Original Article

Surgical Fixation of Fourth and Fifth Metacarpal Shaft Fractures with Flexible Intramedullary Absorbable Rods: Early Clinical Outcomes and Implications

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Abstract

Background: To avoid the irritation of tendons and soft tissues as well as hardware-related problems, we designed an intramedullary fixation with bioabsorbable rods for the treatment of the metacarpal shaft fractures.
Methods: Five patients with nine shaft fractures of the fourth and fifth metacarpi were treated with intramedullary absorbable implants and followed up with an average of 4.2 months postoperatively.
Results: At final follow-up, all patients achieved fracture union with no signs of inflammatory or subcutaneous effusion. There was no shortening, angulatory, or rotatory deformity. There was almost full active extension range of motion (ROM) of the metacarpophalangeal joints while the active flexion ROM of these joints was 80.7 ± 9.6°. Compared with the contralateral hand, the grip strength of the injured hand was 94.0 ± 9.6%. X-rays showed that the arch of the second to fifth metacarpal heads was smooth. There were no intramedullary lytic changes and soft tissue swellings.
Conclusion: The intramedullary absorbable implants are a safe, simple, and practical treatment for fourth and fifth metacarpal fractures with good early clinical outcomes and no significant complications.

Key words: Absorbable Implant; Follow-up; Intramedullary Fixation; Metacarpal Fracture

Introduction

Fourth and fifth metacarpal shaft fractures are one of the most common hand injuries encountered in clinical practice. In these fractures, angulation deformity is frequently found. Although some of these fractures can be treated conservatively, grossly displaced and comminuted fractures should be surgically corrected either with closed reduction and stabilization with percutaneous Kirschner wires (K-wires) or open reduction internal fixation with plate and screws.[1,2] The benefit of the plate and screws fixation is that it provides an extremely rigid fixation while the K-wire fixation is the least invasive method.[3] However, even with K-wires, there can still be hardware-associated complications such as wire track infection, soft tissue irritation, and tendon adhesion or rupture.[1,4,5] With open reduction and internal fixation, the hardware may need to be removed at a later date, especially if the patient complains of hardware-related pain.

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Bioabsorbable implants are being used with increasing frequency in the treatment of small bone fractures or fractures involving the joint surface.[6-9] Compared with conventional hardware, bioabsorbable implants are thought to provide gradual load transfer to the healing tissue, reduced need for hardware removal and radiolucency, which facilitates postoperative radiological evaluation.[10]

To avoid the irritation of tendons and soft tissues as well as hardware-related problems, we designed an intramedullary fixation with bioabsorbable rods for the treatment of the

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metacarpal shaft fractures. We undertook a descriptive case series of patients who sustained fourth and/or fifth metacarpal shaft fractures and underwent fixation with bioabsorbable intramedullary rods and investigated their clinical outcomes including bone union time, range of motion (ROM) for the involved fingers, grip strength, as well as the potential implications for the bioabsorbable implants.

Methods

After obtaining the approval from Review Ethical Board of Beijing Jishuitan Hospital and the informed consent from all patients, we treated five patients with nine shaft fractures of the fourth and/or fifth metacarpi with open reduction and internal fixation using intramedullary bioabsorbable implants [Figure 1]. All the patients received outpatient operations in Department of Hand Surgery, Beijing Jishuitan Hospital.

Under brachial plexus block anesthesia, the patient was supine on the operating table with the injured limb place on an arm board, then a longitudinal or curved incision was made at the dorsal side of the fourth and/or fifth metacarpal shaft(s). The cutaneous nerves and extensors were visualized, retracted, and protected. The hematoma and fibrous tissue at the fracture sites were removed. The medullary canal was expanded with a 2 mm K-wire. Using a 2 mm drill, a hole was made on the lateral side of the metacarpal neck, just proximal to the metacarpophalangeal joint (MPJ) capsule with 30° of angulation with the long axis of the metacarpus. After the fracture was reduced anatomically and stabilized using a combination of the Jahss maneuver and open reduction with bone reduction forceps, a self-reinforced poly-L-lactide (SR-PLLA) absorbable rod (Biofix, Conmed Linvatec Biomaterial Ltd., Finland) with a diameter of 2 mm was inserted through the hole at the metacarpal neck in a retrograde direction [Figure 2]. With the absorbable rod settled in firmly, the finger was flexed and extended passively to check the stability of the fixation and digital alignment [Figure 3]. After the intraoperative fluoroscopy verification and clinical examination to make sure that rotational deformity had been corrected, the rod handle was cut off to leave only 2 mm outside the metacarpus.

