ORIGINAL ARTICLE

Comparing hand strength and quality life of locking plate versus intramedullary k wire for transverse midshaft metacarpal fractures

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ABSTRACT

Aim In the scientific literature there are no papers that clarify which method of surgical fixation in transverse metacarpal fractures has the best functional outcomes. The aim of this study was to compare the hand strength obtained using two different methods in the treatment of these fractures.

Methods A total of 52 patients who presented a transverse metacarpal fracture were enrolled. They were divided in two groups: 26 patients treated with K-wire (IMN) and 26 patients treated with plate and screws (PW). The evaluation criteria were: fracture healing time, performed force testing collected ultimate tensile strength and grip, the Disability Arm Shoulder and Hand (DASH) score, and the range of motion of the hand.

Results In both groups obtained results were comparable in terms of full hand function, healing and total range of motion and DASH. Results in group K were slightly better than group PW in terms of strength and grip pain within 3 months from osteosynthesis.

Conclusion Neither of the two techniques, either in the literature or in biomechanical studies, shows to have superior functional outcomes for fixation of transverse metacarpal fractures. Since the K-wire is cheaper and has no intrinsic complications as compared with plating (such as scar and tendon irritation), fixation with the latter is preferable to the plate in the treatment of these fractures in non-expert hands.

Key words: finger, grip, hand, joint, pain, stiffness

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INTRODUCTION

Metacarpal fractures account for 6% of all fractures in the adult population (1). De Jonge et al. performed a retrospective analysis of 3,858 metacarpal fractures seen over a 23-year period in a Netherlands institution, finding that men aged 10–29 years showed the highest incidence of metacarpal fractures (2.5%) (2). They found that bicycle accidents in particular accounted for the vast majority of metacarpal fractures across all demographic variables, while accidental fall was the mechanism of injury over a bimodal distribution of age groups less than 9 or older than 50 years old. According to Nakashian et al. (3) a typical patient suffering from a metacarpal fracture is a young, sporty patient with a high demand for work on the part of the hands. Many metacarpal fractures can be treated non-operatively; however, some are treated most effectively with surgical stabilization. It was postulated that plates (PW) (Figure 1) would have a signifi-

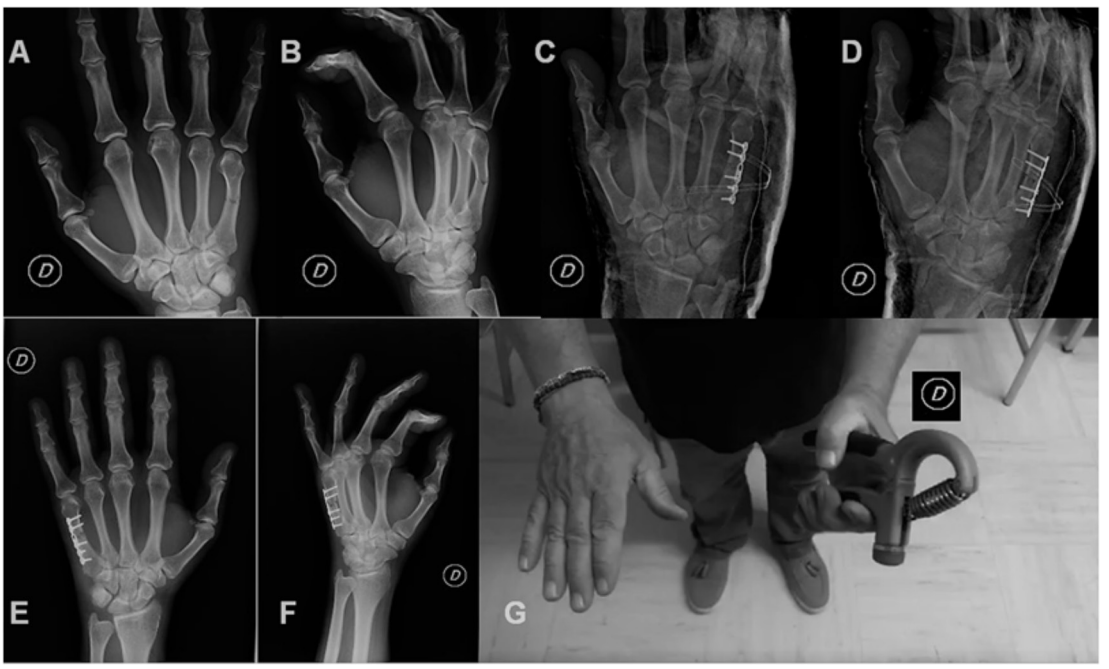

Figure 1. A 42-year-old male with transverse fracture of the right V metacarpus from fist. A, B) Pre-operative X-rays show the above fracture in detail; C-D) postoperative X-rays show the surgical treatment with plate and screws; E-F) control X-rays at 6 months; G) result in the grip test at 6 months (Pasquino A, 2018)

