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Comparison of single and double dorsal wires in the extension block technique for mallet fractures

Retrospective observational study

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Abstract

Mallet fractures are avulsion fractures of the extensor tendon from the distal phalanx base and often occur due to sudden flexion or axial loading. In this study, we aimed to compare the clinical and radiological results of patients treated with single and double dorsal wires from the dorsal in the extension block method.

Patients to whom a single wire from dorsal was applied were assigned to Group 1 (n: 22), and those to whom double wires were applied were assigned to Group 2 (n: 23). Surgical treatment was decided for patients with more than 1/3 of the fracture fragment containing the joint surface and volar subluxation. The range of motion of the distal interphalangeal (DIP) joint was measured with a goniometer. The displacement of the fragment was measured before and after surgery on lateral radiographs. The presence of bridging callus formation on anterior-posterior and lateral radiographs was evaluated for a union.

There were 30 male (66.7%) and 15 (33.3%) female patients. The mean age of the patients was 32 years. Radiographic union was obtained in all patients. Pseudoarthrosis was not observed in any patient. The Crawford score was excellent in 13 (28.9%) cases, the score was good in 18 (40%) cases, the scores were moderate in 13 (28.9%) cases, and the score was poor in 1 case (2.2%). There were no complications in 35 (77.8%) cases, dorsal bump complications occurred in 9 cases (20%), and osteoarthritis and dorsal bump complications occurred in 1 (2.2%) case. We did not observe nail deformity, skin necrosis, infection, or fingertip sensitivity. We found similar functional and clinical results between the groups.

We recommend using single dorsal wire, as using double dorsal wires requires extra operation time, effort, and fluoroscopy.

Abbreviations: Corp = corporation, DIP = distal interphalangeal, IBM = International Business Machines, K = Kirschner, PA = posterior-anterior.

Keywords: bony mallet finger, closed reduction, distal interphalangeal joint, dorsal pin, Kirschner wire

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Informed consent was obtained from all individual participants included in the study.

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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1. Introduction

Mallet fractures are avulsion fractures of the extensor tendon from the distal phalanx base and often occur due to sudden flexion or axial loading. Wehbe and Schneider recommended conservative treatment for all mallet fractures regardless of fracture fragment and subluxation.[1] As a result of displaced mallet fractures, extensor mechanism imbalance may occur, and consequently, extensor loss in distal interphalangeal (DIP) joint. Thus, swan neck deformity may occur. Surgical treatment is recommended when the fracture fragment contains more than 30% of the joint surface and in the presence of volar subluxation.[2] Ishiguro defined the extension block method applied percutaneously with Kirschner (K) wires. In this technique, an indirect reduction is achieved by sending a K-wire to mid phalanx over the dorsal fragment, and the DIP joint is fixed with another K-wire, which is run palmar to fracture.[3] This technique was modified by 2 dorsal wires, as the single-wire applied from the dorsal was insufficient to provide rotational control of the fragment.[4]

Our study aimed to compare the clinical and radiological results of patients treated with single and double wires from the dorsal in the extension block method.

2. Materials and methods

This study was conducted retrospectively. Between 2015 and 2018, a total of 75 patients who underwent extension block pinning due to mallet fractures were examined. Patients were

excluded if there was less than 1 year of follow-up, fracture involving less than 1/3 of the joint surface, open and comminuted fracture, and open physis. Furthermore, patients for whom more than 5 weeks had passed between surgery and injury time, and patients with preoperative DIP joint osteoarthritis were omitted. The remaining 45 patients were divided into 2 groups. Patients to whom a single wire from dorsal was applied were assigned to Group 1, and those to whom double wires were used were assigned to Group 2. Written informed consent was obtained from all patients, and ethical approval was obtained (number: HNEAH KAEK 2018/KK/35, date: 15.10.2018).