After soft tissue closure, a short arm splint was applied for 2–3 weeks. All the patients were then followed up and received rehabilitation instructions in the outpatient department by their operation doctors. During the follow-up, ROM of the involved fingers, grip strength, and radiographs were evaluated. Measurement data were expressed as mean ± standard deviation (SD). The patients were instructed to begin active ROM twice a day (for 5 min each time) during this period and then advancing as tolerated after the splint was removed.

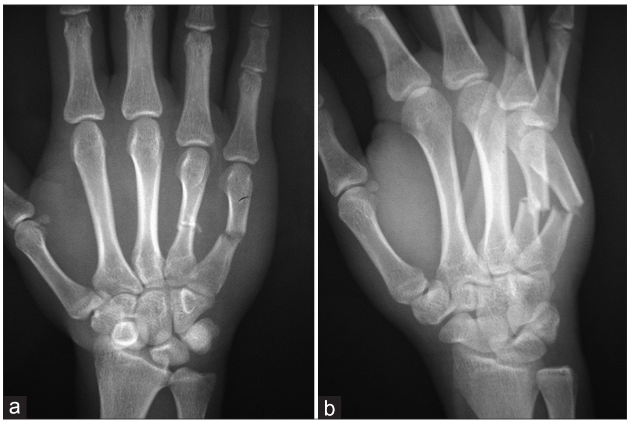

Figure 1: Preoperative – (a) Posteroanterior and (b) lateral radiographs of a patient's right hand, demonstrating that there were the shaft fractures of the fourth and fifth metacarpi with dorsal angulation.

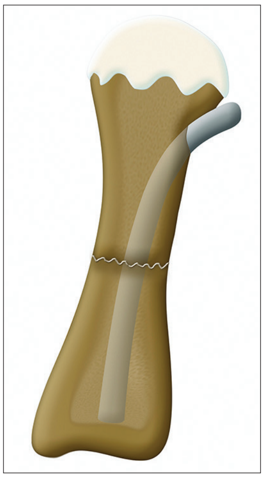

Figure 2: Schematic diagram showing retrograde intramedullary fixation of a metacarpal shaft fracture with a bioabsorbable rod.

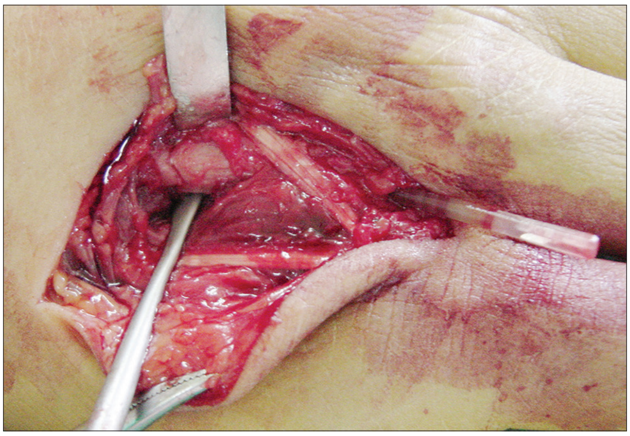

Figure 3: Intraoperative photography showing the fracture of the fourth metacarpus reduced, and a self-reinforced poly-L-lactide absorbable rod with a diameter of 2 mm inserted through the drilled hole at the metacarpal neck.

Results

The patients' data are listed in Table 1. There were no neurovascular problems and associated injuries before operations. Two patients had undergone unsuccessful closed reduction in their local hospital prior to being referred to our tertiary center.