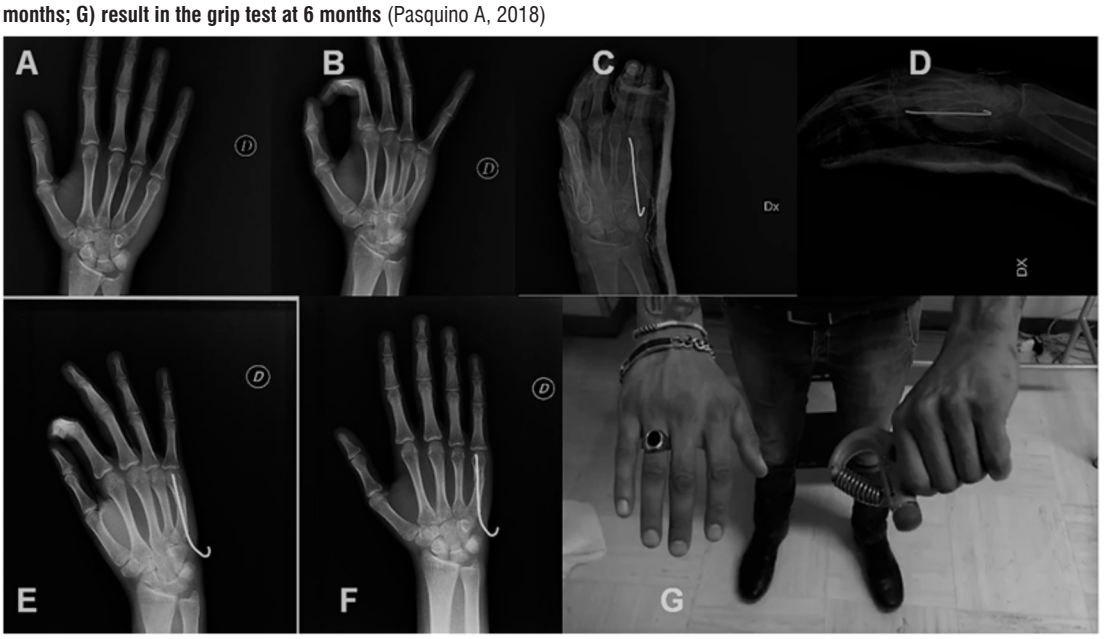

Figure 2. An 18-year-old male with transverse fracture of the right V metacarpus from bike fall. A, B) Pre-operative X-rays show the above fracture in detail; C-D) postoperative X-rays show the surgical treatment with plate and screws; E-F) control X-rays at 6 months; G) result in the grip test at 6 months (Pasquino A, 2017)

cantly higher load to failure than crossed K-wires and that intramedullary (Figure 2) metacarpal nails (IMNs) and XK-wires would have equivalent load to failure (4,5).

The aim of this study was to compare the hand strength obtained using two different methods in the treatment of these injuries.

PATIENTS AND METHODS

Patients and study design

The patient databases of the Vito Fazzi Hospital, S. Croce e Carle Cuneo Hospital and AORN San Pio. Level I Trauma Centres were retrospectively evaluated for the patients with a metacarpal fracture admitted during the period between January 2015 and January 2019.

Patients with metacarpal shaft fracture were enrolled after the application of the following exclusion criteria: multiple metacarpal fracture, metacarpal articular fracture, metacarpal metaphysis fractures, no previous upper limb fractures, no contralateral upper limb fracture, neurovascular injuries, age under 14 years, coexisting haematological or oncological disorders, metabolic bone diseases, rheumatoid disorders, and a follow-up period of less than 24 months. Images of the contralateral hand were not routinely obtained.

All fractures were classified according the anatomic X-ray's classification (6-9). Fifty-two enrolled patients were divided into two groups: the plate and screws (PW) and the K-wires (IMN) groups (Table 1). The patients were informed in a clear and comprehensive way of the type of treatment and other possible surgical and conservative alternatives.

