Modified Dynamic Suzuki Wire Frame for Proximal Interphalangeal Joint Fracture – A Case Report

Dr. Pranav Agrawal[1], Dr. Gaurav Agrawal[2]

Abstract

Complex comminuted fractures of the base of the middle phalanx, proximal phalanx and proximal interphalangeal joint are a treatment challenge, as deformity, stiffness and loss of function are quite frequent and disabling, following surgical treatment. We present a case of a 31-year male who suffered from comminuted intra-articular fracture and dislocation of the middle phalangeal base of the little finger and middle finger of the same hand, a year apart. Both were closed injuries of the dominant hand. We used a modified dynamic Suzuki wire frame for treatment of both fractures in an acute setting and at late presentation for the middle finger and little finger respectively. Minimal soft tissue injury, capsulo-ligamentotaxis, early mobilisation with frame and early return to function were key aspects of this treatment. Modified dynamic Suzuki frame is a simple, minimally invasive, dynamic external fixation device, that allows early motion at PIPJ and eventually good remodelling and function at PIPJ and DIPJ, even in the long term. It can be used in modified forms for comminuted fractures of bases of distal and proximal phalanges as well.

Keywords: Suzuki frame, phalanx fracture, middle phalanx, modified suzuki frame, hand fractures, ligamentotaxis

Introduction

Fractures involving the tubular bones of the hand are the most common skeletal injuries. The preferred method of treatment is one that offers limited soft tissue damage and enables mobilization of the injured digit(s) as soon as fracture stability permits.[1]

Technical treatment of phalangeal fractures depends on characteristics of the fracture, requirements of the patient, and judgment of the treating surgeon.

Operative treatment is reserved for unstable fractures or those creating unacceptable articular incongruity.[1]

The optimal outcome from surgical treatment demands an appropriate surgical plan, atraumatic soft-tissue handling, and stable fixation to facilitate early motion; however, complications such as non-union, malunion, infection, and stiffness can occur even in the setting of appropriate treatment.[1]

Thorough clinical evaluation is usually required to determine the appropriate treatment course for each patient. The patient's age, hand dominance, occupation, avocations, medical comorbidities (including tobacco use), goals, limitations, and tolerances are important factors for the treating surgeon to consider.

[1] Consulting Orthopaedic and Joint Reconstruction Surgeon, Lilavati Hospital & Research Centre
[2] Clinical Associate - Orthopaedic Surgery, PD Hinduja Hospital, Khar
Corresponding author: Dr Pranav Agrawal, Consulting Orthopaedic and Joint Reconstruction Surgeon, Lilavati Hospital & Research Centre
Email: drpragr@gmail.com

All authors worked equally in the preparation of this manuscript in terms of concept, surgery, literature search, data acquisition and manuscript preparation, editing and review.

The mechanism of injury and associated injuries often help determine the course of treatment. Advanced medical imaging may be used for understanding fracture morphology when necessary.[1]

Unlike long bones, acceptable alignment limitations vary based on the anatomic location of the fracture as well as the age of the patient. One of the key general determinants of whether a fracture will require operative treatment is its inherent stability.[1]

Fractures of phalangeal bases and fractures of proximal interphalangeal joints include a wide spectrum of injuries, from stable avulsion fractures to complex fracture-dislocations. Most surgical treatment modalities, when indicated and implemented in these, are often fraught with complications as mentioned earlier. Restoration of anatomy, minimal soft tissue dissection and early mobilisation of joints have shown to concede good results in terms of functional recovery and return to routine activity.

Case

History

A 31-year male presented to us with a history of cricket ball injury to the little finger of his right dominant hand. He complained of pain, swelling and inability to perform a full range of motion of the little finger proximal interphalangeal joint of right hand since the time of injury which was 12 days before presentation. He found it difficult to write, work or play cricket.

There was no injury to other fingers, limbs or vital organs. He had no medical comorbidities. He played competitive cricket for his local association and wanted to get back at the earliest. After the injury, he had self-treated with an adhesive tape and finally presented on the 12th day when swelling failed to subside.

On examination, the proximal interphalangeal joint (PIPJ) of the right little finger was swollen, tender and had a flexion deformity of 15 degrees. Minimal extension was possible but with pain. Further flexion of 5 – 10 degrees was possible but with pain.