Table 1: Patients' data and follow up results

No.	Gender	Age (years)	Etiology	Description of the fractures	Time from injury to operation (days)	Follow-up time (months)	Bone healing time (weeks)	Postoperative ROM (degrees)	Grip strength (%, vs. contralateral hand)	Complications
1	Male	20	Direct blow with clenched fist against a solid surface	Right 5th MC shaft linear fractures with angulation deformity	5	5	7	90	105	None
2	Male	18	Direct blow onto the metacarpus from a heavy object	Right 4th and 5th MC shaft linear fractures with angulation deformity	11	5	7	83 (5th finger) and 74 (4th finger)	90	None
3	Male	23	Fall from a height	Right 4th and 5th MC shaft linear fractures with angulation deformity	10	4	8	89 (5th finger) and 72 (4th finger)	95	None
4	Male	24	Motor accident	Right 4th and 5th MC shaft linear fractures with shortening and angulation deformity	22	4	7	70 (5th finger) and 68 (4th finger)	80	None
5	Male	33	Direct blow with clenched fist against a solid surface	Right 4th and 5th MC shaft linear fractures with angulation deformity	5	3	9	90 (5th finger) and 90 (4th finger)	100	None

MC: Metacarpal; ROM: Range of motion.

The patients were followed up for 3–5 months with a mean of 4.2 ± 0.8 months. All wounds healed by primary intention. The fractures achieved clinical and radiological union within 7–9 weeks with a mean of 7.6 ± 0.9 weeks. All patients returned to their activities of daily living and original occupation without any significant problems.

At the end of the follow-up period, no signs of inflammation or aseptic effusion were found around the metacarpal head. There was full active extension of the involved digits. The average active flexion of MPJ was 80.7 ± 9.6° [Figure 4]. Using a grip strength myometer, we found that the average grip strength of the injured hand was for 94.0 ± 9.6% compared to the contralateral hand. The radiographs showed no shortening or angulation deformity [Figure 5], and clinically there was no rotational deformity in any of the patients. Radiographs also showed that there were no signs of bone resorption in intramedullary canal and no signs of swelling around the soft tissue.

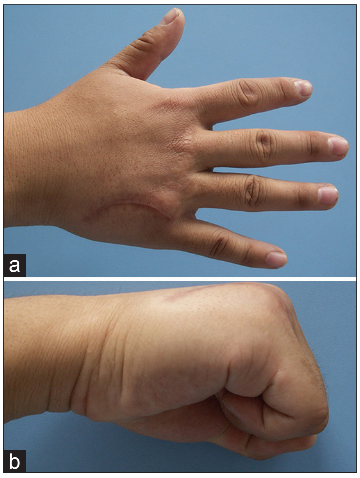

Figure 4: Clinical photography illustrating good hand functional recovery after the operation. (a) Extension of the fingers and (b) flexion of the fingers.

Discussion

Traditional surgical fixation techniques comprise of mini plates, screws, and K-wires. The major advantage of plate and screw fixation is that the fixation is usually rigid enough to allow early active ROM exercises. However, there are also some disadvantages such as high cost, stress shielding, tendon irritation, and hardware-associated pain,[1] which in some patients may require additional operations. Although K-wire fixation is a relatively cheap and simple procedure, the fixation strength is limited, with wire tract infection being a common postoperative complication.[1,4] In order to avoid another operation for hardware removal and its potential-associated risks such as refracture, bioabsorbable plates, and screws were developed.[6,8,9] However, these bioabsorbable plates are usually much thicker than conventional metal plates in order to match the material strength. In hand surgery, thicker and bulkier plates are usually too cumbersome and impractical. Therefore, intramedullary bioabsorbable rod fixation can be a viable alternative in that, it provides a stable internal fixation, does not cause tendon irritation, and thus can reduce the need for further surgical procedures such as implant removal. A study about spinal fusion with SR-PLLA rods and K-wires in a rabbit model has proved that successful fusion could be achieved in both groups after 12 weeks postoperatively.[11] However, it is still lack of evidence of long-term and large-series studies about the clinical outcome

