Long-term follow-up of unoperated, nonscissoring spiral metacarpal fractures

Brittany B Macdonald MD¹, Amanda Higgins BScO², Susan Kean BScPt²,
Carolyn Smith BScO², Donald H Lalonde MD FRCSC^{2,3}

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BACKGROUND: Spiral metacarpal fractures can result in shortening of the metacarpal shaft, which may lead to extension lag at the metacarpophalangeal joint and reduced grip strength. These fractures have been surgically treated to restore metacarpal length; however, there are complications associated with surgery, postoperative management and wound healing, which further threaten power recovery in the hand.

OBJECTIVE: To determine the effect of conservative management of unoperated, nonscissoring spiral metacarpal fractures.

METHODS: Sixty-one consecutive patients presenting with nonscissoring spiral metacarpal fractures were treated nonoperatively and studied prospectively to determine the natural history of their power outcome. Thumb fractures and those requiring surgical intervention for scissoring were excluded.

RESULTS: Follow-up data of a minimum of five months (mean follow-up 87 weeks) were available for 13 patients. Mean grip strength at final follow-up was 36.18 kg on the uninjured side and 36.58 kg on the injured side. The strength-difference values did not differ significantly from zero ($P=0.72$).

CONCLUSION: The loss of metacarpal length associated with these fractures may not cause a power deficit sufficiently large to significantly affect grip strength and functional recovery in the hand. A prospective randomized controlled trial of operated versus unoperated, nonscissoring metacarpal fractures is warranted.

Key Words: Conservative management; Grip strength; Nonscissoring; Power; Spiral metacarpal fracture; Unoperated

Metacarpal fractures are among the more common fractures of the upper extremity (1-7), accounting for 18% of all below-elbow fractures in the United States (5). Freehan and Sheps (8) reported that metacarpal fractures represented 42% of 72,481 reviewed cases of hand fractures. Spiral metacarpal fractures commonly result in some shortening of the metacarpal shaft (9), which may subsequently cause extension lag at the metacarpophalangeal (MCP) joint and reduced grip strength (9-13). Several studies have documented the relationship between shortening and hand function (1,9,12,14-21), although the maximum amount of shortening that occurs following metacarpal fracture and acceptable limits appear to be controversial.

Historically, spiral fractures occurring without scissoring have been treated surgically to restore metacarpal length and prevent these losses in power and function. Although previous studies have demonstrated beneficial outcomes in hand function following operative treatment of spiral metacarpal fractures (5,18,22-28), surgical management is not without consequences and complications (27-31). Stripping of the interosseus, which power MCP flexion from the underlying bone for internal fixation, for example, may also lead to power loss. Furthermore, one must consider the cost, complications and consequences associated with surgery, postoperative management and wound healing.

Le suivi à long terme de fractures spiroïdes non déplacées et non opérées des métacarpiens

HISTORIQUE : Les fractures spiroïdes des métacarpiens peuvent provoquer un raccourcissement diaphysaire, qui peut s'associer à un déficit d'extension de l'articulation métacarpophalangienne et à une diminution de la force de préhension. Ces fractures peuvent être opérées pour rétablir la longueur du métacarpien, mais des complications sont liées à la chirurgie, à la prise en charge postopératoire et à la guérison, ce qui menace le rétablissement de la force de la main.

OBJECTIF : Déterminer l'effet d'une prise en charge prudente des fractures spiroïdes non déplacées et non opérées des métacarpiens.

MÉTHODOLOGIE : Soixante et un patients consécutifs ayant une fracture spiroïde non déplacée du métacarpien ont été soignés sans être opérés et ont fait l'objet d'une étude prospective pour déterminer l'évolution naturelle de la force de leur main. Les fractures du pouce et celles qui devaient être remplacées par voie chirurgicale étaient exclues.

RÉSULTATS : Les chercheurs possédaient des données de suivi colligées sur au moins cinq mois (suivi moyen de 87 semaines) au sujet de 13 patients. La force de préhension moyenne au dernier rendez-vous de suivi était de 36,18 kg du côté non blessé et de 36,58 kg du côté blessé. Ces différences ne variaient pas de manière significative par rapport à zéro ($P=0,72$).

CONCLUSION : La diminution de la longueur du métacarpien associée à ces fractures ne limite peut-être pas assez la force de la main pour vraiment nuire à son rétablissement fonctionnel et à sa récupération. Il faudra effectuer un essai aléatoire et contrôlé prospectif des fractures non déplacées des métacarpiens qui sont opérées par rapport à celles qui ne le sont pas.