There was an associated adduction deformity at PIPJ. There was no crepitus or abnormal mobility at the joint. Capillary refill and distal sensations were normal. There was no injury to any other fingers. There were no lacerations or cuts, making it a closed injury.

Simple radiographs of the hand in anterior and oblique views showed a comminuted intraarticular fracture of the base of the middle phalanx of the right little finger. The phalangeal shaft had impacted into the fractured base thereby making it a fracture-dislocation of PIPJ. No other injuries were noted.

A finger immobilisation splint was applied and the pre-operative protocol was started

Management

All pre-operative investigations being normal, the patient underwent a Modified Dynamic Suzuki wire frame application under ring block anaesthesia. It is a fairly simple procedure vis a vis the complexity of the fracture of a small bone.

The patient was positioned supine with his right arm kept extended on a radiolucent side table which can facilitate the entry and thereby use of a C-arm. After thorough aseptic precautions, 5 ml of 2% plain Xylocaine was infiltrated at the base of the little finger as a ring block. Few minutes were allowed for ring block to act.

Constructing a Modified Suzuki Splint

A 1 mm K (Kirschner)wire was percutaneously drilled, using a wire driver, into the distal condyle of the proximal phalanx of the little finger, along the rotational axis of the condyle. Another 1 mm K wire was drilled parallel to the first in the neck of the involved middle phalanx. The exact positions of both K wires were confirmed on the C-arm view.

The distal K wire was bent 90 degrees upon itself, about 2 or 3 mm away from the skin of the phalanx on both sides. An AO wire bender was used for the bend and this K wire was cut few millimetres from the bend.

After doing a similar bend for the proximal K wire, it was further bent 90 degrees upon itself, about 1 cm away from the distal K wire and then bent again 1 cm distal to the second bend in the opposite direction, thereby creating an 'S' shaped bend configuration.

This 'S' shaped bend was then hooked onto the distal K wire under the tension of its own length and elas-

Figure 1: Intra operative picture of the completed Modified Suzuki frame

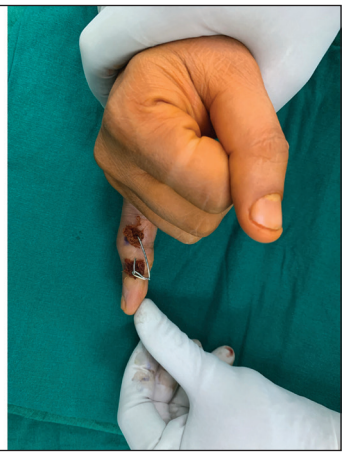

Figure 2: Intra operative picture of the completed Modified Suzuki frame (Lat View)

ticity of wire material and the pin tracks were dressed using betadine solution.

A Sterile gauze and roller bandage dressing was done. This completed the construct. (Figure 1, 2)

The tension in a modified Suzuki frame that comes due to the wire's elasticity, provides distraction at the fracture site and thereby capsulo-ligamentotaxis. The distraction was confirmed on C-arm images intraoperatively. (Figure 3 a,b)

Figure 3a: Intra operative C-arm views of completed Suzuki frame (Note Distraction)

Figure 3b: Intra operative C-arm views of completed Suzuki frame (Note Distraction)

A post-operative X-ray showed good position of the frame. (Figure 4)

Post-Operative Care

The patient was encouraged to perform active flexion and extension of his little finger as soon as the anaesthesia had worn off and there was relief from pain. He was taught active and assisted flexion-extension exercises on the same day of surgery.

The patient was discharged within few hours of surgery and followed up in the out-patient clinic for dressing and radiography.

The patient could achieve good active flexion and extension within 2 weeks of application of the frame. He could achieve near full flexion and extension passively with the frame in position.

The frame was removed in OPD at 3 weeks from its application and active and passive movements were encouraged.

X-ray done at 6 weeks showed good consolidation of fracture and re-modelling of the joint surface.

