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HANDSURGERY

A single K-wire to prevent poor outcomes in closed soft-tissue mallet finger management due to patient non-compliance

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Abstract

Introduction Soft-tissue mallet finger occurs due to loss of terminal extensor tendon secondary to rupture of distal phalanx. Although using noninvasive splints for 6–8 weeks is the gold standard for conservative treatment of closed soft-tissue mallet injuries, patient compliance is an important factor impacting on patient outcomes. In this study, we used a single Kirschner Wire (K-W) to fix the distal interphalangeal (DIP) joint in extension in those patients failed to comply with routine splinting.

Materials and methods In this prospective study, 190 patients with Doyle type 1 closed soft-tissue mallet finger deformity were included in four groups between 2011 and 2015. These groups were determined according to treatment modalities. Patients in the first group were treated with a finger splint ($n=109$). Patients in the second group first received a finger splint and then K-W was applied due to lack of adequate compliance ($n=23$). Patients in the third group were treated with K-W only ($n=47$), and the fourth group did not accept surgical treatment nor conservative treatment ($n=11$). After 20 weeks of follow up, we evaluated the results with functional measurements according to Crawford criteria and patient satisfaction. Additionally, the mid-term outcome was assessed with a follow-up at 2 years.

Results At 20th week postoperatively, average DIP extension lag was 6 degrees (0–30) for the first group, 6.1 degrees (0–30) for the second group, 3.8 degrees (0–25) for the third group, and 17.3 degrees (7–30) for the fourth group. Total patient satisfaction was 85%, which was considered excellent or good. Swan neck deformity was observed in 11% of patients. Osteomyelitis and KW related complications were not observed. There were no statistically significant differences between short-term and mid-term results.

Conclusion Internal fixation via K-W may be a suitable treatment option compared to splint therapy for management of closed soft-tissue mallet finger in noncompliant patients. Using this treatment approach, the success rate for patients could satisfactorily be improved.

Keywords Mallet finger · Compliance · Extensor tendon · Finger deformity

Introduction

Terminal extensor tendon rupture from the distal phalanx due to a sudden flexion force is known as mallet finger [1]. This rupture may include the bone fragment (bony mallet finger), while it can also be seen in the form of a tendon rupture (soft-tissue mallet finger) [1, 2]. Conservative treatment using a splint for 6–8 weeks is generally preferred in acute closed soft-tissue mallet finger injuries [1–4].

For successful treatment, effective communication about the importance of wearing the splint and adherence to strict guidelines for removal/changing of the dressing is important [4]. However, patient compliance is one of the most important factors that affects the success of conservative treatment. The patient should receive clear and useful information on this issue. Younger patients, low patient cooperation, and skin complications caused by the splint have adverse effects on treatment success. This may result in undesired circumstances such as prolongation of treatment, loss of labor, need for a secondary surgical operation, and finger deformity [5].

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In this prospective study, we evaluated the success of single Kirschner-wire (K-W) fixation treatment in noncompliant patients with soft-tissue mallet finger.

Patients and method

The study was approved by the Clinical Researches Ethical Committee (Istanbul Medeniyet University 2011-122). Between 2011 and 2015, all patients admitted to Yeni Yuzyil University, Gaziosmanpasa Hospital, Hand, and Upper Extremity Surgery Clinic due to the Doyle type 1, closed soft-tissue mallet finger injury were included in this prospective study [6]. Informed consent was obtained from all patients participating in this study. All patients underwent X-ray evaluation prior to the study inclusion to rule out any patients with bone avulsion-fracture (Doyle type 2 and 3 mallet finger) and severe swan neck deformity. Demographic features, injured finger, and whether it was a dominant hand injury or not were recorded. Complications, operation duration, and time to return to work have been documented and analyzed.

Before the treatment, patients were informed about the treatment procedures and the rules to be followed. Nonsurgical treatment with the Stack splint was planned as the first option, and surgery, internal fixation with K-W, was planned as the second option. Patients who stated that they could not use the splint from the beginning were initially considered non-compliant.

