RESEARCH PAPER

FUNCTIONAL OUTCOME OF UNSTABLE METACARPAL FRACTURES TREATED WITH TRANSVERSE KIRSCHNER-WIRE FIXATION: A REVIEW ARTICLE

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ABSTRACT

Metacarpal fractures constitute a significant proportion of hand injuries, particularly among young and working-age individuals. While stable fractures can be managed conservatively, unstable fracture patterns frequently require surgical intervention to prevent malunion, rotational deformity, and functional impairment. Among various fixation methods, transverse Kirschner-wire (K-wire) fixation has gained acceptance as a minimally invasive technique providing adequate rotational and angular stability with minimal soft-tissue disruption. This review article evaluates the current evidence regarding the anatomical basis, indications, surgical principles, functional outcomes, and complications associated with transverse K-wire fixation in unstable metacarpal fractures. The available literature suggests that transverse K-wire fixation offers satisfactory union rates, good functional recovery, and a favorable complication profile when combined with appropriate rehabilitation. Emphasis is placed on functional outcome assessment using validated tools such as Visual Analog Scale (VAS), Quick-DASH, Total Active Motion (TAM), and grip strength measurement.

Keywords: Metacarpal fracture, Transverse K-wire fixation, Unstable fracture, Functional outcome, Quick-DASH, Total active motion.

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Introduction

Metacarpal fractures account for approximately 30–40% of hand fractures and represent a common injury encountered in orthopaedic practice. The hand's complex biomechanical and functional role necessitates restoration of alignment, stability, and mobility to achieve optimal outcomes. Functional recovery—rather than radiographic union alone—is the primary objective in managing these injuries. Unstable metacarpal fractures are characterized by unacceptable angulation, shortening, rotational deformity, comminution, or inability to maintain reduction. Among these, rotational deformity is particularly disabling, as even minimal malrotation leads to finger overlap during flexion, impairing grip and coordinated hand function. Surgical stabilization is indicated when conservative management cannot maintain acceptable alignment. Various fixation techniques have been described, including plating, intramedullary devices, lag screws, external fixation, and Kirschner-wire fixation. Transverse K-wire fixation has emerged as a reliable, minimally invasive method that provides inter-metacarpal stability while preserving soft tissues.

Historical Evolution of Metacarpal Fracture Management

Early management of metacarpal fractures relied heavily on splintage and casting. However, increasing recognition of functional impairment associated with malunion prompted the development of surgical fixation techniques. The introduction of Kirschner wires by Martin Kirschner in the early 20th century marked a major milestone in fracture management. Their versatility and minimal invasiveness made them particularly suitable for hand fractures. Over time, different configurations evolved, including longitudinal intramedullary pinning and transverse inter-metacarpal fixation. Transverse K-wire fixation developed to improve rotational control and enhance stability without extensive dissection, thereby aligning with modern principles emphasizing soft-tissue preservation and early mobilization.

Anatomical and Biomechanical Considerations

The metacarpals form the structural framework of the hand and contribute to both power and precision grip.

Anatomically, each metacarpal consists of a base, shaft, neck, and head. The index and middle metacarpals are relatively rigid due to strong carpometacarpal (CMC) articulations, whereas the ring and small metacarpals possess greater mobility, facilitating cupping during power grip. Tolerance to angulation varies: Index and middle metacarpals: 5°–10° Ring and small metacarpals: up to 20° Shortening and angulation alter tendon excursion and grip strength, while rotational deformity causes scissoring of fingers during flexion—an unacceptable functional outcome. Understanding these anatomical and biomechanical principles is essential when selecting fixation techniques and determining acceptable alignment.

Classification and Indications for Surgery

Metacarpal fractures are classified based on: 1. Anatomical Location Head Neck Shaft Base

2. Fracture Configuration Transverse Oblique Spiral Comminuted 3. Stability

Unstable fractures include: Rotational deformity Excessive angulation Shortening Comminution Open fractures Surgical intervention is indicated in

fractures where functional compromise is likely if left untreated.