Table 1. Characteristics of the plate and screws (PW) and intramedullary metacarpal nail (IMN) patients

Variable	Plate and screws (PW)	Intramedullary metacarpal nail (IMN)
Number of patients	26	26
Age (mean±SD) (years)	33.62 (±18.64)	32.34 (±18.75)
Gender (male/female)	23/3	24/2
Mechanism of injury (No; %)		
Fall from a bike	4 (15.38)	1 (3.85)
Traffic accident	6 (23.09)	5 (19.23)
Work accident	4 (15.38)	8 (30.77)
Punch	12 (46.15)	12 (46.15)
Side of injury (Right/Left)	11/15	12/14
Metacarpal fracture site (No, %)		
I	1 (3.85)	1 (3.85)
II	2 (7.69)	1 (3.85)
III	5 (19.23)	6 (23.09)
IV	8 (30.77)	8 (30.77)
V	10 (38.46)	10 (38.46)
NUSS Score (mean±SD)	12.6 (±8.33)	12.7 (±9.64)

NUSS, Non-union scoring system

The final decision was made by the senior author considering the patient's preference.

Patients were treated according to the ethical standards of the Helsinki Declaration, and were invited to read, understand and sign an informed consent form.

Azienda Sanitaria Locale (ASL) Lecce, Italy Ethical Committee approved this research.

Methods

Both groups underwent the same rehabilitation protocol after 21 days of cast.

Stretching exercises included: wrist range of motion, flexion, extension, side to side.

Wrist range of motion, flexion- gently bend your wrist forward, hold for 5 seconds, do 2 sets of 15); extension - gently bend your wrist backward, hold this position for 5 seconds, do 2 sets of 15; side to side - gently move your wrist from side to side - a handshake motion, hold for 5 seconds in each direction, do 2 sets of 15.

Strengthening exercises included: opposition stretch, wrist flexion, wrist extension, and finger spring.

Opposition stretch**:** rest your hand on a table, palm up, touch the tip of your thumb to the tip of your little finger, hold this position for 6 seconds and then release, repeat 10 times; wrist flexion**:** hold a can or hammer handle in your hand with your palm facing up, bend your wrist upward, slowly lower the weight and return to the starting position, do 2 sets of 15, gradually increase the weight of the can or weight you are holding; wrist extension**:** hold a soup can or hammer handle in your hand with your palm facing down, slowly bend your wrist up, slowly lower the weight down into the starting position, do 2 sets of 15, gradually increase the weight of the object you are holding; grip strengthening**:** squeeze a soft rubber ball and hold the squeeze for 5 seconds, do 2 sets of 15; finger spring**:** place a large rubber band around the outside of your thumb and fingers, open your fingers to stretch the rubber band, do 2 sets of 15.

To assess bone healing on radiographs, the Non-Union Scoring System (NUSS) was used (10).

The functional evaluation of the two groups during the follow-up was quantified with the Disability Arm Shoulder and Hand Score (Quick DASH) (3-10). Other criteria were: the time until complete bone healing, complications, re-

operation rates, ability to return to full work, the range of motion of metacarpal, and performed force testing collected ultimate tensile strength and grip (average grip strength was calculated for 3 attempts in both the injured and healthy hand using a hand dynamometer). The minimum follow-up was designated as 12 months after surgery, and the functional evaluations were made at 1, 3, 6,12 and 24 months postoperatively.

Statistical analysis

Continuous variables were expressed as the mean±standard deviation (SD) as appropriate. The Shapiro-Wilk normality test was used to evaluate the normal distribution of the sample. The t test was used to compare continuous parameters. The study sample size was considered sufficient to evaluate a difference in post- to pre-operative measurements greater than 0.5 SD units with a power >80%.

The reliability and validity of the correlation between bone regenerate/bone healing and x-rays were determined by the Cohen's kappa (k). Statistical significance was set at $p < 0.05$.

RESULTS

The mean of follow-up was 26.54 (±1.12; range 24–56) months for IMN and 26.56 (±1.18; range 25–57) months for PW ($p>0.05$).

The surgery lasted an average of 19.8 (±8.4; range 8-33) minutes in IMN, while 42.7 (±18.8; range 24-78) minutes for PW ($p<0.05$).

In both groups, patients demonstrated wound healing within 25 days.

During the follow up no complications in PW group were detected. In only one case a non-union with malrotation of metacarpal bone was found.

The average time of bone healing was 96.5 (±6.7; range 83-123) days after the surgery in IMN and 93.8 (±12.6; range 65-128) days for PW ($p>0.05$).

The average range of motion (ROM) of metacarpal-phalanx joint was 254.2° (±8.9;248-260) after the surgery in IMN while 256.1° (±9.4;249-260) for PW ($p>0.05$).

The trend of hands grip until 3rd-month follow-up scores was statistically significant for IMN group between groups ($p<0.05$); however, after the sixth month after surgery, there was no significant difference ($p>0.05$) (Figure 3).