The patients were classified into four groups:

- Group 1 ($n = 109$)—compliant group monitored after receiving finger splint
- Group 2 ($n = 23$)—finger splint applied initially and then K-W was applied due to lack adherence to treatment and non-compliance (until day 16);
- Group 3 ($n = 47$)—patients who stated initially that they could not comply with the treatment and received K-W application on the same day;
- Group 4 ($n = 11$)—patients who did not give consent for surgical treatment despite failing to apply the conservative treatment regularly;

Primarily, Stack splints, which holds the distal interphalangeal joint (DIP) at 10° hyperextension without hindering the movement of the proximal interphalangeal (PIP) joint, were applied to all patients who presented with soft-tissue mallet finger injury, The Patients were informed and instructed on the full-time use of the splint and hygiene procedure.

The patients were followed up weekly during the first month and then were reassessed on 6th, 12th and 20th week after receiving the initial treatment. Patients were also evaluated 2 years after first presentation for mid-term outcomes and compared to the short-term results. Patients who failed to attend to outpatient clinics more than twice during the first month and those not evaluated during the 6th and 20th weeks due to non-attendance were not included in the study. A total of 190 patients with regularly documented follow-ups were included in the study. Patients were assessed whether they were able to comply to treatment during the first 2 weeks of control. Patients were classified as compliant and noncompliant based on the following assessment: Patients who did not remove the splint and complied with the treatment plan were classified as compliant, whereas patients who did not use the splint properly, removed it several times, or did not comply with the treatment plan were classified as noncompliant. The patients, who were non-adherent with conservative treatment or were considered non-compliant at the onset of treatment were suggested to internally fix the DIP joint via K-W.

Surgical technique

All of the operations were performed under digital block anesthesia. Single-shot intravenous antibiotic was applied before pinning. A K-W (with a thickness of 0.8 mm) was inserted from the tip of the finger and moved proximally into the middle phalanx to hold the DIP joint at 5–10 degrees of extension. The position of the K-W was intraoperatively checked by fluoroscopy (Fig. 1). The exposed end of the K-W was cut 5 mm outside and curled. Average operation time was 12.4 min (8–20 min). The patients were allowed to use their hand actively. It was suggested that patients who did not work at desk jobs should not go to work. Additional protective splint use was not obligatory, but we recommended to preserve the current wire with a conventional aluminum splint when working. At the end of the sixth week after K-W insertion or splinting, all the splints and K-Ws were removed, and the patients were asked to use a night splint during the next 6-week period. A special physical treatment protocol was not utilized.

Clinical evaluation

Eight weeks after treatment (20th week), the outcomes of the treatment were evaluated by a blind observer in accordance with Crawford criteria [7] for extension lag level (measured from the dorsal via goniometer), best active DIP flexion, and pain using the visual analogue scale (VAS) score. This score gives "excellent" for full DIP extension, full flexion, and no pain; "good" for 0°–10° of extension lag, full flexion, and no pain; "fair" for 10°–25° of extension lag, any flexion loss, and no pain; and "fair" for > 25° of extension lag or persistent pain. During the assessment, the patients were also