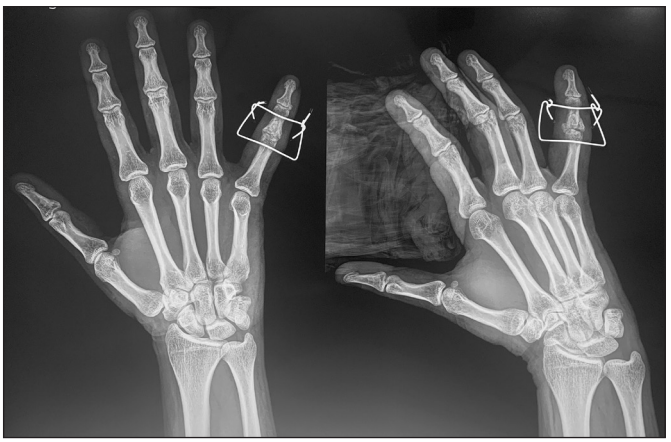

Figure 4: Immediate post-operative X-ray in AP and Oblique views

Figure 5: X-ray at 6 weeks showing good consolidation of fracture & remodelling of the joint surface

(Figure 5).

The patient could now actively flex his PIPJ to about 80 degrees and distal inter phalangeal joint to about 30 degrees. (Figure 6, 7)

Figure 6: Clinical picture of extension of the little finger (PIPJ) at 3 months

Figure 7: Clinical picture of flexion of the little finger at 3 months with good flexion at DIP

His grip strength was very good and he could hold heavy objects as well as perform fine activities.

There was no pin track infection or loosening in the course of treatment. The patient did not complain of pain and NSAIDs were hardly needed for a few days post-operatively. There was no rotational, coronal or sagittal deformity.

The patient returned to active sporting and cricket at 6 months from the injury.

A Year After the Injury

Almost a year after the injury and its treatment, the patient injured the middle phalangeal base of the middle finger of the same hand in a similar fashion while playing cricket. He was diagnosed on x-ray as having a fracture-dislocation of the proximal interphalangeal joint. (Figure 8)

Figure 8: Fracture dislocation of the base of middle phalanx of the middle finger

He presented 2 days after the injury. Despite there being an acute comminuted fracture-dislocation of the base of the middle phalanx, we applied a modified Suzuki splint. It provided a distraction at the fracture site, ligamentotaxis and reduction of the dislocation. (Figure 9a, 9b)

Figure 9a: AP view of completed Suzuki splint for a middle finger fracture

Figure 9b: Lateral view of completed Suzuki splint for a middle finger fracture

The same finger also had a displaced mallet finger (Dorsal avulsion fracture of base of distal phalanx). An extension block wiring was done for that in the same anaesthesia. We immobilised the finger for 3 weeks to let the mallet finger heal and then mobilised the PIPJ with the Suzuki frame in situ.

This frame was removed at 6 weeks from application and the fracture showed good reduction and healing. (Figure 10)

At 6 weeks, at the time of writing this case report, his range of movement at the PIPJ was ~ 70 degrees and active ROM was improving. He was able to sign with a pen and

Figure 10: Xray at 6 weeks showing consolidation of the fracture

his fine motor movements were improving as well.

(We will publish functional outcomes of both fingers when we observe the improvements over a long follow up).

Discussion

Swanson et al observed that fractures of the hand can be complicated by deformity from no treatment, stiffness from over-treatment, and both deformity and stiffness from poor treatment. [2]

The primary objectives of phalangeal fracture treatment are to restore anatomy, preserve function, minimize recovery time and expedite return to activity. The preferred treatment restores anatomy, minimizes soft tissue injury, and enables mobilization of the injured digit as soon as fracture stability permits. Phalangeal fractures lead to quite a lot of disability and loss of productivity. [3]

Fractures of the proximal interphalangeal joint include a wide spectrum of injuries, from stable avulsion fractures to complex fracture dislocations. Management of complex proximal interphalangeal joint (PIPJ) fracture-dislocations is challenging, with the potential of long-term sequelae including pain, stiffness, and functional loss. Several treatment modalities exist, none of which consistently produce good results.[4] Early mobilization is preferred to avoid stiffness and encourage articular cartilage regeneration via restoration of synovial fluid transport.[5]

