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Original article

## Treatment of finger phalangeal fractures using the Ichi-Fixator system: A prospective study of 12 cases



### Traitement des fractures des phalanges digitales par le système Ichi-Fixator: étude prospective sur 12 cas

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#### ABSTRACT

External fixators are an effective treatment option for comminuted or unstable phalangeal fractures. We developed a new linked-wire type of external fixator (the Ichi-Fixator) for finger phalangeal fractures, which enables fine adjustment of the fixation under fluoroscopy guidance either in a static way or with distraction through small screws inside the fixator. This technique was designed to improve on the stability and rigidity of conventional percutaneous Kirchner wire fixation. We assessed the effectiveness of the fixator through 12 cases of open or percutaneous fixation in comminuted or unstable phalangeal fractures. All patients were examined for postoperative complications, functional recovery, pain on visual analog scale (VAS), and the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) score at the final follow-up visit. Patients could perform all routine activities with normal grip strength and a full range of hand motion without pain after treatment. This treatment, which reduces the postoperative discomfort and may allow an immediate return to work, will clearly boost patient satisfaction. Linked-wire type external fixation enhances the security of fixation, facilitates postoperative mobilization, and may allow an immediate return to work.

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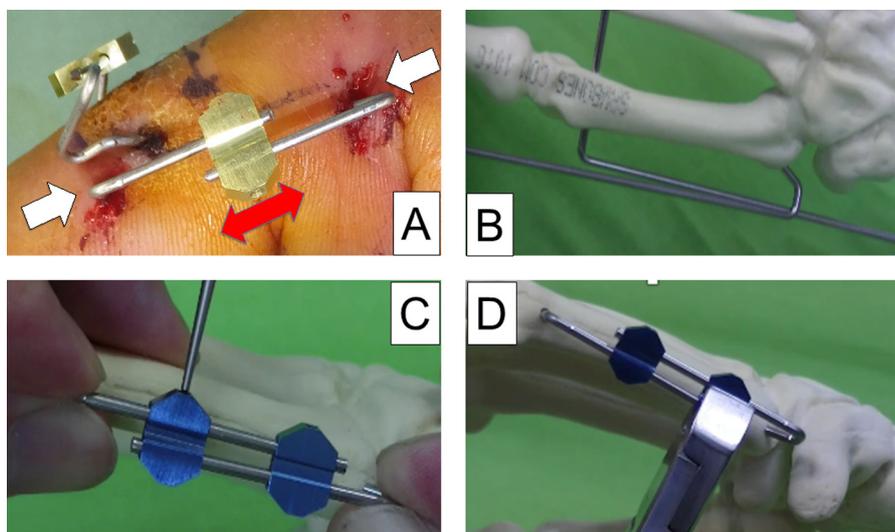
#### R É S U M É

Le fixateur externe est une option de traitement efficace dans les fractures phalangiennes comminutives ou instables. Nous avons développé une nouvelle méthode de fixation externe (Ichi-Fixator) pour fractures phalangiennes, qui permet d'ajuster la fixation sous radioscopie, soit en montage statique soit en distraction grâce aux petites vis dans le fixateur. Cette technique est conçue pour augmenter la stabilité et la rigidité dans le traitement conventionnel par brochage percutané. Nous avons évalué la stabilité du fixateur dans 12 cas de fixation percutanée ou à ciel ouvert dans des fractures phalangiennes comminutives ou instables. Tous les patients ont été évalués: présence de complications postopératoires, récupération fonctionnelle, douleur selon une échelle visuelle analogique (VAS), le questionnaire Quick Disabilities of the Arm, Shoulder, and Hand (Q-DASH) à la fin de la période de suivi. Les patients étaient capables de poursuivre les activités de la vie quotidienne avec une force de préhension normale et une mobilité complète des articulations sans douleur. Ce traitement, qui améliore le confort postopératoire et permet le retour immédiat au travail, peut beaucoup augmenter la satisfaction des patients. L'ostéosynthèse par fixateur externe de type broches connectées augmente la sécurité de la fixation, facilite la mobilisation postopératoire et peut permettre le retour immédiat au travail.

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**Fig. 1.** Surgical Technique. Before the screw is fastened, the fracture site can be adjusted (white arrow: compression, red arrow: distraction) (A). The wires are bent to 90° and aligned in parallel (B). The wire is fixed using small screws inside the fixator under fluoroscopy guidance (C). The metal clamp is fixed using a clasper (D).