Increasingly, conservative management of nonscissoring spiral metacarpal fractures has come into favour in the absence of absolute indications for a surgical approach (10,11,16,32). Despite potential shortening of the metacarpal, a nonoperative approach preserves the integrity of the intrinsic muscles of the hand, thereby benefiting functional recovery, while also avoiding the aforementioned consequences and costs of surgery. Unfortunately, however, few studies exist documenting the long-term natural history of unoperated spiral metacarpal fractures. The purpose of the present study was, therefore, to investigate this outcome.

We conducted a prospective consecutive case series of unoperated, nonscissoring spiral metacarpal fractures to document the effect of conservative management on resultant power in the hand despite the metacarpal shortening that is often associated with these fractures.

METHODS

Sixty-one consecutive patients presenting with nonscissoring spiral metacarpal fractures, who were treated conservatively between December 2006 and June 2011, were studied prospectively to determine the natural history of their power outcome and range of motion. Patients presenting with thumb metacarpal fractures and those

¹University of Ottawa, Ottawa, Ontario; ²Department of Plastic Surgery, Saint John Regional Hospital, Saint John, New Brunswick;

³Dalhousie University, Halifax, Nova Scotia

Correspondence: Dr Brittany B Macdonald, Dalhousie University, 5909 Veterans' Memorial Lane, 8th Floor, Abbie J Lane Building, Halifax, Nova Scotia B3H 2E2. Telephone 902-817-4152, e-mail bmacd097@uottawa.ca

requiring surgical intervention for scissoring were excluded. Patients who were lost to follow-up without at least five months of measurement data were also excluded. Research ethics approval was obtained from the Horizon Health Network Research Ethics Board (Miramichi, New Brunswick) and informed consent was obtained from all patients. Patients ranged in age from nine to 72 years.

Technique

Patients presenting with fractures of the 2nd to 5th metacarpal were examined for scissoring. If scissoring was present, they underwent closed reduction or surgery and were excluded from the study. Those who did not have scissoring were immobilized in a splint for the first week of follow-up, with the wrist in 20° of extension, the MCP joint of the affected metacarpals and one adjacent unaffected metacarpal in a 30° comfortably flexed position and the interphalangeal (IP) joints in extension. After one week, they were re-examined to ensure scissoring had not occurred.

At one week, if patients were deemed likely to follow instruction, and if they were off all pain medication, they were allowed to remove their splint for showering and evening exercises. They continued to wear the splint in the daytime during busy activity and at night for sleep. During quiet times, patients could remove their splint and “move the hand, but not use the hand”, providing that any movement they performed did not cause pain and that they were not on any pain medication. If any movement caused pain, they were not allowed to try that movement again for the next three days. Splinting was discontinued at three weeks or when fractures were no longer tender to palpation (clinical healing).

Follow-up visits were conducted at three, six and ≥22 weeks postinjury. At each follow-up visit, average grip strength and active range of motion measurements of the hand were collected. Average grip strength was calculated from three consecutive grip strength measurements using a dynamometer. Active range-of-motion measurements of the affected digit were recorded at the MCP, proximal IP and distal IP joints in both flexion and extension. Hand dominance, date of injury and active range of motion commencement date were also recorded for each patient.

Statistical analysis

SAS version 9.2 (SAS Institute, USA) was used for all statistical analyses. Only the latest observation for each patient with a follow-up period of at least 22 weeks was included in the analysis; thus, 13 observations were used. The initial analysis included computation of descriptive statistics for patients' average grip strength on their uninjured and injured sides, as well as for the differences between these values. The latter results were used in conjunction with graphical methods and hypothesis testing in determining that the single-sample *t* test was appropriate for testing whether the differences in average grip strength between patients' uninjured and injured sides differed significantly from zero.

RESULTS

The long-term follow-up threshold for which grip strength was measured was set at five months. This was achieved in 13 patients. There were eight males and five females, with a mean age of 33 years. The mean ($\pm$ SD) duration of final follow-up was 86.92 $\pm$ 59.25 weeks postinjury. Demographic data and fracture distribution are summarized in Table 1. The remainder of the patients were excluded if they did not return for follow-up at ≥5 months.

Mean grip strength, measured at the time of each patient's final follow-up, was 36.18 $\pm$ 12.05 kg on the uninjured side and 36.58 $\pm$ 12.81 kg on the injured side. The mean grip strength difference for the uninjured side minus the injured side was -0.41 $\pm$ 4.03 kg. These grip strength-difference values were not found to differ significantly from zero ($P=0.72$).