Static external fixation (JESS & other forms), including traction devices, have been used frequently in the treatment of comminuted PIPJ fractures. These however consistently contribute to joint stiffness and osteoarthritis.[6,7,8] To avoid this, early mobilization is necessary, not only for joint stiffness but also to help the damaged articular cartilage to repair.[5]

Volar plate avulsion fractures of the middle phalangeal base, most often involve only a small fragment avulsed by the detached volar plate and they result from hyperextension injuries or dorsal dislocations. Instability of the joint results when the fracture fragment involves more than 40% of the articular surface. In this case, volar plate arthroplasty, ORIF or hemihamate autograft procedures are indicated to restore joint congruity and stability.[9] Stern *et al*. reported that open reduction and internal fixation can accomplish an anatomical reduction in some cases but should be approached carefully, since extensive soft-tissue dissection around the joint may disturb smaller fragments of their blood supply and lead to joint stiffness.[10]

Suzuki *et al* developed a skeletal traction system for comminuted intraarticular fractures and fracture-dislocations of the hand in 1994. Their system consists of two or three Kirschner wires and rubber bands and was easy to assemble. It was compact, comfortable and effective, in allowing early motion of the affected digits.

They published excellent results through seven cases of severe articular injuries in the hand. At the time of follow-up (Avg 13.1 months), the average range of the affected PIP joint motion was about 80 degrees. The final active motion of the injured DIP joint ranged from 0 to 40 degrees in flexion and that of the affected thumb (trapezial fracture) was not limited. The average follow-up period was 13.1 months. (Figure 11) [11]

Suzuki *et al*. demonstrated that the clinical results could be satisfactory because even slight active motion may encourage the nutrition and remodelling of the articular surface and prevent joint stiffness. [12]

Deshmukh, Slade and other authors also published series of cases with good results from using either the original or a little modified version of the Suzuki frame. They reported that capsule-ligamentotaxis by the Pin and Rubber Traction System achieves proper articular congruity and healing during early mobilization. [13,14]

In a study published by Nanno *et al*, there were no significant differences in active range of motion of the finger, union rate, and infection rate between 24 fresh and 15 old fractures that received Suzuki (PRTS) frame treatment. During treatment for old fractures, joint contractures often occurred as opposed to fresh cases after surgery.

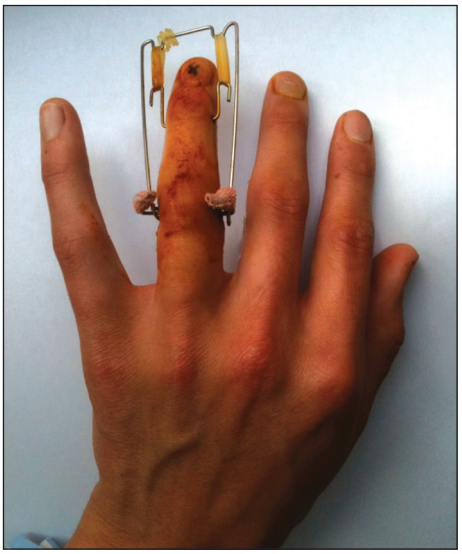

Figure 11: Clinical picture of PNTS as described by Suzuki.
Source: Boussakri H, Elibrahimi A, Elmrini A. Dynamic Distraction External Fixation Derived from the SUZUKI Frame for Pip Joint Fractures. SM J Orthop. 2015;1(5):1025

They observed that old fractures must be put through an early range of motion exercises not only to prevent joint stiffness but also to encourage nutrition and remodelling of the articular surface. They recommend the use of PRTS for old fractures of the PIP joint as well as fresh ones. [15]

Richter *et al* studied 26 patients over an average long term follow up of 8 years. They found flexion at the PIP joint to be about 95 degrees, extension loss to be 0 degrees, with an average range of motion at PIPJ to be about 85 degrees. X-rays showed an initial anatomic reduction with complete joint congruency in only 20% of the cases, but over time there was an extra-ordinary remodelling of the joint surface in 89% without obvious signs of degeneration of the joint. They concluded that dynamic traction and early motion of intraarticular PIP joint fractures are the treatment of choice, as virtually pain-free and good motion is achieved in the long- term due to the remarkable remodelling capacity of the joint surface. [16]

In our patient, who suffered comminuted intraarticular fractures of the base of the middle phalanx of the dominant hand, twice, a year apart, we used the modified dynamic Suzuki wire traction frame in an acute and a late presentation setting. Both times, the procedure was a simple one with simple inventory and could be done on a daycare basis under ring block anaesthesia. The inherent traction by the frame and ability to put the joint through an early range of motion provided the necessary capsulo-ligamentotaxis and movement at the joint which encouraged good articular cartilage healing and remodelling. Good functional results were obtained including the return of the patient to his sport.