When the patients were admitted to the emergency department, posterior-anterior (PA) and lateral X-rays were taken of the affected finger. The ratio of the fracture fragment to the articular surface and the amount of fragment displacement were measured via lateral radiography, and the presence of volar subluxation was evaluated.[5] Surgical treatment was decided for patients with more than 1/3 of the fracture fragment containing the joint surface and volar subluxation. The fractures were classified according to the Wehbe and Schneider scale.[1] The operations were performed under a digital block, axillary block, or general anesthesia. No tourniquets were used on any patient. A single surgeon (BK) performed all procedures.

2.1. Surgical technique

All operations were performed under fluoroscopic control. The affected finger was maximum flexed. In Group 1, 1 K-wire was sent at a 30 to 40° angle to the mid phalanx head, from dorsal to volar and distal to proximal. Likewise, in Group 2, 2 K-wires were sent parallel to 1 another in 2 to 3 mm intervals. These wires created an extension block for the fracture fragment. Extension and traction were performed on the distal phalanx. Dorsal pressure was applied to the distal phalanx base, and the reduction was obtained. One K-wire was sent from the distal phalanx tip to the middle phalanx retrogradely from the palmar side of the fracture fragment, and the DIP joint was fixed.

No splints were used on any patient after surgery. The dressing was changed every day. PA and lateral control radiographs were taken at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year postoperatively. K-wires were removed in the sixth postoperative week under the digital block in the outpatient clinic. Active and passive finger movements were given after removing the wires, and hand rehabilitation programs were started.

A goniometer measured the DIP range of motion. Clinical results were evaluated by Crawford criteria.[6] Radiographically, the presence of bridging callus formation on anterior-posterior and lateral radiographs was considered as a union. The displacement of the fragment was measured before and after surgery on lateral radiographs.

2.2. Statistical analysis

International Business Machines (IBM) SPSS Statistics 22 for statistical analysis [IBM corporation (Corp). Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, New York: IBM Corp.] programs were used to evaluate the findings obtained in this study. The normalities of parameter distributions were assessed using Shapiro Wilk tests. Descriptive statistics (mean, standard deviation, frequency) and Student *t* tests were used to compare the parameters of the 2 groups. Wilcoxon Signed-Rank tests were used for intragroup comparisons of non-normally distributed parameters. Fisher Exact tests, Fisher Freeman Halton tests, and Yates Correction for Continuity were used to compare qualitative data. Significance was evaluated at $P < .05$.

3. Results

The study was performed using data from 45 fingers (one from each of the 45 patients). There were 30 males (66.7%) and 15 (33.3%) female patients. The mean age of the patients was 32 (range: 17–66) years. Twenty two (48.9%) of the cases were in Group 1, and 23 (51.1%) were in Group 2. The right side was affected in 23 patients (51.1%), and the left side was affected in 22 (48.9%) patients. Radiographic union was obtained in all patients, and pseudoarthrosis was not observed. The Crawford score was excellent in 13 (28.9%) cases, this score was good in 18 (40%) cases, this score was moderate in 13 (28.9%) cases, and this score was poor in 1 case (2.2%). There were no complications in 35 (77.8%) cases, dorsal bump complications occurred in nine cases (20%), and osteoarthritis and dorsal bump complications occurred in 1 (2.2%) case. Dorsal bump is swelling in the DIP joint's dorsal caused by the union at the false angle in an avulsion fracture. We did not observe nail deformity, skin necrosis, infection, or fingertip sensitivity (Tables 1 and 2). There were no statistically significant differences between groups in terms of age, duration of injury, percentage of the joint surface, DIP flexion degree, DIP extension loss degree, follow-up time, gender, side, distribution of operated finger, trauma mechanism, presence of volar subluxation, Wehbe and in Schneider classification, Crawford evaluation criteria, complication rate and type of anesthesia ($P > .05$ for all variables).

There was no statistically significant difference between the groups regarding preoperative and postoperative fragment displacement ($P > .05$). Postoperative displacement significantly declined in both groups ($P < .05$) (Table 3). In all cases, the fracture fragment position was maintained until the union, and no rotation or displacement was observed (Figs. 1 and 2).

