



Suzuki Frame Results in the Treatment of Comminuted Phalanx Fractures

Mehmet Cenk Turgut¹  Serdar Toy² 

1 Health Sciences University, Erzurum City Hospital, Department of Orthopedics and Traumatology, Erzurum, Turkey

2 Ağrı Training and Research Hospital, Department of Orthopedics and Traumatology, Ağrı, Turkey

Abstract

Background: Comminuted fracture of the PIP joint is one of the most challenging fractures to be treated in hand surgery practice. The pins and rubber traction frame is an easy method to perform for these fractures. This study aimed to present the treatment stages of patients who had PIP joint fractures-dislocations with the pins and rubber traction frame and the functional results of patients.

Methods: The results of eight patients with fracture-dislocations of the PIP joint between 2016 and 2019 were retrospectively analyzed. Age and gender of patients, time between trauma and surgery, postoperative follow-up periods, affected area on the joint surface, postoperative complications, range of motion of PIP and DIP joints, affected finger, and the causes of the trauma were recorded.

Results: Five (62.5%) patients were male, and three (37.5%) patients were female in this study. The mean age of the patients was 28.50 ± 3.42 years. The mean range of motion of the PIP joint examined in the postoperative 12th month was 4.88° to 86.25° . In the same period, the mean range of motion of the DIP joint of the patients was 4.38° to 86.25° . We obtained union in all patients. Malunion or nonunion and osteomyelitis were not seen in any patients.

Conclusions: The pins and rubber traction frame is a method that can be used safely and effectively in fractures of the phalanx joints that are difficult, comminuted, and involving the joint.

Key words: Proximal Interphalangeal Joint, Fracture, Dislocation, Dynamic Fixation, Frame.

INTRODUCTION

Metacarpal and phalanx fractures are amongst the most frequently encountered orthopedic injuries (1). These fractures account for 10% of all fractures or 1/3 of all hand injuries (2). The proximal interphalangeal joint (PIP) is a

hinge-style joint. It contributes to the grip dynamics of the hand with movements in the direction of flexion-extension and little rotational movement. The middle phalanx is subject to frequent injuries due to its weakness in soft tissue support. Some injuries only concern soft tissue, while others may be comminuted fractures (3). In these

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fractures, the fragments will shift according to the pulling directions of the flexor and extensor tendons. While phalanx shaft fractures are generally stable, oblique and spiral fractures tend to slip and require close follow-up in conservative treatments. In these fractures with difficult closed reductions, if the fracture line concerns more than 30% of the middle phalanx joint surface or if flexion of more than 30 degrees is required for the continuation of reduction, it is considered unstable and requires surgical intervention. Kirschner wire fixation, traction systems, static or dynamic external fixators, volar plate arthroplasty, and open reduction internal fixation (ORIF) are the surgical options of choice for these fractures (4, 5).

Comminuted fractures of the PIP joint are rare. These fractures are often accompanied by subluxation. Open reduction internal fixation or external fixation application and early motion protocol are valid treatment methods. Joint stiffness, degenerative arthritis, swelling, and pain are the most common complications (6). It is one of the most challenging fracture types to be treated in hand surgery practice.

Many techniques have been described in PIP joint fracture-dislocations (7-9). The pins and rubber traction frame described by Suzuki et al. (10) is an easy method to perform for the fracture-dislocations of the PIP joint. This method does not require unique materials. This method allows for early joint motion.

In this study, we aim to present the treatment stages of eight patients who had PIP joint fractures-dislocations with the pins and rubber traction frame and the functional results of patients.

MATERIALS AND METHODS

The study protocol was approved by the Erzurum BEAH KAEK Ethics Committee (Date: 04.01.2021, No: 2021/01-15). The study was conducted in accordance with the principles of the Declaration of Helsinki.

