A Trial of the Effect of 2-Step Orthosis Treatment for Mallet Finger Fractures

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Context: Many patients report poor therapeutic outcomes following mallet finger fracture surgery. A more reliable technique is urgently needed. **Objective:** To present a novel treatment for mallet finger fractures using a 2-step orthosis method. **Design:** Prospective, observational study. **Setting:** Hospital. **Participants:** Patients with mallet finger fractures. **Interventions:** The finger is fixed with splints for 6 weeks, including 3 weeks for the proximal interphalangeal joint in the flexion position and the distal interphalangeal joint in the hyperextension position (first splint) and 3 weeks for the distal interphalangeal joint in the hyperextension position (second splint). Up to week 8, the second splint was attached at night and during physical exertion. **Main Outcome Measures:** Crawford criteria, Abouna–Brown criteria, bone fusion, grip strength, Doyle classification, Ishiguro classification. **Results:** Sufficient bone fusion was achieved 12 weeks after fixation; at which time, the range of motion with the distal interphalangeal joint flexed, and extended in the 3 patients was 50° and 0°, 70° and –3°, and 60° and 0°, respectively. The right and left hand grip strengths in the 3 patients were 58 and 55 kg, 62 and 58 kg, and 31 and 29 kg, respectively; there were no problems with respect to function or work. The first 2 patients could start sports again with partial return after 1 week and complete return after 12 weeks and 8 weeks, respectively. For the third patient, rehabilitation was complete after 16 weeks. Evaluation of the fracture sites based on the Crawford criteria showed the condition to be perfect, and evaluation based on the Abouna–Brown criteria showed success. **Conclusions:** This method provides satisfactory fixation and can prevent proximal interphalangeal joint contracture. Favorable long-term outcomes were confirmed in all patients, suggesting that this method may be effective for previously untreated mallet finger fractures with little displacement.

Keywords: mallet finger fracture surgery, conservative therapy, 2-step orthosis method, hand therapy, early sports return

Mallet finger injuries often occur during sports, and patients usually desire an early return to sporting activity. When surgical treatment is performed for previously untreated mallet finger fractures, it frequently results in proximal traction of bone fragments, and thus displacement, which makes it difficult to maintain the new position after manual reduction.¹ Percutaneous wiring is widely used to treat previously untreated patients, with favorable clinical outcomes.^{2,3} In addition to percutaneous wiring, there have been reports on surgical techniques that are based on internal fixation using a hook plate and immobilization of the proximal interphalangeal (PIP) joint when PIP joint extension starts to happen.^{4,5} Acar et al⁶ compared surgical techniques using a hook plate and a Kirschner wire and found that although there are reports of good therapeutic outcomes with open reduction and fixation, there are also reports of poor outcomes, and the disadvantages include nail malformation, loss of bone fragments, and skin damage. Therefore, we urgently need a more reliable technique.

Systematic reviews of mallet finger treatment indicate that both surgical and nonsurgical treatments can achieve excellent clinical progression. Based on this, we can conclude that these treatment methods are of similar efficacy, and treatment must be selected for patients on an individual basis.⁷

Regarding the use of splints, Kalainov et al⁸ reported that in patients with little displacement, conservative treatment methods that include fixation are essential. However, reports suggest that the

sequelae include symptoms such as swan-neck deformity and extension lag.⁸

In this study, we present our novel 2-step orthosis method for treating mallet finger fractures and the associated patient outcomes. The present authors have previously reported the long-term efficacy of this method.⁹

Methods

Study Design

This prospective observational study comprised a 2-step procedure (Figure 1) that involved fixing fingers in place with splints for a total of 6 weeks, comprising 3 weeks with a first splint and 3 weeks with a second splint, followed by movement, starting with autonomic distal interphalangeal (DIP) joint movement.

Patients

Patients who underwent our 2-step orthosis method for mallet finger fracture at the Fuchinobe General Hospital were included. The ethics committee of the Fuchinobe General Hospital (approval no. 17-007) approved this study. Patients and their family members received thorough explanations about the procedure from the attending physician and therapist, and we obtained their oral and written informed consent.

Procedures

Figure 2 shows the protocol for the 2-step orthosis method and subsequent hand therapy, which were as follows⁹:

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	First step	Second step
Appearance
Position	DIP joint mild extended position PIP joint flexion 30°–45°	DIP joint mild extended position
Type	Circumference	Figure-8
Material thickness	1.0 mm	1.6 mm
Term	3 wk from initial visit Total 6 wk 3 wk after the first step splint	
Mounting time	Throughout the day	Throughout the day

Figure 1 — Two-step orthosis method. DIP indicates distal interphalangeal joint; PIP, proximal interphalangeal joint.