4. Discussion

In the treatment of mallet fractures, some authors have emphasized the need to obtain a compatible joint without subluxation. In contrast, others emphasize the importance of anatomical reduction for a near-total range of motion and prevent postoperative arthritis and stiffness.[7,8] Several methods have been described for surgical treatment, including extension block pinning,[2,3,9] wires,[10] pullout sutures,[11] biodegradable arrows,[12] and hook plates.[13]

The extension block method described by Ishiguro is applied as percutaneous K-wires. It is widely used, has gained popularity, and good results have been reported. This technique is simple, effective, minimally invasive, and cost-effective. There is no incision. The operation time is also short. Besides, skin necrosis, infection, nail deformity, and soft tissue scar formation are prevented.

Jörgsholm et al treated 36 mallet fractures containing more than 1/3 of the joint surface with the extension block method. According to Crawford criteria, they obtained 23 excellent or good, 11 medium, and 2 poor results, found mean extension loss 0° (range: 0–20°), and found a mean DIP flexion of 70°.[14] Inoue treated 14 displaced large-fragmented mallet fractures with extension block pinching and obtained 8 excellent, 4 good, 1 moderate, and 1 poor result according to Crawford criteria, and

Table 1

Distribution of parameters between groups.

	GROUPS		
	GROUP 1 (One Wire) n: 22	GROUP 2 (Two Wire) n: 23	*P* values
Age (mean)	33.7	32.2	.686
Gender n (%)			
Male	12 (54.5%)	18 (78.3%)	.170
Female	10 (45.5%)	5 (21.7%)	
Side n (%)			
Right	11 (50%)	12 (52.2%)	1.000
Left	11 (50%)	11 (47.8%)	
Affected finger n (%)			
2	2 (9.1%)	1 (4.3%)	.880
3	4 (18.2%)	6 (26.1%)	
4	5 (22.7%)	4 (17.4%)	
5	11 (50%)	12 (52.2%)	
Trauma mechanism (%)			
Sudden Pull	0	1 (4.3%)	.291
Simple Fall	9 (40.9%)	9 (39.1%)	
Collision	8 (36.4%)	7 (30.4%)	
Assault	0 (0%)	2 (8.7%)	
Door Jam	2 (9.1%)	0 (0%)	
Carrying A Carton	0 (0%)	1 (4.3%)	
Ball Strike	1 (4.5%)	3 (13%)	
Punch	2 (9.1%)	0 (0%)	
The time between injury and surgery (day)	6.91	6.78	.553
Follow up time (Month)	14.73	13.22	.199
Anesthesia type n (%)			
General	8 (36.4%)	5 (21.7%)	.420
Local	14 (63.6%)	17 (73.9%)	
Peripheral block	0	1 (4.3%)	

N = number.

found the method simple and reliable with low morbidity.[15] In another study where 24 mallet fractures were treated with extension block pinning, the average loss of extension was 4°, flexion was 77°, and 92% of cases yielded excellent and good results according to Crawford criteria. They emphasized that this method is useful if anatomical reduction cannot be achieved by non-surgical procedures and has advantages such as rapid fracture healing, minor complications, and excellent DIP range of motion.[2]

Lee et al modified Ishiguro's method and applied 2 dorsal pins with 3 mm spacing parallel to 1 another to better reduce the fracture, prevent rotation of the fragment, and for more stable fixation. All patients had an anatomical reduction, and satisfactory clinical and radiological results were obtained.[4] In a study comparing mallet fractures treated with the extension block method comparing the single and double dorsal pin, similar clinical and radiological results were obtained between the groups.[16]

Lee et al conducted a retrospective study to investigate a relationship between the pin insertion angle and postoperative extension loss. They evaluated 75 patients. They reported that the extension- block K-wire insertion angle negatively correlated with postoperative extension loss, whereas fracture size and the time between injury and surgery had a positive correlation. They concluded that a slightly hyperextended DIP joint position and using an insertion angle of the extension-block K-wire of 40 to 45 degrees might help reduce postoperative extension loss.[17]

Table 3

Evaluation of pre-operative, postoperative fragment displacement between and within groups.

