Retrograde Intramedullary Screw Fixation for Metacarpal Fractures: A Systematic Review

Genoveffa R. Morway, D.O.[1], Taylor J. Rider, M.S.[1], Christopher M. Jones, M.D.[2]

1 Philadelphia College of Osteopathic Medicine, Department of Orthopedic Surgery
2 Rothman Institute

Introduction

Metacarpal fractures are one of the most common types of upper extremity fractures in the U.S., being the most common for ages 18-34[1]. Some of these fractures require operative fixation, including irreducible, malrotated, unstable, and open fractures. Traditional types of fixation have included Kirschner (K) wires, lag screws, and plates-and-screws. K-wire fixation allows limited soft tissue dissection but has a high complication rate including infection, loosening, and loss of reduction[2,3]. Plate and screw fixation allows for more rigid fixation but, again, the complication rate is high and includes extensive soft tissue dissection, tendon adhesions, and issues with hardware prominence[4,5].

A newer technique, first described in 2010[6], is retrograde headless intramedullary screw (RIS) fixation. Figure 1 demonstrates pre- and post-operative x-rays of a RIS used in a metacarpal fracture. Touted benefits of RIS include reduced operative time, minimal-to-no post-operative immobilization requirement, early range of motion, and low complication rates. However, due to the novelty of this technique, much is still not known including specific indications, contraindications, and long-term outcomes.

The purpose for this review is: 1) to critically evaluate the clinical and biomechanical outcomes of RIS fixation for metacarpal fractures and 2) to compile a complication profile for this procedure from current literature.

Methodology

A comprehensive literature search was performed in May 2020 using Cochrane, PubMed, EBSCO, and EMBASE databases. The following key words were used and appeared in the title, abstract, or keywords field: “metacarpal”, “fracture”, “intramedullary”, “IM”, “fixation”, “retrograde”, and “screw”. All references in the included studies were cross-referenced for inclusion if any were missed on initial search. Inclusion criteria consisted of use of intramedullary screw, published between 2000-2020, at least level 4 evidence (level 5 permitted for biomechanical studies), and reporting either clinical or biomechanical outcomes. Clinical studies were assessed for multiple outcomes of interest including concomitant procedures, Disabilities of the Arm, Shoulder, and Hand (DASH) score, grip strength, range of motion (ROM), patient satisfaction, fracture union, time to union, malunion, complications, reoperations, revision surgery including hardware removal, and time to return-to-work. Biomechanical studies were assessed for construct stiffness, load-to-failure (LTF), displacement, energy absorption, and failure mechanism. Studies were reviewed independently by two authors and MINORS scores calculated by each reviewer to assess methodological quality of each study, with scores ranging from 9-12 in non-comparative studies and 13-17 in comparative studies.

Figure 1: Left- Pre-operative x-ray demonstrating short oblique 5th metacarpal fracture. Right: Post-operative x-ray demonstrating successful RIS insertion

Results

After applying our inclusion criteria, 13 clinical studies and 6 biomechanical studies were included for data extraction and analysis.

Clinical Studies

Thirteen studies, all Level III or IV evidence, were included for analysis. Two of these were comparative studies, comparing RIS to K wire and plate-and-screw (PS) fixation[7,8 9-11]. The studies examined 603 metacarpal fractures with a mean follow up of 7.8 months with one study not reporting follow up[8]. Characteristics of patients treated include 84.0% male, a mean age of 32.1 years, with 69.4% of fractures involving the 5th metacarpal. The nature of the fractures treated varied but all were extraarticular involving the neck or shaft. Most studies treated short oblique, transverse, and comminuted fractures with one study also choosing to include long oblique[11]. Operative techniques included open extensor tendon split approaches in 7 studies, percutaneous approaches in 3 studies, and sagittal band incision and repair in one study.

The outcomes examined included time to union, percentage with union, grip strength, total active motion, DASH score, and time to return-to-work. **Table 1** shows the means, standard deviations, and studies reporting for each of these outcomes.

The overall complication rate was 2.8% (17 / 603). The complications included post op stiffness (n=6), extension lag (n=2), Reflex Sympathetic Dystrophy (n=2), hypertrophic scar (n=1), trigger finger (n=1), proximal screw migration (n=1), early arthrosis (n=1), asymptomatic periarticular click (n=1), joint space narrowing (n=1), and nickel allergy (n=1). Not included in the complication rate, but worth noting, was the incidence of refracture of the metacarpal (after full healing) with resultant bent or fractured screw, which was found to be 9 / 603 or 1.5% of those treated[11-15].

Results (cont’d)

Post-operative protocols varied widely between studies. Most studies used minimal post-operative dressing, such as buddy strapping, and began ROM immediately while others employed a splint or cast for up to 21 days.

Outcome (Unit)	Mean	Standard Deviation	Studies Reporting
Time to union (weeks)	5.5	1.1	8
Percentage with union (%)	93.9	12.2	4
Grip strength (kg)	38.2	4.0	6
Grip strength compared to contralateral (%)	96.1	6.3	8
Total active motion (degrees)	250.2	4.3	7
DASH score	2.5	2.1	4
Time to return to work (weeks)	4.7	2.1	6

Table 1: The outcomes, means, standard deviation, and number of studies reporting these means.

Biomechanical Studies

Six studies examined RIS fixation in 80 metacarpals, 70 of which were cadaveric and 10 of which were sawbones[15-20]. Each of the studies tested the metacarpals in different ways such as 3-point-bending, 4-point-bending, cantilever bending, and using a pulley to recreate grip force. Each of the studies examined LTF, which ranged from 70.6 – 467.4 N.

Each of the studies compared RIS fixation to other forms of fixation including non-locking and locking plates and K wires. Most studies found RIS to have similar or higher LTF than K wires, though one study did find K wires to be superior[16]. Plates and screws were always found to have a higher LTF than RIS in the studies that compared the two[17-20].

Discussion

- RIS demonstrates good clinical outcomes with high union rate and excellent restoration of strength, range of motion, and function.
- Buddy strapping fingers with early range of motion is appropriate post op protocol
- RIS patients returned to work at an average of 4.7 weeks[4,7,10,23-25].
- The 2.8% complication rate of RIS is far smaller than those reported for K wires (26-35%) and plate and screws (16-22%) in recent reviews[21,22]. This may, however, be due to lack of reporting and/or the retrospective nature of the reviewed RIS studies.
- Most studies, both clinical and biomechanical, applied this modality to transverse or short oblique fractures of the metacarpal shaft or neck. One case of application to a long oblique fracture resulted in significant shortening, suggesting RIS may not perform well in long oblique and spiral fracture morphology[10].
- None of the reviewed studies addressed violation of articular cartilage and its potential sequalae.

Discussion (con’t)

- Comparing the results of this review to those of other modalities, RIS strength appears to be equivalent or higher than K wires and weaker that plates and screws[21,22]. This can be interpreted as an ideal finding, with a construct that is not too stiff to inhibit callus formation but stable enough to allow early range of motion and finger use, as documented by Jones, et al[17].
- Several studies commented on bent and broken screws upon metacarpal re-fracture but these cases were not included in the complication rate presented here. However, concerns were expressed regarding difficulty of screw removal
- Study limitations include the variety of outcome measures reported between studies, limiting direct comparison, the paucity of long-term follow-up, and that all included studies were Level III, IV, or V evidence.

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