Conclusion

Modified dynamic Suzuki frame is a simple, minimally invasive, dynamic external fixation device, that allows early motion at PIPJ and eventually good remodelling and function at PIPJ and DIPJ, even in the long term. It can be used in modified forms for comminuted fractures of bases of distal and proximal phalanges as well.

References

1. Shannon Carpenter, Rachel S, Rohde. Treatment of Phalangeal Fractures. *Hand Clinics. 2013*;29(4).
2. Swanson AB. Fractures involving the digits of the hand. *Orthop Clin North Am 1970*;1(2): 261–74.
3. Van Onselen EB, Karim RB, Hage JJ, *et al*. Prevalence and distribution of hand fractures. J Hand Surg Br 2003;28(5):491–5.
4. Keramidas E, Solomos M, Page RE, *et al*. The Suzuki frame for complex intra-articular fractures of the proximal interphalangeal joint of the fingers. *Ann Plast Surg 2007*;58(5):484-488.
5. Salter RB, Simmonds DF, Malcolm BW, *et al*. The biological effect of continuous passive motion on the healing of full-thickness defects in articular cartilage. An experimental investigation in the rabbit. *J Bone Joint Surg Am 1980*;62(8):1232-1251.
6. Ellis, SJ, Cheng, R, Prokopis, P. Treatment of proximal interphalangeal dorsal fracture-dislocation injuries with dynamic external fixation: a pins and rubber band system. *J Hand Surg 2007*; 32A: 1242–1250.
7. Inanami, H, Ninomiya, S, Okutsu, I. Dynamic external finger fixator for fracture dislocation of the proximal interphalangeal joint. *J Hand Surg Am 1993*; 18: 160–164.
8. Majumder, S, Peck, F, Watson, JS. Lessons learned from the management of complex intra-articular fractures at the base of the middle phalanges of fingers. *J Hand Surg Br 2003*; 28: 559–565.
9. Schenck RR. Classification of fractures and dislo- cations of the proximal interphalangeal joint. *Hand Clin 1994*;10(2):179–85.
10. Stern, PJ, Roman, RJ, Kiefhaber, TR. Pilon fracture of the proximal interphalangeal joint. *J Hand Surg Am 1991*; 16: 844–850.
11. Boussakri H, Elibrahimi A and Elmrini A. Dynamic Distraction External Fixation Derived from the SUZUKI Frame for Pip Joint Fractures. *SM J Orthop. 2015*;1(5):1025.
12. Suzuki, Y, Matsunaga, T, Sato, S. Pins and rubbers traction system for treatment of comminuted intraarticular fractures and fracture-dislocations in the hand. *J Hand Surg Br 1994*; 19: 98–107.
13. Deshmukh, SC, Kumar, D, Mathur, K. Complex fracture-dislocation of the proximal interphalangeal joint of the hand. Results of a modified pins and rubbers traction system. *J Bone Joint Surg Br 2004*; 86: 406–412.
14. Slade, JF, Baxamusa, TH, Wolfe, SW. External fixation of proximal interphalangeal joint fracture-dislocations. *Atlas Hand Clin 2000*; 5: 1–29.
15. Nanno M, Kodera N, Tomori Y, Takai S. Pins and rubbers traction system for fractures of the proximal interphalangeal joint. *J Orthop Surg (Hong Kong). 2019* May-Aug;27(2)
16. Richter M *et al*. Long-term follow-up of fracture dislocations and comminuted fractures of the PIP joint treated with Suzuki's pin and rubber traction system. *Handchir Mikrochir Plast Chir. 2008* Oct;40(5):330-5. German.