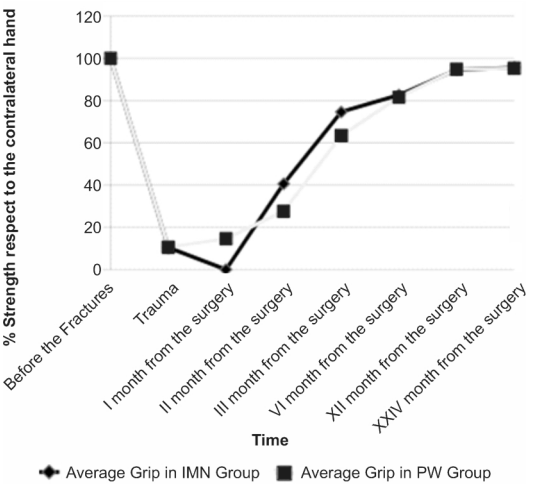

Figure 3. The trend of hands grip. Until 3rd-month follow-up, scores were statistically significant for IMN group ($p<0.05$); after the sixth month after surgery, there was no significant difference*

*IMN group, patients treated with K-wire; PW group, patients treated with plate and screws;

The trend of Quality life measured with QuickDASH until 3rd-month follow-up scores was statistically significant for IMN group between the groups ($p<0.05$); however, after the sixth month after surgery, there was no significant difference ($p>0.05$) (Figure 4).

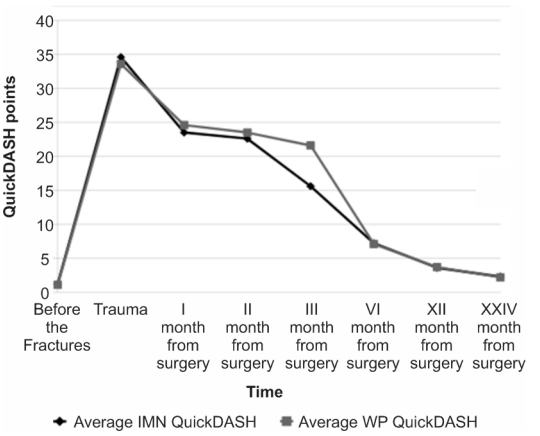

Figure 4. The trend of quality life measured with QuickDASH. Until 3rd-month follow-up, scores were statistically significant for IMN group ($p<0.05$); after the sixth month after surgery, there was no significant difference*

*IMN group, patients treated with K-wire; PW group, patients treated with plate and screws; DASH, disability arm shoulder and hand;

The average correlation between osteosynthesis and bone healing at the moment of X-ray callus was absolutely correlated in IMN clinical results (k=0.8674±0.12) as in PW (k=0.8658±0.12) ($p>0.05$) for surgery.

DISCUSSION

Metacarpal fractures are common and can be stabilized in multiple ways (12). Unlike other meta-

carpal fracture fixation methods, the biomechanical stability of proximally-locked IMNs for MC fractures has not previously been compared to other commonly utilized techniques. Our data suggest that plate-screw constructs were 11 and 15 times more stable than XK-wires and IMNs, respectively. Although XK-wire constructs showed a trend toward greater stability than proximally-locked IMNs, these two techniques did not offer significant instability (4).

Dreyfuss et al. reported that metacarpal shaft fractures plate fixation (statistically) is advantageous in several parameters as compared to pin fixation, including grip strength, digital range of motion, residual rotation, and DASH scores (11). Our results show that radiographic fracture reduction was achieved equally in both groups; operative time was significantly longer for surgical plate implantation as compared with pinning. A high number of our patients were found to have residual rotational deformity in their fingers, especially in fractures which were fixated by pins.

Metallic plates allow rigid and stable fixation of metacarpal (MC) shaft fractures and adequately restore length. Disadvantages include extensive periosteal dissection, that is less significant with the new generation locking plates, and the possible necessity for future plate removal, reported in ~15% of MC fractures in more recent studies (12-14).

The most important complications to consider when dealing with metallic implants are plate prominence, stiffness, tendon irritation and rupture, infection, bone atrophy, and osteoporosis due to stress shielding. On the contrary, absorbable implants incrementally transfer load to a healing fracture thereby limiting stress shielding, while promoting bone union (11-15).

Physical properties of absorbable implants make them useful for magnetic resonance imaging and for radiolucent, facilitating postoperative radiological evaluation (12). In addition, they offer the theoretical advantage of circumventing the need for a second operation for hardware extraction (12).

The biomechanical properties of absorbable implants are comparable with their metallic counterparts, allowing them to achieve adequate fracture stabilization (12).

