Acta Orthop. Belg., 2019, **85**, 240-246

ORIGINAL STUDY

Excellent functional recovery after Kirschner-wire extension blocking technique for displaced closed bony mallet finger injuries; results of 36 cases

Armelle J.A. Meershoek, Jort Keizer, Roderick M. Houwert, Mark van Heijl, Detlef van der Velde, Philippe Wittich

From the department of Surgery, St Antonius Hospital Nieuwegein, Utrecht, The Netherlands

Bony mallet finger injuries comprise 30% of all mallet injuries. Operative treatment of bony mallet fingers injuries still remains controversial. The aim of this study was to describe the k-wire extension blocking technique and the functional results using the PRWHE questionnaire.

A single center retrospective observational cohort of 36 patients was defined between January 2010 and December 2015. Inclusion criteria for this study were acute fractures with 1) persistent displacement of more than 3 mm in extension splint, 2) palmar subluxation of the distal phalanx or 3) fracture fragments consisting of more than one third of the joint surface. According to the PRWHE questionnaire, excellent results were observed with a mean follow up period of 32 months of all patients. Two patients developed a clinically relevant superficial wound infection and one patient developed a nail deformity. In conclusion, the k-wire extension blocking technique is safe and results in excellent mid-term functional outcome.

Keywords : bony mallet injury ; extension blocking technique ; functional outcome ; patient-rated-wrist/hand evaluation.

Level of evidence IV according to the Oxford Centre for Evidence Based Medicine 2011 Levels of Evidence.

INTRODUCTION

Mallet finger injuries are commonly observed in the emergency department *(6)*. A mallet finger injury occurs during forced flexion or less frequently due to hyperextension of the extended finger, mostly in active individuals, particularly those who participate in ball sports. This injury results in a discontinuity of the extensor tendon at the distal phalanx resulting in an extension lag. In most cases, disruption of the extensor tendon mechanism is purely tendinous (70%); less frequently (30%) it comprises an avulsion fracture at the insertion of the terminal extensor tendon on the dorsal base of the distal phalanx which is known as a bony mallet finger injury *(22)*.

■ Armelle J.A. Meershoek, MD[1,2,*].
■ Jort Keizer MD[1,2,*].
■ Roderick M. Houwert MD. PhD[1,2].
■ Mark van Heijl MD. PhD[2].
■ Detlef van der Velde MD. PhD[1].
■ Philippe Wittich MD. PhD[1].

[1]*Department of Surgery, St Antonius Hospital Nieuwegein, The Netherlands.*

[2]*Department of Surgery, University Medical Center Utrecht, The Netherlands.*

Correspondence : Armelle J.A. Meershoek, Department of Surgery, internal postbox G.04.129, Heidelberglaan 100, 3584 CX, Utrecht, The Netherlands, Phone: 003188-7556965

E-mail : A.J.A.Meershoek@umcutrecht.nl

Acknowledgements: Declaration of conflicting interests: Armelle J.A. Meershoek, Jort Keizer, Roderick M. Houwert, Mark van Heijl, Detlef van der Velde and Philippe Wittich declare that they have no conflict of interest in this study. Funding statement: No funding was received for this study.

Treatment of bony mallet finger injuries still remains controversial *(12,21,22)*. Most authors recommend conservative treatment with immobilisation in an extension splint but surgical treatment might be preferred in specific cases *(2–5,11)*. Surgical treatment is probably indicated in cases of failure of splinting therapy, palmar subluxation of the distal phalanx and avulsion fractures involving more than one third of joint surface *(9)*. For internal fixation of bony mallet injuries, many different techniques have been reported including the use of Kirschner-wires (k-wires), screw fixation, internal sutures, tension band fixation, biodegradable meniscus arrow and mini plate fixation *(1,17)*. Complications of surgical treatment includes wound infections, nail deformities, failure of osteosynthesis, loss of reduction, joint stiffness and osteomyelitis *(11)*.

Most previous studies used the Crawford score as primary outcome parameter *(13,20)* in which an excellent outcome is no pain with full range of motion at the distal interphalangeal joint, a good outcome is no pain with less than 10 degree extension deficit, a fair outcome is no pain with 10-25 degrees of extension deficit and a poor outcome is persistent pain or more than 25 degrees of extension deficit. However, studies investigating patient related functional outcome after surgical treatment of displaced bony mallet finger injuries are lacking.