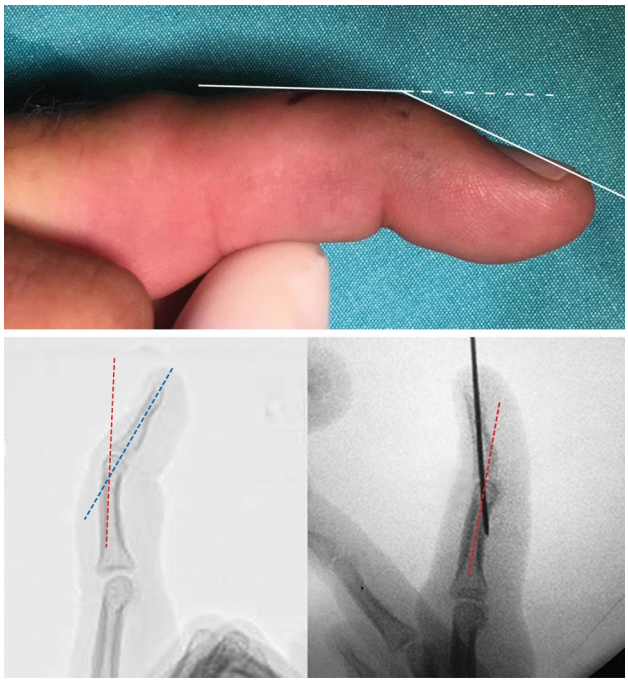

Fig. 1 Mallet finger deformity with 25° distal interphalangeal joint active lag extension at ring finger (above). Intraoperative X-ray view of application K-wire for fixation distal interphalangeal joint in hyperextension position (below)

clinically evaluated based on the level of satisfaction. X-rays were not routinely performed during the visits. Additionally, the mid-term results (2-year follow-up) were assessed by measuring extension lag and DIP flexion.

For the statistical analysis, the Bonferroni, Kruskal Wallis, Dunn and Fisher Freeman Hinton tests were used using the Number Cruncher Statistical Systems (NCSS) 2007 (Kaysville, Utah, USA) program, and the level of evidence for the results were evaluated.

Results

Patient demographics are summarized in Table 1. The dominant hand was affected in 62% of patients. The duration of applying the splint was on average 3.2(±2, 2–9) days for groups 1 and 2; and 4.5 days (±2.3, 3–10) for the group 4. The time to surgery for group 2 was 11 days (±2.2, 8–16); and 2.3 days (±1.7, 1–8) for group 3. The average follow-up duration of the patients was 24 months (±2.6, 22–30).

In the short-term results at 20th week, the average DIP extension lag was 6 (±6.8) degrees for group 1; 6.1(±8.3) degrees for group 2; 3.8 (±6.1) degrees for group 3; and 17.3 (±8.1, 7–30) degrees for group 4. There was no statistically significant difference between groups 1 and 3, but group 4 significantly performed worse compared to other groups ($p > 0.05$). Active DIP joint flexion was significantly better in group 3 (71 ± 6.4°) similar in groups 1, 2 and 4 (Table 2).

The results according to the Crawford criteria shown in Table 3. The results were statistically worse in group 4 compared to the other groups ($p < 0.01$). The results of binary comparative statistical analysis were not significant between groups 1, 2, and 3 ($p > 0.05$).

Skin problems (maceration and compression-related surface ulcerations) were observed in 6 patients (7%) in the splint group (group 1). The problems were solved conservatively in all of these cases. Swan neck deformity was observed in 5 patients (7%) in the pin groups (groups 2 and 3), 8 patients (7%) in the splint group (group 1) and 5 patients(46%) in the group using splints irregularly (group 4). Problems with the nail bed were observed in a total of 4 patients (3%) in the splint group. Local skin infections developed in 2 cases (3%) in the pin groups and was successfully treated with oral antibiotics. Osteomyelitis was not observed in any of the patients. X-rays were performed if patients described excessive pain with movement during the visits. Signs indicating osteoarthritis were not observed in any of these patients.