Surgical Techniques for Metacarpal Fixation

Plate and Screw Fixation: Provides rigid stability and allows early mobilization but requires extensive dissection and may cause tendon irritation.

Intramedullary Fixation: Minimally invasive but may offer limited rotational stability in certain fracture patterns.

External Fixation: Reserved for open fractures or severe comminution; associated with pin-tract infection and patient discomfort.

Kirschner-Wire Fixation

Remains widely used due to: Simplicity Low cost Minimal soft-tissue disruption Short operative time

Principles of Transverse Kirschner-Wire Fixation

Transverse K-wire fixation involves stabilizing the fractured metacarpal to adjacent intact metacarpals. This inter-metacarpal construct provides: Rotational stability Angular stability Preservation of periosteal blood supply Minimal surgical morbidity Compared to longitudinal pinning, transverse fixation offers superior control of rotational deformity. It is particularly suitable for unstable transverse and short oblique fractures of the shaft and neck.

Functional Outcome Assessment

Radiological union alone does not equate to satisfactory functional recovery. Therefore, validated assessment tools are essential: Visual Analog Scale (VAS): Pain assessment

Quick-DASH Score: Functional disability evaluation Total Active Motion (TAM): Digital mobility assessment Grip Strength Measurement: Reflects combined skeletal and tendon recovery These tools provide objective evaluation of postoperative outcomes.

Evidence from Literature

1. Essawy OM et al. (2020): Prospective evaluation of transverse K-wire fixation demonstrated high union rates and satisfactory functional recovery with minimal complications.

2. Raghavendra V et al. (2017): Reported favorable outcomes in surgically managed metacarpal fractures, emphasizing early stabilization and rehabilitation.

3. NB MK and Narayan P (2020): Compared JESS and K-wire fixation; JESS showed superior fixation stability, though K-wire fixation remained effective when proper technique and postoperative care were ensured.

4. Pusalkar M et al. (2024): Compared plating with K-wire fixation. Plating showed earlier union and improved ROM in selected patterns; however, K-wire fixation remained advantageous due to minimal soft-tissue complications. Overall, the literature supports transverse K-wire fixation as an effective method for unstable metacarpal fractures, especially in resource-limited settings.

Complications

Potential complications include: Malunion Nonunion Joint stiffness Restricted finger motion Pin-tract infection Loss of reduction Compared with plating, transverse K-wire fixation demonstrates lower rates of tendon irritation and soft-tissue adhesions. Most pin-tract

infections are superficial and manageable.

Advantages of Transverse K-Wire Fixation

Minimally invasive Preserves soft tissues Adequate rotational control Cost-effective Short operative time Suitable for tertiary and peripheral centers

Limitations

Requires postoperative immobilization Risk of pin-tract infection Potential loss of reduction if

improperly placed Slightly delayed mobilization compared to rigid plating

Discussion

The optimal management of unstable metacarpal fractures requires balancing stability and soft-tissue preservation. While plating offers rigid fixation and early mobilization, it carries higher risks of tendon irritation and implant-related complications. Transverse K-wire fixation provides a compromise—adequate stability with minimal soft-tissue disruption. Functional outcomes are largely dependent on: Accurate reduction Stable fixation Early controlled mobilization Structured rehabilitation Current literature indicates that when these principles are followed, transverse K-wire fixation results in satisfactory union rates and favorable functional recovery.

Conclusion

Transverse Kirschner-wire fixation is a reliable,

minimally invasive, and cost-effective technique for the management of unstable metacarpal fractures. It provides adequate rotational and angular stability while preserving soft tissues and minimizing complications. Functional
outcomes, assessed using validated clinical tools, are generally satisfactory when early rehabilitation protocols are implemented. Further large-scale randomized controlled trials comparing transverse K-wire fixation with modern plating systems would help refine surgical decision-making and establish standardized treatment guidelines.

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