## 1. Introduction

Finger phalangeal fractures are common injuries [1,2]. These fractures can be treated conservatively or surgically depending on the mechanism of injury, fracture pattern, and stability of the fracture site. Conservative treatment such as cast application and splint immobilization is generally suitable for reducible and stable fractures. However, surgical treatment is indicated for displaced and unstable fractures, shortening, rotation, angulation, intra-articular fractures (step-off > 1 mm), and open fractures [3]. Conservative treatment of these fractures is likely to result in stiffness or osteoarthritis.

When treating phalangeal fractures, it is important to perform anatomical reduction, minimize soft tissue damage, and achieve early mobilization. A less invasive treatment is preferred to accomplish these goals. External fixation is an effective treatment option for managing various types of fractures. It allows for early mobilization while maintaining restoration of articular congruity through capsule ligamentotaxis. Establishing a stable bony construct by external fixation should prevent adhesions and improve the functional outcome.

We developed a new linked-wire type of external fixator (Ichi-Fixator system (IFS); Neomedical, Saitama, Japan) that involves the insertion of two wires and external wire fixation using a metal clamp [4]. This system facilitates fine-tuned distraction, compression, and fixation of fractures through small screws inside the fixator under fluoroscopy control (Fig. 1A). Ethical approval was obtained from the regional ethics review board of our hospital.

In this report, we describe the outcomes of percutaneous fixation with the above-described linking-wire type of external fixator (IFS) for finger phalangeal fractures.

## 2. Materials and methods

### 2.1. Patients

Twelve patients (11 males and 1 female) with middle and proximal phalangeal fractures were included in this study. Their mean age was 42 years (range, 14–59 years). Surgical treatments were carried out in our hospital from 2017 to 2018. The patients underwent surgery an average of 10 days (range, 1–20 days) after

their injury. They were followed for a mean of 4.4 months (range, 3–10 months).

The fracture site was the proximal phalanx in eight patients and the middle phalanx in four patients. Seven patients had interphalangeal fractures (IPF) and five patients had pure phalangeal fractures (PPF). Most fractures were comminuted (91%), and all were unstable. Both manual and percutaneous reduction was difficult for two fractures, and one open fracture was treated by open reduction and external fixation using the IFS.

Using this external fixator requires specific fixator pins (1.2 or 1.5 mm) and a metal clamp. The fixation technique varied depending on the type of fracture. Five patients underwent fixation without straddling the joints (cases 8–12). Seven patients underwent fixation across the joints, three patients underwent static fixation (cases 1, 3 and 4) and four patients underwent dynamic (compression or distraction) fixation (cases 2, 5–7). After the operation, immediate total active mobilization was allowed in all cases. The fixator was easily removed on an outpatient basis without anesthesia.

We examined all patients for postoperative complications and assessed their functional recovery by determining total active motion (TAM) as described by Duncan et al. [5], pain on a visual

**Table 1**

Data and outcomes for the 12 patients in our case series.

Patient	Age	Fracture	Result at last follow-up visit			Functional outcome	Complications
			Pain	QuickDASH	TAM (°)		
1	59	I/P/A	0	0.00	218	Good	–
2	36	I/P/A	1	13.64	258	Excellent	–
3	50	L/P/A	1	2.27	255	Excellent	–
4	47	T/P/A	0	2.27	94	Fair	IP stiffness
5	46	R/P/A	2.6	15.61	250	Excellent	–
6	48	L/M/A	1	38.64	238	Excellent	–
7	53	M/M/A	0	25.00	226	Excellent	–
8	14	R/P/E	1	4.55	260	Excellent	–
9	32	I/M/E	1	2.27	222	Excellent	–
10	14	L/P/E	1.3	2.27	283	Excellent	–
11	49	L/P/E	1	25.00	144	Fair	MCP stiffness
12	51	L/P/E	0	0.00	242	Excellent	–

T: Thumb; I: Index; M: Middle finger; R: Ring finger; L: Little finger; P: proximal phalangeal fracture; M: middle phalangeal fracture; E: extra-articular fracture; A: articular fracture.