Table 1 Patient demographics and characteristics

	Group 1 ($n = 109$)	Group 2 ($n = 23$)	Group 3 ($n = 47$)	Group 4 ($n = 11$)
Gender				
Men	96	19	40	10
Women	13	4	7	1
Age	38 (22–43)	42 (28–52)	32 (20–44)	30 (18–35)
Finger				
Index finger ($n = 11$)	7	1	3	0
Long finger ($n = 71$)	42	9	16	4
Ring finger ($n = 37$)	22	5	9	1
Little finger ($n = 71$)	38	8	19	6
Follow up (min.–max. months)	24 (22–29)	23 (22–25)	28 (23–30)	24 (22–28)

Table 2 Movements of the distal interphalangeal (DIP) joint at 20th week

	Group 1	Group 2	Group 3	Group 4	*p***
Extension lag (°)	6.0 ± 6.8 (0–30)	6.1 ± 8.3 (0–30)	3.8 ± 6.1 (0–25)	17.3 ± 8.1 (7–30)	$^{1-2}p = 1.000$ $^{1-3}p = 0.125$ $^{1-4}p = 0.001$ $^{2-3}p = 1.000$ $^{2-4}p = 0.001$ $^{3-4}p = 0.001$
DIP flexion (°) (active range of motion)	65 ± 6.9 (45–80)	63 ± 11.2 (40–70)	71 ± 6.4 (42–80)	61 ± 10.5 (50–80)	$^{1-2}p = 1.000$ $^{1-3}p = 0.001$ $^{1-4}p = 1.000$ $^{2-3}p = 0.003$ $^{2-4}p = 1.000$ $^{3-4}p = 0.038$

**Kruskal Wallis test and post hoc Dunn test (*p*: Significance level of the comparative results of the groups)

Table 3 Results according to Crawford criteria at 20th week

	Group 1	Group 2	Group 3	Group 4	*p***
Excellent	39	14	24	0	$^{1-2}p = 0.636$ $^{1-3}p = 1.000$ $^{1-4}p = 0.001$ $^{2-3}p = 1.000$ $^{2-4}p = 0.001$ $^{3-4}p = 0.001$
Good	58	6	18	2	
Fair	10	2	3	7	
Poor	2	1	2	2	

**Kruskal Wallis test and post hoc Dunn test (*p*: Significance level of the comparative results of the groups)

Table 4 Patient satisfaction

	Group 1	Group 2	Group 3	Group 4	*p**
Excellent	65	14	36	1	$^{1-2}p = 1.000$ $^{1-3}p = 0.335$ $^{1-4}p = 0.001$ $^{2-3}p = 0.964$ $^{2-4}p = 0.011$ $^{3-4}p = 0.001$
Good	25	5	7	3	
Fair	14	2	2	5	
Poor	5	2	2	2	

*Fisher Freman Halton test (*p*: Significance level of the comparative results of the groups)

The patient satisfaction data shown in Table 4 indicate that the there was no statistical significant difference between groups 1–3, but group 4 was significantly worse compared to other groups ($p > 0.05$). The average return time to the work was 4.9 weeks for group 1; 5.1 weeks for group 2; 4.8 weeks for group 3; and 5.3 weeks for group 4. The differences were not statistically significant between groups ($p > 0.05$). In group 2 and 3, 51% of the patients were able to start their work with dressings placed on their fingers.

In the mid-term results at about 2 years (22–30 months) after trauma the average DIP extension lag was 6 (± 6.7) degrees for group 1; 6.2 (± 8.3) degrees for group 2; 4.0 (± 6.1) degrees for group 3; and 17.9(± 8.1) degrees for group 4. Active DIP joint flexion was 69 (± 7) degrees for group 1; 69 (± 11.1) degrees for group 2; 73 (± 6.5) degrees for group 3; 57 (± 10.1) degrees for group 4. There was no statistically significant difference between short-term and mid-term results in extension lag and DIP joint flexion ($p > 0.05$).

Discussion

Untreated cases or unsuccessful treatment of mallet finger injuries may result in permanent extension lag or swan neck deformity in the mallet finger [8, 9]. Exact therapeutic consensus could not be met in soft-tissue mallet finger treatment; however, no statistically significant difference was found between splint use and surgical treatment in the literature [10, 11]. Hence, conservative treatment using a splint is mostly evaluated as the first treatment option in closed mallet finger injuries [10]. Flexion of the finger during splint use may result in the loss of splint benefit. Treatment should be adapted and modified in cases, where patients do not comply with the conditions of use [5, 11]. Low patient compliance is the weak spot of conservative treatment [5, 12]. Patient cooperation is a must to obtain favorable results, and adhesive splints have even been defined in literature for this purpose [3, 13].