A written informed consent was obtained from each patient. In our study, the results of eight patients with fracture-dislocations of the PIP joint (Figure 1) between 2016 and 2019 were retrospectively analyzed. The pins and rubber traction frames were performed on patients with fracture-dislocations of the PIP joints in our study. Eight patients (five men, three women) were included in our study. Patients were followed postoperatively for at least

12 months. Patients' age, gender, time between trauma and surgery, postoperative follow-up periods, affected area on the joint surface, postoperative complications, range of motion of PIP and DIP joints, affected finger, and causes of the trauma were recorded.

Figure 1: A 27-year-old male patient had left-hand ring finger PIP joint comminuted fracture-dislocation after a motorcycle accident (A, B). The anteroposterior and lateral radiographs of the patient (C, D).

Figure 1: A



Figure 1: B



Figure 1: C



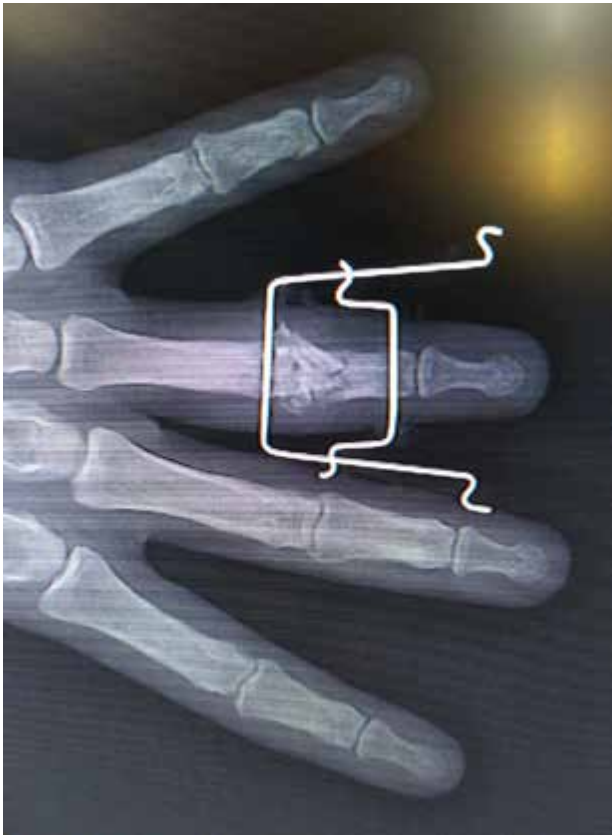
Figure 1: D

Surgical Procedure

Regional anesthesia was applied to all patients as a standard procedure. Under fluoroscopy control, a long Kirschner wire (1.2 mm) was passed transversely just proximal to the joint-related fracture (this wire was the axial pull pin). This wire was bent 90 degrees, approximately 5 mm close to the skin, and its ends were made into hooks. A second Kirschner wire of the same size was passed through the middle of the intact fragment distal to the fracture transversely, parallel to the first wire. As previously described, it was bent 90 degrees to be close to the skin, and the ends were made into hooks again (this wire was the hook pin). Rubbers were used to pull both Kirschner wires whose ends were made into hooks. The traction force between the fracture fragments, the thickness and the number of rubbers were adjusted accordingly under fluoroscopic control (Figure 2). If there was luxation within the fracture, a third Kirschner wire was used to correct the subluxation. Our entire surgical procedure was performed, as described by Suzuki (10). All of our patients received one dose of antibiotics, preoperatively and postoperatively, and nonsteroid analgesic drugs were prescribed to all patients postoperatively.

Figure 2: The patient was treated with the pins and rubber traction frame (A, B). The radiographs of this frame (C, D).

Figure 2: A**Figure 2: B**

Figure 2: C**Figure 2: D**

Postoperative Care

Anteroposterior and lateral hand radiographs of all patients were seen one day after the operation. Weekly controls were made for four weeks, and radiographs were checked for any deterioration in the fracture line. The patients were given new dressings every three days and were advised to keep their bandages clean. At the end of the third week, a strict physical therapy program that would last about 8-12 weeks was prepared for the patients. The pins of all patients were removed at the end of four weeks in the outpatient clinic without anesthesia, except for one patient with a pin-track infection. All patients received physiotherapy afterwards.