Figure 2 — Two-step orthosis and hand therapy protocol. ROM indicates range of motion.

1. Two-step orthosis

Step 1. After injury, a splint was created to facilitate DIP hyperextension and 45° flexion of the PIP joint. The splint was a 1.0-mm Orfit cast (Orfit Industries, Wijnegem, Belgium), produced with a full-circumference mold. Then, 2- or 3-week fixation was allowed (first splint). The shape of the first splint was corrected after the initial study⁹ because the Velcro made it too bulky. In this study, we used Orfit cast because it does not need Velcro.

Step 2. From week 2–3 to week 6: After 2–3 weeks of fixation with the first splint, another splint (1.6-mm Orfit soft cast [Orfit Industries] figure-8 splint) was created to facilitate slight extension of the DIP joint. A further 3 weeks of fixation with the second splint was allowed (total splint-fixation period: 6 wk).

2. Hand therapy

From 6 weeks, patients started performing active range of motion (ROM) exercises. In cases where swelling on the posterior aspect of

the DIP remained, we performed scar massage on this portion, from the proximal to the distal area, after the swelling had reduced. Patients underwent DIP joint blocking training; at other times, they wore the splint. From 8 weeks, patients added other movement exercises and stretching. Patients performed exercises to strengthen the extensor tendon with gradual increase in exercise intensity. If at this stage there remained an insufficient extension angle, patients wore the splint only at nighttime until around 12 weeks. We recommended taping if the patient intended to use his or her finger tips during the daytime.

Results—Case Presentation

Case 1

Age: 50-year-old man.

Diagnosis: Left ring mallet finger fracture; Doyle classification, type IVb; Ishiguro classification, type C (Figure 3).

	First visit	3 wk	12 wk	1 y	Sports return period /outcome
Case 1					Partial return 1 wk Complete return 12 wk
Male, 50 y, left ring finger					Crawford criteria Perfect
DIP Ex/Flex	—15/15	0/—	0/60		Abouna–Brown criteria Success
Pain VAS	8/10	1/10	0/10		
Case 2					Partial return 1 wk Complete return 8 wk
Male, 35 y, left middle finger					Crawford criteria Perfect
DIP Ex/Flex	—10/10	20/—	—3/70		Abouna–Brown criteria Success
Pain VAS	9/10	3/10	0/10		
Case 3					Partial return 3 wk Complete return 16 wk
Female, 17 y, right index finger					Crawford criteria Perfect
DIP Ex/Flex	—5/5	10/—	0/60	0/60	Abouna–Brown criteria Success
Pain VAS	8/10	2/10	0/10	0/10	

Figure 3 — Results of 3 cases at the first visit, after 3 weeks, after 12 weeks, after 1 year, and at the sports return period. DIP indicates distal interphalangeal joint; VAS, visual analog scale.

History: Injury occurred while the patient was playing softball, and the diagnosis was mallet finger fracture. He did not want surgical treatment, so we initiated the 2-step orthosis method 3 weeks after injury.

Previous history: Not significant.

Sports and Work: Basketball and desk work.

Outcome: The right and left hand grip strengths were 58 and 55 kg, respectively. There were no problems with respect to function or work. The patient could partially resume sports after 1 week, with complete return after 12 weeks. The Crawford criteria showed the condition to be perfect, and the Abouna–Brown criteria showed success. The QuickDASH-JSSH (Japanese Society for Surgery of the Hand Version of the Quick Disability of the Arm, Shoulder, and Hand questionnaire) sports items score¹⁰ was 5 at 3 weeks after fixation, but it improved to 1 at 12 weeks.

Case 2

Age: 35-year-old man.

Diagnosis: Left middle mallet finger fracture; Doyle classification, type IVb; Ishiguro classification, type C.

History: Injury occurred when the patient forcefully struck a door with his hand, and the diagnosis was mallet finger fracture. He did not want surgical treatment, so we initiated the 2-step orthosis method 3 weeks after injury.

Previous history: Not significant.

Sports and Work: Golf and desk work.

Outcome: We achieved sufficient bone fusion 12 weeks after fixation, at which time the ROMs with the DIP joint flexed and extended were 70° and –3°, respectively. The right and left hand grip strengths were 62 and 58 kg, respectively. There were no

problems with respect to function or activities of daily living and work. The patient could partially resume sports after 1 week, with complete return after 8 weeks. The Crawford criteria showed the condition to be perfect, and the Abouna–Brown criteria showed success. The QuickDASH-JSSH sports items score was 5 at 3 weeks after fixation, but it improved to 1 at 12 weeks.

Case 3

Age: 17-year-old woman.