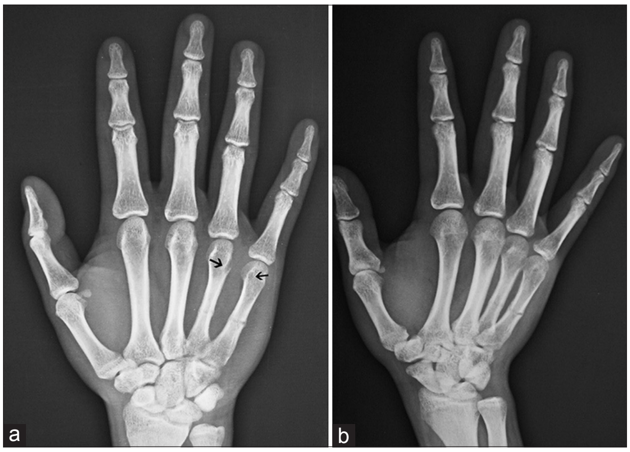

Figure 5: Postoperative – (a) Posteroanterior and (b) lateral radiographs, demonstrating anatomical reduction of the fractures. The arrows indicate the insertion points of the intramedullary implants.

of SR-PLLA rods. Since the strength of bioabsorbable rod will gradually reduce after its insertion, it tends to shift the stress gradually to the metacarpal bones, which is biomechanically favorable for bone union and modulation. This may be a contributory factor in achieving good clinical outcomes in the current literature.[12]

Intramedullary rods can be inserted in an antegrade or a retrograde direction (as in our case series). Antegrade rod insertion can avoid injury to the MPJ and the extensor mechanism, and this had traditionally been the insertion technique with intramedullary K-wires.[13-17] However, this "bouquet" technique required a proximal surgical incision and was more technically challenging to perform. In addition, in order to control any rotational deformity, the technique often required the use of a proximal locking pin or multiple rods in one canal.[18] Lord first describe retrograde intramedullary fixation of metacarpal fractures in 1957. Compared with antegrade fixation, this was a less technically challenging procedure to do, however, with retrograde fixation, Lord encountered problems with limitation of metacarpophalangeal motion, which led to joint stiffness.[19] Even though we also performed retrograde fixation, in our technique, the incision is made over the lateral side of the metacarpal neck reducing the risk of damage to the extensor tendons and the rod does not violate the MPJ meaning that early joint motion is possible. In addition, compared with the proximal dorsum of the metacarpus, there is more abundant soft tissue coverage around the lateral side of the metacarpal neck and fixation of both the fourth and the fifth metacarpal fractures can be undertaken with only one incision.

In our case series, none of the patients had any rotational deformity of the digits postoperatively. We found that the 2 mm straight rod inserted tightly to the canal, and there was some bending of the rod to contour with the alignment of the bone. We believe that this tight "press fit" with minimal allowance provided enough stability to avoid any rotational deformity postoperatively.

Our previous biomechanical research compared the three-point bending rigidities of the intramedullary fixation using 2 mm bioabsorbable rods with crossed fixation using 1 mm K-wires. The results showed that the bending rigidity of the bioabsorbable intramedullary fixation is similar to that of crossed K-wires fixation.[20] It means that the fixation strength of our method is suitable for limited early active ROM exercises. Although a thicker 3.2 mm bioabsorbable rod can provide much higher bending rigidity, it is quite difficult to bend the rod while it is in the intramedullary canal in order to align with the contour of the bone. Therefore, this method cannot be used in the second and third metacarpals that form a stiffer central pillar, as opposed to the fourth and fifth metacarpals which form mobile borders. If a prebent 2.4 mm bioabsorbable rod is available, this will make the rod easier to align with the contour of the bone in the medullary canal and achieve the required bending rigidity. Also, a 2.4 mm rod can be used for shaft fractures of the second and third metacarpals.

Foreign body reactions such as swelling and edema have reported with bioabsorbable implants in previous studies.[7] However, we have not found such kind of the reactions in our case series. We believe that embedding the implants within the medullary canal can greatly decrease the foreign body reactions as well as its irritation to the soft tissues.

Although our data revealed quite good early results for this new fixation methods with no apparent complications, it is still a single institutional study. Also, there is lack of a control group that hinders more robust comparison of results. The results need interpretation in light of these limitations.

Flexible intramedullary absorbable rods are a safe, practical treatment for shaft fractures of the fourth and fifth metacarpi. They are also cost-effective, negating the need for the removal of hardware.[21] Therefore, we recommend that they should be used more widely in routine clinical practice.

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Conflicts of interest

There are no conflicts of interest.