RESULTS

We obtained union in all patients. Malunion or nonunion and osteomyelitis were not seen in any patients.

In our study, five (62.5%) patients were male, and three (37.5%) patients were female. The mean age of the patients was 28.50 ± 3.42 (range: 24-34) years. The mean time between trauma and surgery was 3.88 ± 2.29 (range: 1-7) days. The mean postoperative follow-up period of the patients was 14.88 ± 2.74 (range: 12-20) months. The average percentage of the affected joints of the fractured-dislocated phalanges was found to be 47.25% (range: 35%-62%) (Table 1).

Table 1. Summary of the results

Patients	Gender	Age	Delay (day)	Follow-up (month)	Joint Fracture %	Complication	PIP ROM-Flex	PIP ROM-Ext	DIP ROM-Flex	DIP ROM-Ext	Injured Finger	Cause of Injury
1	Male	24	2	12	54	None	0	85	0	100	Middle	Sport
2	Male	27	1	12	40	Some stiffness in the DIP joint	7	90	10	85	Ring	Traffic accident
3	Female	27	4	14	45	Pain	5	90	5	80	Ring	Fall
4	Male	34	6	15	62	None	0	85	0	90	Middle	Sport
5	Male	32	7	16	45	Pin-track infection	5	80	0	90	Small	Sport
6	Male	25	5	13	35	Some stiffness in the DIP joint	10	90	15	70	Middle	Sport
7	Female	29	1	17	42	Pain	5	90	5	85	Index	Traffic accident
8	Female	30	5	20	55	None	7	80	0	90	Small	Fall

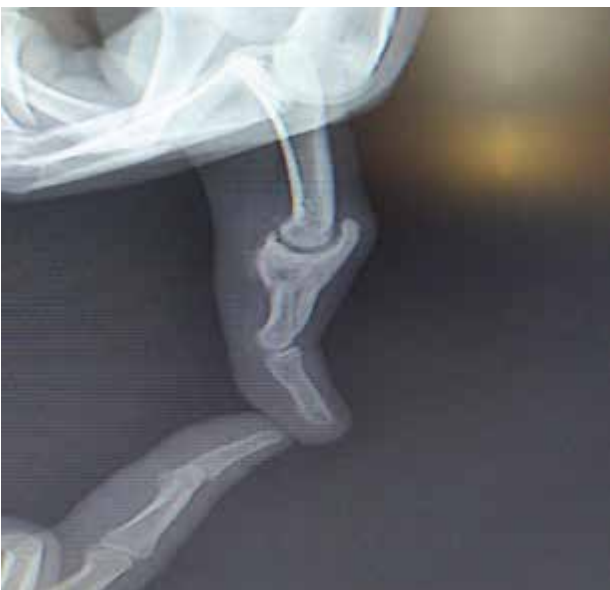
Considering the cause of injury, four (50%) patients developed fracture-dislocations in the PIP joint during sports activities, two (25%) patients due to traffic accidents, and two (25%) of them as a result of falling. Complications that develop during the postoperative follow-up of the patients are moderate pain in two patients (25%), limitation of movement in the DIP and PIP joints in two (25%) patients, and pin-track infection in one (12.5%) of them.

The mean range of motion of the PIP joint of patients examined in the postoperative 12th month was 4.88° to 86.25° (range: 0-10° and 80-90°) (Figure 3). In the same time period, the mean range of motion of the DIP joint of the patients was 4.38° to 86.25° (range: 0-15° and 70-100°) (Figure 3).

Figure 3: The final follow-up evaluation of the patient (A, B). The anteroposterior and lateral radiographs of the patient (C, D)

Figure 3: A



Figure 3: B**Figure 3: C****Figure 3: D**

DISCUSSION

This study discussed the results of the operations performed with pins and rubber traction frame in a total of 8 patients with fractures in their phalanges with comminuted fracture-dislocations. Patients could use their fingers with pins and rubber traction frame functionally after the follow-up period. The functional and clinical results of patients obtained in our study were excellent and good, except for two patients with limitation of movement in the DIP and PIP joints.