Diagnosis: Right index mallet finger fracture; Doyle classification, type IVb; Ishiguro classification, type C.

History: Injury occurred while the patient was playing volleyball, and the diagnosis was mallet finger fracture. She did not want surgical treatment, so we initiated the 2-step orthosis method 2 days after injury.

Previous history: Not significant.

Sports and Work: Basketball and student.

Outcome: We achieved sufficient bone fusion 12 weeks after fixation; at which time, the ROMs with the DIP joint flexed and extended were 60° and 0°, respectively. The right and left hand grip strengths were 31 and 29 kg, respectively. There were no problems with respect to function or activities of daily living. The Crawford criteria showed the condition to be perfect and the Abouna–Brown criteria showed success. We instructed the patient to tape her hand when playing basketball for 3 weeks, and rehabilitation was complete after 16 weeks. Radiography results 1 year after treatment are shown in Figure 3. The fusion state, pain, ROM, and muscle strength were also good. The QuickDASH-JSSH sports items score was 5 at 3 weeks after fixation, but it improved to 1 at 12 weeks.

Discussion

With the fixation method used for the first splint, due to PIP extension and DIP hyperextension, we achieved relaxation of the lateral band and oblique retinacular ligaments. We believe that this resulted in sufficient pulling of the ruptured end of the terminal tendon, and this maintained a favorable reduced position without proximal traction of bone fragments. With respect to the tendon reduction process, after approximately 3 weeks, there was marked proliferation of fibrocytes and fibroblasts on the surface of the ruptured tendon, and the tensile strength of the tendon was high¹¹; thus, a switch was made to the second splint, which was a DIP extension splint. We believe that this switch enabled PIP joint movement, thus minimizing PIP joint contracture duration, so that we did not observe contracture in any patient at week 5.

However, Katzman et al¹² challenged the need for immobilizing the PIP joint, demonstrating that PIP joint motion and intrinsic tendinous tension did not cause a tendinous gap in the transected terminal tendon. Therefore, only the motion of the DIP joint influences “gapping” at the site of terminal band tearing of the flexor tendon, with full extension of the DIP closing the gap and flexion increasing the gap. Accordingly, the first step of the orthotic management of a mallet finger is immobilization to firmly maintain the DIP joint in an optimal position (slight hyperextension) for 3 weeks. We identified smaller residual extension lags compared with the values reported in previous studies with the use of our 2-step orthosis. This, in our opinion, is indicative of the superiority of the 2-step orthosis for improving extension lag compared with traditional orthoses. However, it is notable that owing to our small sample size, no significant between-group differences in active-flexion ROM were identified in our study.¹²

The favorable outcomes of the 2-step orthosis in our study can be largely explained by Bunnell’s¹³ proposal regarding the importance of approximating the tendon over the DIP joint. Flexion of the PIP joint produces a 3-mm advancement of the lateral bands of the flexor tendon, whereas hyperextension of the DIP joint promotes approximation of the torn extensor tendon at the DIP joint.

In a study of 21 mallet finger fracture patients, Kalainov et al⁸ reported a mean duration of 5.5 weeks for palmar thermoplastic DIP joint extension splint fixation. They also reported that all patients showed bone fusion; however, in patients in the Wehbe and Schneider type-IIb group, the extension lag was 13°, and 8 of 13 patients (62%) continued to show swan-neck deformity and PIP hyperextension. The present authors have previously reported favorable results using this method for treating patients with swan-neck deformity associated with mallet finger fractures. We consider that swan-neck deformity develops in patients with severe terminal tendon injury, due to the lateral band and oblique retinacular ligaments undergoing dorsal transposition. Therefore, it appears that this fixation method is effective in the PIP-flexion position and DIP hyperextension position, so that we achieved sufficient pulling in the terminal tendon and prevented dorsal transposition of the lateral band and oblique retinacular ligaments. This suggests that this position can prevent factors favoring proximal traction of bone fragments, and therefore, we consider that this method is also effective for treating mallet finger fractures.

One limitation to this method is that bone fusion is difficult to achieve in obsolete cases, but we suggest that the 2-step splint orthosis method may be successful for old cases, such as Case 1.

Finally, we must consider that in patients with severe DIP joint swelling, replacement of the splint is required after 1 week. Furthermore, we must avoid strong compression, so that ulcers do not form on the dorsal side of the DIP.

The limitations of the study were the small number of cases and the lack of a comparison group. Ideally, future studies should be prospective, randomized, and blinded to better ascertain the efficacy of this technique.

Conclusions

This report describes patients who underwent our 2-step orthosis method to treat mallet finger fractures. Even in patients with large bone fragments, we achieved bone fusion, with favorable short- and long-term outcomes.

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