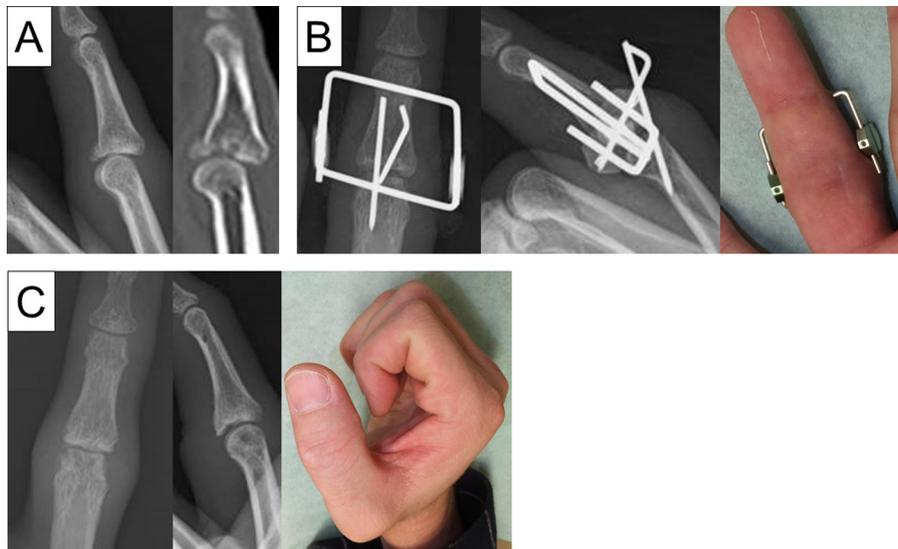
analog scale (VAS), and the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) score at the final follow-up visit.

### 2.2. Surgical technique

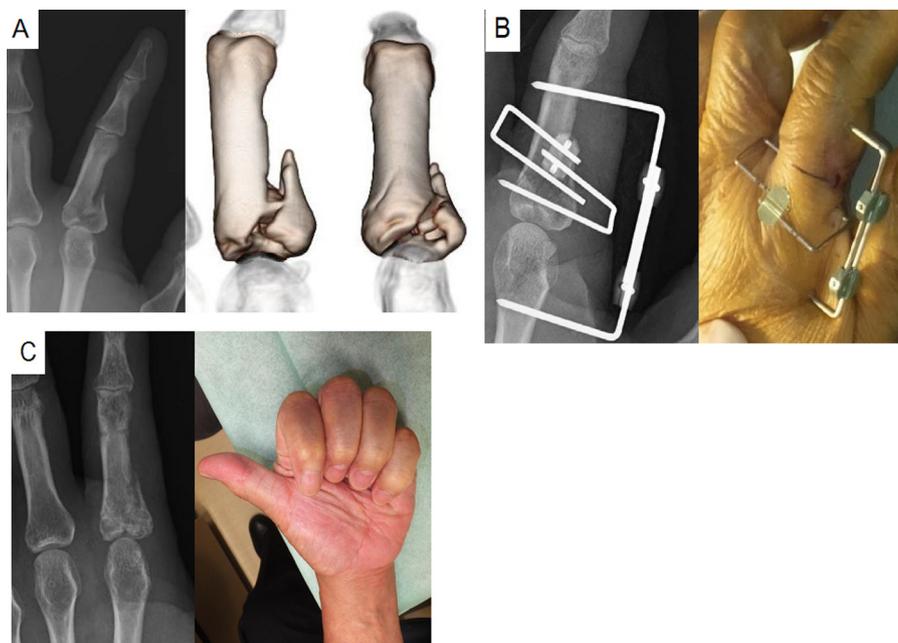
After fluoroscopy-guided closed or open reduction, two or three 1.2- or 1.5-mm fixator pins were inserted in the phalangeal bone depending on the type of fracture. The pins were bent to 90° using multiple specific benders until they became parallel (Fig. 1B). Both wires were cut with a flat wire cutter and metal clamp. The fracture was manually reduced under fluoroscopy, and the wires were fixed with a screw (Fig. 1C). Finally, the pins were firmly fixed using a clasper (Fig. 1D).

### 3. Results

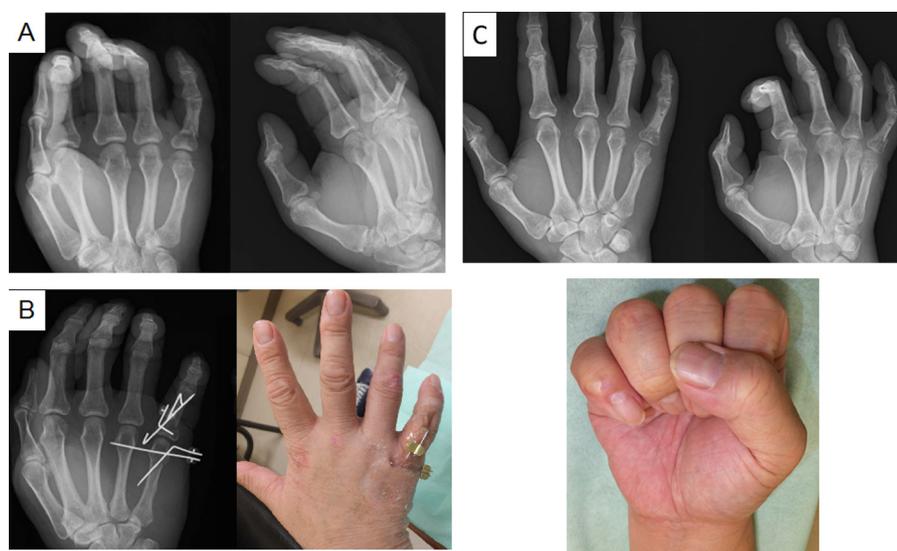
All 12 fractures achieved complete union. No fractures developed infection, non-union, pin loosening, failure, or reduction loss. One patient developed stiffness. The external fixator was removed after a mean of 6.3 weeks in IPF and 6.2 weeks in PPF. All patients immediately returned to work after the external fixator was removed. At the end of the follow-up period, the mean TAM, pain on VAS and QuickDASH were 220° in IPF and 237° in PPF, 0.8 in IPF and 0.9 in PPF, and 13.9 in IPF and 6.8 in PPF, respectively (Table 1). The results were excellent in 9 patients (75%) (Fig. 2), good in 1 patient (8%) (Fig. 3), and fair in 2 patients (17%) (Fig. 4). One of the patients with a fair outcome had a