It is necessary to carefully evaluate whether there are rotational deformity and angulation in the comminuted fracture-dislocations of the phalangeal joints. The fingers are flexed to assess the rotational deformity. Overlapping or rotational asymmetry of nails is also investigated. The full lateral radiograph is examined to evaluate the angulation. If there is excessive angulation, tendon injury should be considered (11).

The aim of treatment in the comminuted fracture-dislocations of the phalangeal joints is to provide stable reduction that allows early motion. In addition, joint cartilage integrity should be ensured in these fractures, and arthritis development should be prevented. Moreover, conservative methods are insufficient to provide stability in these fractures.

ORIF should be considered in unstable PIP joint fracture-dislocations if the displacement in the fracture fragment is more than 2 mm or if the piece is large enough to carry the mini-screw (12). However, open reduction is challenging in some fractures that may be difficult to fix with open surgery. They should be securely treated; for this purpose, it would be wiser to maintain the length by applying external fixators.

More popular among percutaneous applications are external fixators prepared with Kirschner wires. Different application methods have been described in the literature (10, 13-15). Inanami et al.(16) described a small dynamic external fixator consisting of two parallel apparatuses with two pulleys at both ends and a center pulley. They reported that they obtain optimal results with no complications. They stated that the final PIP joint range of motion was 88°. Bain et al. (17) and Krakauer and Stern.(18) reported that the hinge was able to restore range of motion almost fully. However, they stated that many complications were encountered.

Skoff (19) described a device composed of two K-wires. He reported that the patient achieved a final range of motion of 115° with this device. Agee (20, 21) described a new technique using three k-wires and was activated by a single rubber band. The pins and rubber traction frame have a significant contribution to stability and are simple to use. The traction frame used in this study is prepared using K-wires and rubber bands (10). Other advantages are that it can be easily applied under fluoroscopy, does not interfere with control graphs, and allows early active movement.

Badia et al. (22) treated six patients with fracture-dislocations of the PIP joint with a simple dynamic fixator method. They stated that they achieved the reduction in all patients and that the mean range of motion of the PIP joint at the concluding follow-up evaluation was 5° to 89° (range, 0° to 100°). Cardoso and Li (23) operated on two patients with comminuted proximal phalanx fractures and achieved excellent results. Kiral et al. (24) performed on 33 patients with the pins and rubber traction frame in their study. They stated that they achieved satisfactory results. Nanno et al. (25) operated on 39 patients with this technique in their research. They reported that they achieved good results in their study. In our study, we obtained satisfactory results clinically and functionally.

Suzuki et al. (10) treated seven patients for phalangeal fractures. They reported that the final active motion of the injured DIP joint in one patient was from 0 to 40° of flexion. Badia et al. (22) said that one of the six patients had some stiffness in the DIP joint. Cardoso et al. (23) operated on a 50-year-old right-hand dominant female patient. They stated that she showed a pain-free active range of motion of 0 to 75 and 0 to 68 degrees in the MP and PIP joints postoperatively. In our study, two patients had some stiffness in the DIP and PIP joints after the follow-up period.

Our study has some limitations. These limitations are a relatively small sample size, a retrospective design study, and a relatively short follow-up period. Studies with a larger sample size and long-term follow-up period are required to obtain detailed findings.

In conclusion, our study demonstrated promising clinical results with the pins and rubber traction frame for fracture-dislocations and comminuted intraarticular fractures of the PIP joint. This study has demonstrated

that the pins and rubber traction frame successfully treated various complicated intra-articular fractures. This technique provided both anatomical reduction and stable fixation. It also prevented joint stiffness by allowing early motion. The pins and rubber traction frame is a method that can be used safely and effectively in fractures of the phalanx joints that are difficult, comminuted, and involving the joint.

Declarations

The authors received no financial support for the research and/or authorship of this article. There is no conflict of interest.

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