The aim of this study was to describe the surgical technique, complications and functional outcome using a patient related outcome score of surgical treatment of bony mallet finger injuries using the k-wire extension blocking technique.

MATERIAL AND METHODS

Ethical approval was obtained from the local Research Ethics Committee.

Study design

A single center retrospective observational cohort was defined. The study was performed in a large level 2 regional teaching hospital (St Antonius Hospital). All consecutive trauma patients who underwent percutaneous k-wire extension blocking technique for a closed bony mallet finger injury between January 2010 and December 2015 were invited to participate in this follow-up study. All patients included in this study were identified by chart review using diagnosis treatment codes. In general, conservative treatment is the first choice of treatment for bony mallet finger injuries. Indications for surgical treatment and inclusion in this study were acute (< 3 weeks) fractures with 1) persistent displacement of more than 3 mm in extension splint, 2) palmar subluxation of the distal phalanx or 3) fracture fragments consisting of more than one third of the joint surface (type IV B according to the Doyle classification) *(8)*. Patients living abroad were excluded.

The following baseline characteristics were collected: sex, age, injured finger, dominance, American Society of Anaesthesiologists classification (ASA classification) *(9)*, type of anaesthesia (general or loco-regional) and time of surgery.

Surgical technique

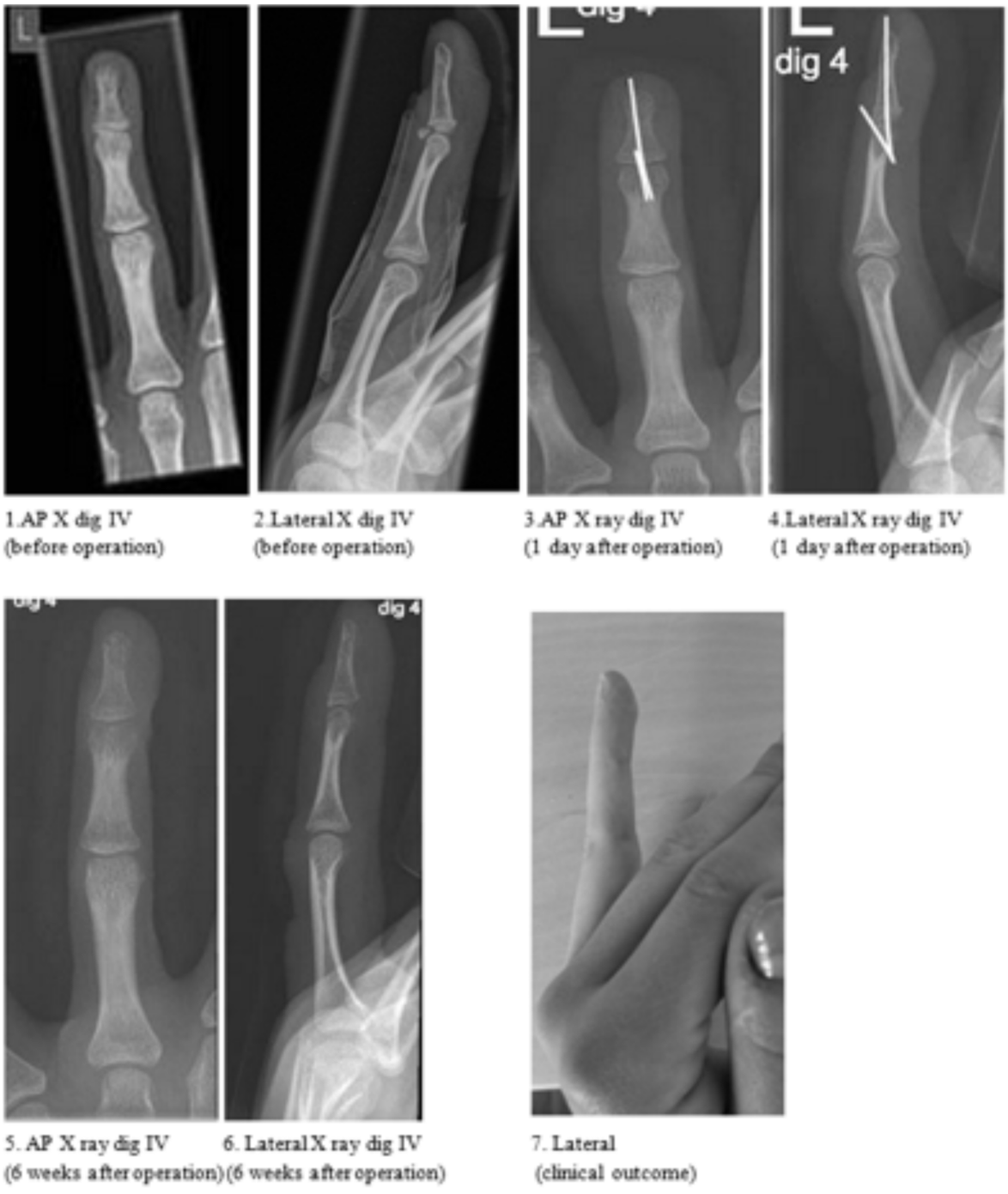
Different trauma surgeons performed the operations. Patients received pre-operative antibiotic prophylaxis (Cefazolin 2 gram intravenous). The operations were performed either under loco-regional anaesthesia or under general anaesthesia.