**Fig. 2.** Case 5. A 46-year-old male patient with a middle phalanx base fracture of the ring finger. Preoperative (A). Postoperative (B). Six-month follow-up showing an excellent outcome (C).



**Fig. 3.** Case 1. A 59-year-old man with a comminuted proximal phalanx base fracture of the index finger. Preoperative (A). Postoperative (B). Six-month follow-up showing a good outcome (C).



**Fig. 4.** Case 9. A 49-year-old man with an open proximal phalanx base fracture and metacarpal neck fracture of the small finger. Preoperative (A). Postoperative (B). Six-month follow-up showing a fair outcome (C).

**Table 2**  
Comparison of the functional outcomes in comparable published case series.

Authors	Excellent (%)	Good (%)	Fair (%)	Poor (%)
Tank et al. [11]	70	19	11	-
Jafari & Ajvadi [12]	78.6	12.5	7.1	-
El-Shaer et al. [13]	30	20	20	30
Our study	75	8	17	-

combined open fracture and metacarpal fracture. The other patient with a fair outcome underwent salvage surgery; the first surgery had been performed as an emergency procedure for repair of an open fracture in another hospital.

#### 4. Discussion

External fixation is generally indicated for open fractures, especially fractures with concomitant soft tissue injury. However, to achieve stable reduction, rigid fixation, and early mobilization, it is important to use a linked-wire type external fixator when treating finger phalangeal fractures. External fixation using K-wires bonded with methyl-methacrylate resin was first described by Crockett in 1974 [6]. Later, a rubber band fixator for proximal phalangeal dislocation fractures was described by Agee in 1978 [7]. These early external fixators dropped out of favor because they were cumbersome and not ideal for hand fracture treatment. Various improved external fixators have since been described, including plastic tubes, cement, and commercial fixators [8–10]. McCulley and Hasting [8] reported using an intravenous cannula as a crossbar to hold the K-wires. However, the length of the sheath was inadequate, and the sheath slipped over the K-wires, adhering to the skin and losing its stability. Tank et al. [11] described improved fixators in which the K-wire with the sterile spinal needle had enough length and resilience. In a study by Jafari and Ajavadi [12], loosening was greatly diminished by using a cement-based external fixator with a concrete-like structure. Although both treatments are readily available and provide good functional outcomes, they do not allow the reduction to be fine-tuned when securing the fixator. Commercial fixators provide rigid fixation of the bony construct but are costly and not always available [13,14]. Three fixators may affect the adjacent finger because of their bulk. The functional outcomes in our

study are not inferior to those obtained with plastic tube and cement fixators and are superior to those obtained with commercial fixators (Table 2).

The IFS gets around these disadvantages. The advantages of the IFS are that it is easy to handle and requires few steps, its low profile has less impact on the adjacent finger, good reduction can be confirmed because the metal clamp is radiolucent, it can be used in different static and dynamic applications depending on the fracture type, and locking the two wires enables rigid two- or three-dimensional fixation.

In our study, the clinical outcomes were fair in two severe cases (open fracture and salvage operation). Although these patients experienced stiffness, they did not develop an infection or loosening and were satisfied with their results once hand function reached a plateau.

The main limitations of our study are the small sample size and short follow-up period. Future studies should include more patients and a longer follow-up period.

#### Conclusion

The IFS is a simple, non-bulky, radiolucent device. It allows for adjustment of fractures during surgery and facilitates early mobilization while maintaining the reduction throughout the postoperative period. The IFS is a definitive treatment option for managing various phalangeal fractures.

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#### Disclosure of interest

The authors declare that they have no competing interest.

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