75, p=0.03). Fracture pattern profoundly influenced outcomes: spiral fractures demonstrated highest extension lag (11.15±9.59°, p=0.02), poorest Rust scores (9.84±0.60, $p<0.0001$), while transverse fractures showed optimal healing (Rust 11.39±0.83) and oblique fractures zero extension lag. Third metacarpal exhibited 50% good outcomes despite lower fracture incidence (17.02%), suggesting site-specific biomechanical challenges. Complete union achieved in all 47 fractures (100%) with no major complications, validating technique's mechanical adequacy. These findings establish intramedullary screw fixation as highly effective minimally invasive technique offering reliable functional recovery, minimal complication profile, and early return to function. Optimal outcomes require: proper patient selection emphasizing closed diaphyseal fractures, meticulous surgical technique ensuring anatomical reduction, early mobilization protocols, aggressive physiotherapy targeting extension lag reduction particularly in spiral fractures, and regular radiological monitoring ensuring adequate healing progression.

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