None of the patients experienced extensor lag. Many of the patients were not willing or available to come in for long-term follow-up. This is not uncommon with patients who experience this type of injury.

TABLE 1

Patient demographics, fracture distribution and duration of follow-up

Patient	Sex	Age, years	Fracture distribution	Total follow-up, weeks
1	Male	11	Left D3	56
2	Female	53	Right D3	88
3	Male	19	Right D4	72
4	Female	54	Right D4	84
5	Male	14	Right D5	115
6	Male	43	Left D4	124
7	Male	33	Left D3	128
8	Female	48	Left D4	27
9	Male	19	Left D4	26
10	Male	46	Left D4	22
11	Female	39	Right D3	24
12	Male	19	Right D3	224
13	Female	32	Right D5	140

D Digit

X-ray representation of the most amount of displacement seen in each case is shown in Figures 1 and 2.

DISCUSSION

In the current study, functional recovery following 13 cases of nonscissoring spiral metacarpal fracture that were treated conservatively resulted in grip strength measurements that were comparable with the uninjured hand at a mean duration of 87 weeks' follow-up. This suggests that the shortening associated with nonscissoring spiral metacarpal fractures does not have a significant effect on power and function in the hand, and that the theoretical reason for operating on these fractures may not justify surgery in these cases.

Spiral metacarpal fractures can result in shortening of the metacarpal shaft (9). Because this shortening can theoretically lead to a decrease in power, a surgical approach has often been used in the management of these fractures to preserve metacarpal length (16). With the wide variety of open and closed surgical techniques and their effectiveness in restoring metacarpal length, surgeons tend to have a reduced threshold for selecting operative fixation of these fractures due to their fear of metacarpal shortening and its effects on power (13,16,33). Closed surgical reduction is less effective at restoring length than open techniques and, therefore, open reduction and internal fixation (ORIF) has tended to be the operative approach of choice (5).

It is important for surgeons to realize that the surgical approach itself can cause damage to the interosseus, which provide MCP flexion power to the hand. This also threatens power recovery in the hand. In addition, exposing the fractures, periosteum and tendons to dissection and to the blood that fills the dissected tissue planes creates scarring and stiffness. It is for these reasons that conservative management of nonscissoring spiral metacarpal fractures has been favoured by some (10).

There are few studies that document the long-term natural history of power recovery in unoperated nonscissoring spiral metacarpal fractures. This is an important question because surgery for these fractures is designed to keep power recovery optimal. If the shortening that occurs in these unoperated metacarpals does not cause a decrease in power in reality, then the justification for surgery only has a basis in inaccurate theory.

There is considerable variability throughout the literature regarding the maximum amount of shortening that results from metacarpal fracture and the acceptable limits of such shortening (1,9,12,14-21,31). Published guidelines regarding the degree of metacarpal shortening that is consistent with good hand function range throughout the literature from 2 mm to 10 mm (9). Various studies have accepted as much as 6 mm (34), 8 mm (35) and 10 mm (1,14) of

Figure 1 X-rays revealing displacement in 12 of the 13 patients. Patient 1 (A); patient 2 (B); patient 3 (C); patient 4 (D); patient 5 (E); patient 6 (F); patient 7 (G); Patient 8 (H); patient 9 (I); patient 10 (J); patient 11 (K); patient 12 (L)

shortening without compromise in hand function. Conversely, studies by both Low et al (20) and Pereira et al (21) demonstrated that shortening of the metacarpals >3 mm decreases both the flexion and extension forces generated by the extrinsic muscles of the hand at the MCP joint. These findings were consistent with those of Jupiter and Belsky (19), who reported an intrinsic/extrinsic imbalance with longitudinal shortening >3 mm.

Meunier et al (12) explain that the short fibre length and high pennation angle of the palmar and dorsal interossei make them optimal for force generation in the hand. Unfortunately, these muscles will, therefore, function optimally within only a small range of muscle fibre lengths and are vulnerable to even minimal changes in bony architecture. Their research determined that a steady linear decrease in interosseus power occurs with proximal translation of the metacarpal, specifically noting that 2 mm of shortening correlated with an 8% decrease in power.

Despite this association between metacarpal shortening and reduced power recorded throughout the literature, both Eglseder et al (16) and Strauch et al (9) have demonstrated via cadaver study that metacarpal shortening in isolated spiral metacarpal fractures is limited to 3.7 mm and 5 mm, respectively, by tethering of the deep transverse metacarpal ligament to adjacent intact metacarpals. Furthermore, Eglseder et al (16) reported that this degree of shortening does not result in functional limitation in the absence of severe angulation or a rotational deformity. These findings suggest that power deficits associated with nonscissoring isolated spiral metacarpal fractures may, therefore, also be limited.