	GROUPS		
	GROUP 1 (One Wire) n:22	GROUP 2 (Two Wire) n:23	*P* values
Fragment displacement (mm)			
Preoperative	1.21	1.27	.829
Postoperative	0.15	0.19	.907
Preoperative-Postoperative *P* values	<.001*	<.001*	

*$P < .001$.

Table 2

Functional and radiological comparison between groups.

	GROUPS		*P* values
	GROUP 1 (One Wire) n: 22	GROUP 2 (Two Wire) n: 23	
Mean involved fragment size	47.91	50.26	.537
Preoperative volar subluxation n (%)	3 (13.6%)	1 (4.3%)	.346
Wehbe Schneider n (%)			
1b	16 (72.7%)	18 (78.5%)	.159
1c	5 (22.8%)	2 (8.6%)	
2b	0 (0%)	2 (8.6%)	
2c	1 (4.5%)	1 (4.3%)	
DIP flexion (degree)	82.73	80	.158
DIP extension loss (degree)	4.77	4.35	.851
Persistent postoperative pain n (%)	2 (9.1%)	1 (4.3%)	.608
Crawford classification n (%)			
excellent	8 (36.4%)	5 (21.7%)	.480
good	7 (31.8%)	11 (47.8%)	
moderate	7 (31.8%)	6 (26.1%)	
poor	0 (0%)	1 (4.3%)	
Complications n (%)	5 (22.7%)	5 (21.7%)	1.000

N = number.