After sterile exposure, closed reduction was attempted. If closed reduction was unsuccessful, open reduction of the displaced fracture fragment was performed. Open reduction was performed in two patients. Alignment was checked under fluoroscopy.

The first step in fracture fixation was hyperflexion of the distal interphalangeal joint. A k-wire (0.8 – 1.0 mm) was percutaneously inserted dorsally just proximal at the insertion of the extensor tendon, close to the avulsion fracture. The k-wire was inserted through the extensor tendon into the mid phalanx in about 30-45 degrees. This k-wire was used to prevent dorsal displacement of the fracture.

The second step was manual fracture reduction by traction and extension of the distal interphalangeal (DIP) joint with palmar pressure to the distal phalanx to correct subluxation positon. After reduction, a second k-wire (0.8-1.2 mm) was placed

percutaneously from the distal phalanx, through the DIP joint into the midphalanx (figure 1) *(14,16)*. Correct placement of the k-wires, fracture reduction and alignment of the DIP joint were verified under fluoroscopy. The k-wires were cut and buried subcutaneously. If needed, wounds were closed with (non) absorbable sutures. Surgical treatment was performed in day-care.



1.AP X dig IV (before operation)
2.Lateral X dig IV (before operation)
3.AP X ray dig IV (1 day after operation)
4.Lateral X ray dig IV (1 day after operation)
5. AP X ray dig IV (6 weeks after operation)
6. Lateral X ray dig IV (6 weeks after operation)
7. Lateral (clinical outcome)

Fig. 1.

Postoperative treatment

Postoperatively, patients received a removable thermoplastic splint for comfort and protection of the k-wires. Patients were allowed to remove the splint occasionally. No regular X-rays were taken during follow up. After 6 weeks, the k-wires were removed in the outpatient department under loco-regional anaesthesia at the base of the injured finger. After k-wire removal, patients were referred to a specialised hand physiotherapist for guided mobilisation. The total number of sessions was dependent on the result of the function in the individual patient.

Outcome assessment

Functional results were evaluated by using the PRWHE (patient rated wrist hand evaluation) questionnaire *(18)*. The PRWHE is developed as a patient reported outcome measure of pain and disability to evaluate the outcome after hand and wrist injuries. This questionnaire is validated in the Netherlands in 2015 *(19)*. The PRWHE contains 15 items that cover two domains: pain (5 items) and functionality (10 items). The score ranges from 0-100, a score of 0 indicating no pain or disability.

All eligible patients were contacted by telephone and invited to complete the PRWHE questionnaire. Patients could either complete the PRWHE questionnaire by telephone or by mail.

Complications as wound infection (superficial or deep), non-union and implant migration were evaluated retrospectively by screening all the patient records by the first author (AJAM). Besides this, all the patient who completed the PRWHE questionnaire were also asked if they suffered a complication. A superficial infection was defined as redness, swelling and/or purulent discharge which could be treated with oral antibiotics. If the infection required surgical debridement or preliminary implant removal, it was considered a deep infection.

Non-union was defined as lack of radiologic healing after 6 months with clinical evidence of pain and/or motion at the fracture site. Implant migration was detected on radiologic follow-up. Nail deformity was a clinical diagnosis and was reported during the outpatient clinic follow up.