References

1. Kollitz KM, Hammert WC, Vedder NB, Huang JI. Metacarpal fractures: Treatment and complications. Hand (N Y) 2014;9:16-23.
2. Meals C, Meals R. Hand fractures: A review of current treatment strategies. J Hand Surg Am 2013;38:1021-31.
3. Dailiana Z, Agorastakis D, Varitimidis S, Bargiotas K, Roidis N, Malizos KN. Use of a mini-external fixator for the treatment of hand fractures. J Hand Surg Am 2009;34:630-6.
4. Balaram AK, Bednar MS. Complications after the fractures of metacarpal and phalanges. Hand Clin 2010;26:169-77.
5. Bannasch H, Heermann AK, Iblher N, Momeni A, Schulte-Mönting J, Stark GB. Ten years stable internal fixation of metacarpal and phalangeal hand fractures-risk factor and outcome analysis show no increase of complications in the treatment of open compared with closed fractures. J Trauma 2010;68:624-8.
6. Dumont C, Fuchs M, Burchhardt H, Appelt D, Bohr S, Stürmer KM.

Clinical results of absorbable plates for displaced metacarpal fractures. J Hand Surg Am 2007;32:491-6.
7. Givissis PK, Stavridis SI, Papagelopoulos PJ, Antonarakos PD, Christodoulou AG. Delayed foreign-body reaction to absorbable implants in metacarpal fracture treatment. Clin Orthop Relat Res 2010;468:3377-83.
8. Hughes TB. Bioabsorbable implants in the treatment of hand fractures: An update. Clin Orthop Relat Res 2006;445:169-74.
9. Ya'ish F, Bailey CA, Kelly CP, Craigen MA. Bioabsorbable fixation of scaphoid fractures and non-unions; analysis of early clinical outcomes. Hand Surg 2013;18:343-9.
10. Ciccone WJ nd, Motz C, Bentley C, Tasto JP. Bioabsorbable implants in orthopaedics: New developments and clinical applications. J Am Acad Orthop Surg 2001;9:280-8.
11. Bezer M, Yildirim Y, Erol B, Güven O. Absorbable self-reinforced polylactide (SR-PLLA) rods vs rigid rods (K-wire) in spinal fusion: An experimental study in rabbits. Eur Spine J 2005;14:227-33.
12. Peiji W, Qirong D, Jianzhong Q, Huayi W, Kailong Z, Nan Y. Intramedullary fixation in digital replantation using bioabsorbable poly-DL-lactic acid rods. J Hand Surg Am 2012;37:2547-52.
13. Kaiser MM, Tafazzoli K, Theilen TM, Schulz AP, Paech A, Wessel LM. Intramedullary nailing for metacarpal 2-5 fractures. J Pediatr Orthop B 2009;18:296-301.
14. Mohammed R, Farook MZ, Newman K. Percutaneous elastic intramedullary nailing of metacarpal fractures: Surgical technique and clinical results study. J Orthop Surg Res 2011;6:37.
15. Blazar PE, Leven D. Intramedullary nail fixation for metacarpal fractures. Hand Clin 2010;26:321-5, v.
16. Corkum JP, Davison PG, Lalonde DH. Systematic review of the best evidence in intramedullary fixation for metacarpal fractures. Hand (N Y) 2013;8:253-60.
17. Fujitani R, Omokawa S, Shigematsu K, Tanaka Y. Comparison of the intramedullary nail and low-profile plate for unstable metacarpal neck fractures. J Orthop Sci 2012;17:450-6.
18. Orbay J. Intramedullary nailing of metacarpal shaft fractures. Tech Hand Up Extrem Surg 2005;9:69-73.
19. Lord RE. Intramedullary fixation of metacarpal fractures. J Am Med Assoc 1957;164:1746-9.
20. Xiong G, Li PC, Zhu Y, Li YC, Zhu J, Zhang YL. Biomechanical research of absorbable implants in metacarpal fractures. Chin J Orthop 2004;24:486-7.
21. Rokkanen PU, Böstman O, Hirvensalo E, Mäkelä EA, Partio EK, Pätiälä H, *et al.* Bioabsorbable fixation in orthopaedic surgery and traumatology. Biomaterials 2000;21:2607-13.