Adhesive splints, which are dorsally glued to the nail, are an option to improve patient compliance and have the advantage to leave the pulp free [3]. However, a study has shown that the adhesive became unglued in about 11% of patients and nail deformity happened in 2.5% [13].

Complications may be observed in conservative treatment up to rates of 45% [4]. These complications mostly occur as maceration in the skin, ulcer on the dorsal skin, and nail bed changes [4]. Even though these complications are temporary and benign, they may impact patient compliance, thus resulting in noncompliance with the

treatment. Failure of conservative treatment is a surgical indication [4, 10]. In our study, patients who were thought to be noncompliant after 2 weeks K-W fixation treatment were performed to DIP joint in hyperextension for preventing treatment failure related to patient compliance. Major challenges observed with splint use were related to the skin problems due to poor hygiene secondary to full-time splint using. In the second group, 16 patients preferred surgery because of the skin complications developed after conservative treatment.

Grot et al. [5] carried out a study in which they classified the patients based on attendance to their appointments, impression of usage of proper splints according to their own expressions, and the adherence to exercise programs. It was determined that the treatment success of compliant patients was better at a statistically significant level in comparison with that of noncompliant patients.

O'Bryne et al. [9] determined that patients compliant to the treatment performed better at a statistically significant level in terms of extension lag in comparison with noncompliant patients. In our study we also observed that Group 4 performed worse in comparison to other groups.

In our study, surgical intervention was suggested as the first treatment option for patients who were thought to be noncompliant to treatment and our compliance rates in the splint group may have been determined to be higher than usual. In another study by Renfree et al. [14] comparing extension orthosis (44 patients) and percutaneous pinning (18 patients) for the treatment of closed mallet finger, the authors reported that pinning resulted in better extension lag and high patient satisfaction. In addition, pinning patients were able to return to work earlier without restrictions. These findings are also corroborated in our study, which was performed in a larger patient group, although it was not statistically significant.

Untreated severe mallet finger deformities lead to swan neck deformity from PIP joint hyperextension and DIP joint flexion [4]. Swan neck deformity can be seen in up to 23% of patients with soft-tissue mallet finger deformity [15, 16]. In our case series, swan neck deformity developed in 21 patients (11%). It was observed especially in the patients with fair and poor Crawford scores. This rate is compatible with the literature and relatively lower. There was no statistically significant difference between the groups.

Most of the participants in this study were young, since our clinic was located near an industrial region (average age was 39 years). Working with K-W can be convenient and time to return to work could be shorter when compared with splints. K-W care is more straightforward and treatment compliance is superior in comparison to splints. According to our study results, it cannot be deduced that internal fixation with K-wire resulted in more successful outcomes; however, our results do show that K-wire is as effective as a splint treatment, and, it indirectly increases the overall success rate by effectively treating noncompliant patients.

The uneven distribution of patients between the groups is one limitation of this study; studies with larger and equal groups may be needed for the confirmation of our results. It could have been valuable to compare the hyperextension between the K-W group and splinting group in the sagittal X-ray. In addition, it could have been beneficial to evaluate for mid-term secondary osteoarthritis in all patients. We did not observe any clinical signs of osteoarthritis in our patients, but we did not perform radiography in all patients during mid-term follow-up.

Conclusion

Noninvasive treatments are frequently suggested as a first-line option in acute closed mallet finger treatment due to its ease of use and treatment success. Although the current level of evidence do not indicate that internal fixation via K-wire is superior to full-time splint use, it can be concluded that it is as successful as splinting and is an appropriate treatment in patients who cannot tolerate splinting use. Taking together, it increases the overall success rate.

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