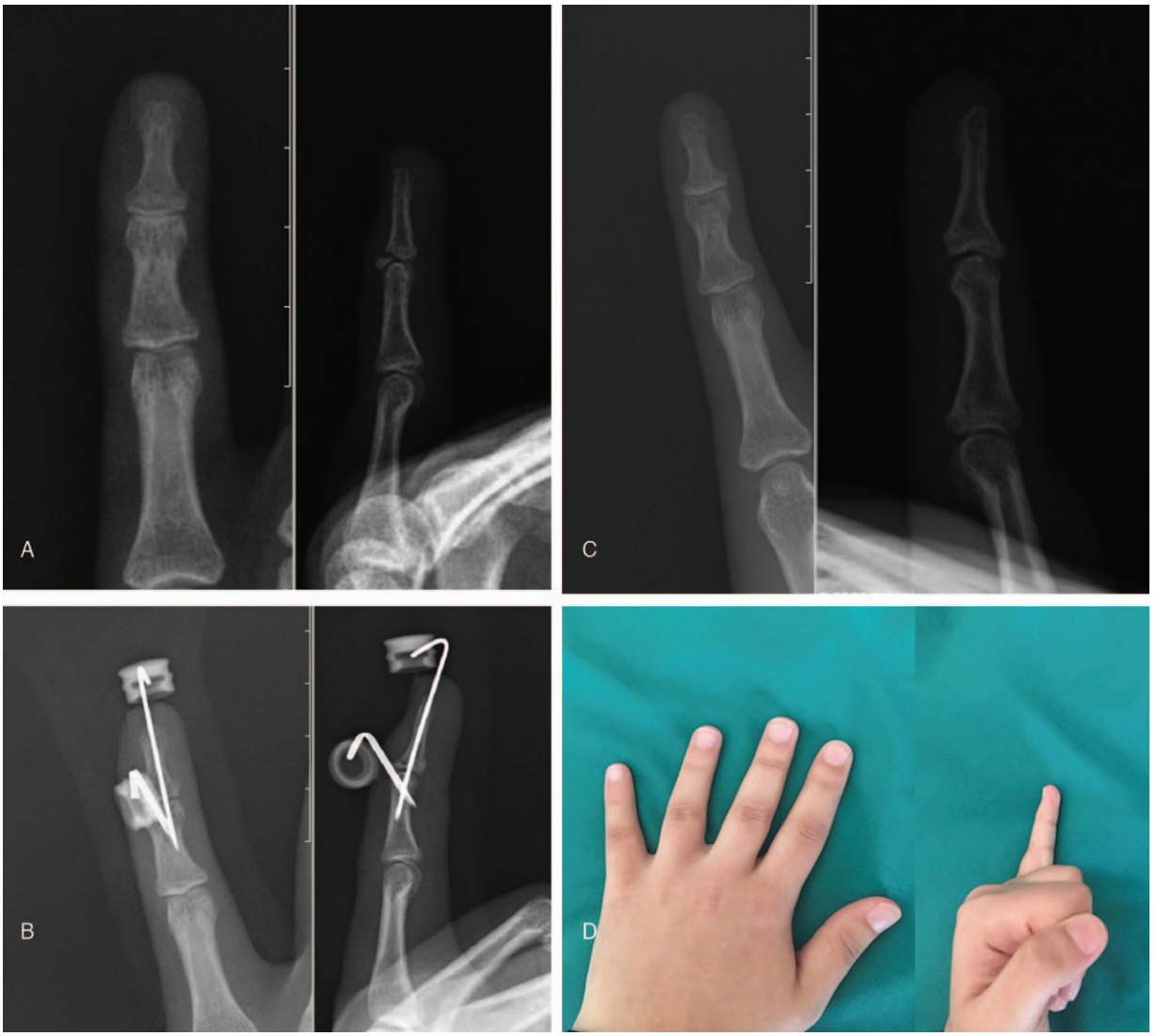

Figure 1. Eighteen-year-old female, mallet fracture of the left little finger, surgery was applied on the tenth day after injury with one dorsal K-wire and one K-wire for extension blocking. Preoperative and postoperative AP and lateral radiographs (A, B), Eight-month postoperative AP and lateral radiograph (C), the clinical image of the patient (D).

Meershoek et al treated 36 mallet fractures with an extension block technique. They achieved excellent results with a mean follow-up period of 32 months for all patients. They declared the K-wire extension blocking technique was safe.[18] Tang et al observed complications of 17 patients with old closed bony mallet fingers. They reported that open reduction and compression with double K-wires were applicable in operating old bony mallet fingers.[19]

Lee et al performed a retrospective analysis of 18 patients with irreducible mallet fractures. They treated patients by the 2-extension block wire technique. The union was achieved in all patients. They reported that the 2-extension block K-wire aided control of dorsal fragment rotation in the sagittal plane.[20]

In our study, the mean DIP extension loss in Group 1 was 4.7°, and flexion was 82°, whereas the mean DIP extension loss in Group 2 was 4.3° and flexion was 80°. These results were consistent with the literature. We fixed DIP joints in 0° extensions in all patients, believing that extension loss would be reduced. We used Crawford criteria to evaluate the range of motion and pain to examine clinical outcomes. In Group 1, we achieved excellent results in 8 patients, good results in 7 patients, and intermediate results in 7 patients. In Group 2, we obtained excellent results in 5 patients, good results in 11 patients, intermediate results in 6 patients, and poor results in 1 patient. We found similar outcomes between groups in terms of functional effects and complications.

We achieved union in all patients in this study. Pseudoarthrosis was not observed in any patient. In both groups, the amount of fracture displacement decreased significantly. In all patients, we found that the reduced fracture fragment position was preserved until the union. These results showed that a single wire application has a similar effect in reducing the fracture fragment and providing stability compared to a double wire application. We did not achieve an anatomic reduction in all cases, but in some cases, we observed that the stepping of the joint was well-formed, and there was no extension loss. We avoided repetitive pin entries and tried to use thin wires to prevent secondary arthritic changes and avoid tendon damage.

Figure 2. Thirty three-year-old male, mallet fracture of the left little finger, surgery was applied on the twelfth day after injury with double dorsal K-wires and one K-wire for extension blocking. Preoperative and postoperative AP and lateral radiographs (A, B), 6-month postoperative AP and lateral radiograph (C), the clinical image of the patient (D).

5. Conclusions

In conclusion, there was no difference between these 2 groups in terms of the clinical and radiological results from using single and double wires from the dorsal in the extension block method to treat mallet fractures. We recommend using a single dorsal wire, as double dorsal wires application requires extra operation time, effort, and fluoroscopy. The use of an extra K-wire has a higher risk of yielding complications. Above all, physicians must closely monitor the patients because there could be a loss of reduction.

Author contributions

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