Van Bussel et al. (13) reported the mid-term functional outcome using the validated patient-related outcome measurement tool (DASH) in 70% of the study population after 30 months on average; the results of these patients reported outcome measures (PROMs) with a mean DASH of 5 and of 7 showing that the functional outcome of this technique is excellent. Also, Van Busel et al. reported the overall, the average grip strength compared with the contralateral hand was 91.7% (n = 13, range: 68%-117%), with only one patient having a persistent loss of >30% after 6 months (13); with regard to mobility, there was no significant difference in postoperative stiffness between metallic and absorbable implants.

DASH scores in our study population were slightly higher than those in similar studies (11-16). Some patients with satisfactory range of motion still complained of residual pain and functional disability during daily activities. Two issues might explain these discrepancies. Average radiographic union time was shorter in the IMN group. The larger exposure required for plate fixation over the bone, especially the stripping of periosteum, seems to be at fault (11-16).

In conclusion, none of the two techniques, either in the literature or in biomechanical studies, shows to have superior functional outcomes for fixation of transverse metacarpal fractures. Since the K-wire is cheaper and has no intrinsic complications than plating (such as scar and tendon irritation), fixation with the latter is preferable to the plate in the treatment of these fractures in non-expert hands.

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TRANSPARENCY DECLARATION

Conflict of interest: None to declare.

REFERENCES

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury 2006; 37:691-7.
2. Jonge JJ, Kingma J, Van der Lei B, Klasen H J. Fractures of the metacarpals. A retrospective analysis of incidence and etiology and a review of the English-language literature. Injury 1994; 25:365–9.
3. Nakashian MN, Pointer L, Owens BD, Wolf JM. Incidence of metacarpal fractures in the US population. Hand (N Y) 2012; 7:426-30.
4. Curtis BD, Fajolu O, Ruff ME, Litsky AS. Fixation of metacarpal shaft fractures: biomechanical comparison of intramedullary nail crossed K-wires and plate-screw constructs. Orthop Surg 2015; 7:256-60.

5. Hiatt SV, Begonia MT, Thiagarajan G, Hutchison RL. Biomechanical comparison of 2 methods of intramedullary K-wire fixation of transverse metacarpal shaft fractures. J Hand Surg Am 2015; 40:1586-90.
6. Grandizio LC, Speeckaert A, Kozick Z, Klena JC. Anatomic assessment of K-wire trajectory for transverse percutaneous fixation of small finger metacarpal fractures: a cadaveric study. Hand (NY) 2018; 13:86-9.
7. Romo-Rodríguez R, Arroyo-Berezowsky C. Minimal invasive osteosynthesis with cannulated screws in metacarpal fractures. Acta Ortop Mex 2017; 31:75-81.
8. Zhu H, Xu Z, Wei H, Zheng X. Locking plate alone versus in combination with two crossed kirschner wires for fifth metacarpal neck fracture. Sci Rep 2017; 7:46109.
9. Shanmugam R, Jian CYCCS, Haseeb A, Aik S. Comparing biomechanical strength of unicortical locking plate versus bicortical compression plate for transverse midshaft metacarpal fracture. J Orthop Surg (Hong Kong) 2018; 26:2309499018802511.
10. Calori GM, Colombo M, Mazza EL, Mazzola S, Malagoli E, Marelli N, Corradi A. Validation of the Non-Union Scoring System in 300 long bone nonunions. Injury 2014; 45 S93-7.
11. Dreyfuss D, Allon R, Izacson N, Hutt D. A comparison of locking plates and intramedullary pinning for fixation of metacarpal shaft fractures. Hand (NY) 2019; 14:27-33.
12. Hazan J, Azzi AJ, Thibaudeau S. Surgical fixation of metacarpal shaft fractures using absorbable implants: a systematic review of the literature. Hand (NY). 2019; 14:19-26.
13. van Bussel EM, Houwert RM, Kootstra TJM, van Heijl M, Van der Velde D, Wittich P, Keizer J. Antegrade intramedullary Kirschner-wire fixation of displaced metacarpal shaft fractures. Eur J Trauma Emerg Surg 2019; 45:65-71.
14. Beck CM, Horesh E, Taub PJ. Intramedullary screw fixation of metacarpal fractures results in excellent functional outcomes: a literature review. Plast Reconstr Surg 2019; 143:1111-8.
15. Oh JR, Kim DS, Yeom JS, Kang SK, Kim YT. A comparative study of tensile strength of three operative fixation techniques for metacarpal shaft fractures in adults: a cadaver study. Clin Orthop Surg 2019; 11:120-5.