The limited clinical research that currently exists regarding outcomes of conservatively managed spiral metacarpal fractures appears to support the findings of Eglseder et al (16) and Strauch et al (9). In a prospective study conducted by Al-Qattan (10), 42 patients presenting with this fracture were treated with a palmar wrist splint and immediate immobilization of all finger joints. In all patients, grip strength progressively increased over the first year to reach an average maximum of 94% of the power in the uninjured hand. Extension lag was initially observed in all injured fingers; however, this was no longer detectable in any patient six months postinjury. A full range of motion was also obtained in almost all patients by six months, and there were no cases of nonunion, complex regional pain syndrome or splint-related complications. All patients returned to work within two to eight weeks.

In another study, Eglseder et al (16) retrospectively reviewed 24 cases of isolated displaced spiral 4th metacarpal fractures that were managed either operatively via ORIF or percutaneous K-wire fixation, or nonoperatively using a short arm cast with an aluminum outrigger for the 4th finger. They noted that the average initial shortening across both groups was limited to 3.1 mm. No final shortening was present after anatomical restoration in the operative group, while metacarpal length was reduced by 2.22 mm following conservative management. Despite these differences in final length, the maximum grip strength of the injured hand was 4 kg to 10 kg less than the contralateral side in both cases. Of the four patients managed operatively, however, one experienced complex regional pain syndrome, while two others experienced occupational setbacks related to pain and subjective loss of range of motion. There were no patient complaints or occupational restrictions sustained by the conservatively managed group. In both of these studies, it is interesting to note that although final grip strength was reduced in all patients regardless of the treatment group, there were no functional complaints or limitations in any of the cases managed conservatively.

The two studies above support the current study in validating the hypothesis that the shortening associated with nonscissoring spiral metacarpal fractures does not, in fact, have a significant effect on power and function of the hand, and that restoring anatomical length with surgery may not be necessary to achieve optimal power. In fact, surgery for this problem may be subjecting patients to unnecessary risks and complications.

Figure 2) X-ray revealing displacement in patient 13

Unfortunately, the insertion of conventional implants disturbs the biology, and operative fixation can produce complications that are detrimental to the final outcome (13,36). Plate prominence, implant failure, superficial or deep infection, joint stiffness, tendon adhesion or rupture, and malunion, delayed union or nonunion are all possible (30,36). Furthermore, these procedures are costly, require special equipment (24,28) and may not necessarily improve power recovery beyond what is achieved using a conservative approach. In a review of 45 metacarpal fractures stabilized via ORIF using miniature plates or screws, Trevisan et al (28) reported a mean grip strength reduction of $3.2 \pm 10.1\%$, which remained stable at two years postfracture; furthermore, a 31.1% complication rate resulted. Westbrook et al (13) noted no significant difference in grip strength measurements following little finger metacarpal shaft fractures that were either treated with ORIF via plate or K-wire fixation, or conservatively with no attempt at reduction. In the 27 patients who underwent plating, however, two developed superficial infections and four had their plates removed due to pain or stiffness at the MCP joint. Two of those patients sustained persistent losses of MCP joint flexion and one developed complex regional pain syndrome. These results support those of the aforementioned study by Eglseder et al (16), which demonstrated no significant difference in final grip strength reduction between the operatively and conservatively managed group of spiral metacarpal fractures. Three of the four surgical patients developed complications, however, while there were no complaints in the 20 patients who were treated conservatively. Because near-complete restoration of metacarpal length is obtained by a surgical approach, one can postulate that the power deficits resulting from operative management of these fractures may be associated with the soft tissue damage and complications resulting from the surgical approach itself.

Limitations of the present study include the high loss of follow-up of the patients who did not return for long-term analysis. In addition, the present study only provides level IV evidence.

In summary, surgical restoration of metacarpal length has long been the traditional approach to nonscissoring spiral metacarpal fractures based on the assumption that metacarpal shortening compromises function. The results obtained from the current study support others in the literature (9,10,16) that demonstrate that the loss of metacarpal length associated with these fractures is limited to a degree of shortening that is not consistent with power deficits sufficiently large

to significantly affect functional recovery in the hand. Furthermore, a review of grip strength outcomes following various approaches to internal fixation has revealed results similar to those obtained via conservative techniques (13,16,28). A properly performed prospective randomized controlled trial of conservative versus surgical management outcome on power is warranted.

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