Statistical analysis

The data were analysed using SPSS (IBM SPSS Statistics for Windows, Version 23.0. Released 2015. Armonk, NY: IBM Corp.). Categorical variables were presented as frequencies. The non-normal distributed continuous variables were presented as means with ranges. No formal statistical analysis could be conducted because of the limited sample size.

Table I . — Baseline characteristics

Characteristics	Total patients (n=36) Total bony mallets (n=38)
Male	23
Median age in years	32 (12-57)
ASA classification	
I	35
II	1
III	0
IV	0
Injured finger	
Dig I	0
Dig II	2
Dig III	7
Dig IV	9
Dig V	20
Anaesthesia	
General	20
Locoregional (Oberst)	16
Median surgery time in minutes	23 (range 10-50)
Median removal Kirschner-wires in days	42 (range 28-57)

Mean scores (range) or numbers are shown

RESULTS

Inclusion of study population

During the study period 36 patients met the inclusion criteria and 38 bony mallets were treated (two patients had two bony mallets). The mean clinical follow up period was 2 months (range 1 month – 5 months) and the mean follow up for the PRWHE questionnaire was 32 months (range 15 months – 65 months). Twenty seven patients (75%) completed the PRWHE questionnaire.

Baseline characteristics

The baseline characteristics are shown in Table I. The median age was 32 years (range 12 years - 57 years). Twenty patients received general anaesthesia. Median time of surgery was 23 minutes (range 10 min - 50 min), from start of anaesthesia until the end of the operation. Implant removal was performed after a median of 42 days (range 28 days - 57 days).

Functional outcome and complications

Table II shows the results of the PRWHE questionnaire. None of the patients described functional loss (score 0 out of 50). Mean pain score was 0.5 (range 0 -10 out of 50) at the end of follow up; only three patients described some sense of pain with a score of respectively 1 out of 50, 3 out of 50 and 10 out of 50.

During follow up, complications were registered. Two patients (5.5%) developed a clinically relevant superficial wound infection requiring oral antibiotic treatment for a period of 7 days. No deep infection was observed nor non-union or implant migration were observed in this study population.

Figure 1 provides an overview of the course of our treatment strategy.

Table II. — Functional outcome using the Patient Rated Wrist Hand Evaluation (PRWHE)

	0	1	2	3	4	5	6	7	8	9	10
Pain at rest	27	0	0	0	0	0	0	0	0	0	0
Pain when doing a task with a repeated motion	27	0	0	0	0	0	0	0	0	0	0
Pain when lifting a heavy project	25	0	0	1	0	1	0	0	0	0	0
Pain when it is at its worst	25	1	0	0	0	1	0	0	0	0	0
How often do you have pain?	27	0	0	0	0	0	0	0	0	0	0
Turning a door knob using my affected hand	27	0	0	0	0	0	0	0	0	0	0
Cut meat using a knife in my affected hand	27	0	0	0	0	0	0	0	0	0	0
Fasten buttons on my shirt	27	0	0	0	0	0	0	0	0	0	0
Use my affected hand to push up from a chair	27	0	0	0	0	0	0	0	0	0	0
Carry a 5kg object in my affected hand	27	0	0	0	0	0	0	0	0	0	0
Use bathroom tissue with my affected hand	27	0	0	0	0	0	0	0	0	0	0
Personal care activities	27	0	0	0	0	0	0	0	0	0	0
Household work	27	0	0	0	0	0	0	0	0	0	0
Work	27	0	0	0	0	0	0	0	0	0	0
Recreational activities	27	0	0	0	0	0	0	0	0	0	0

Twenty seven patients out of the thirty six patients (75%) completed the questionnaire

DISCUSSION

To our knowledge, the present study is one of the first studies focusing on a patient reported outcome score as primary measurement of functional outcome for bony mallet finger injuries.

The Crawford classification is the currently used method to report the functional outcome. Although, this classification is limited in reporting pain and range of motion, while the PRWHE is more sufficient to investigate this. This questionnaire is based on the function and restrictions in daily activities which is probably more important for the individual patient.

In our study, functional outcome (using the PRWHE questionnaire) was excellent. Hofmeister et al. described 92% excellent results for surgically treated mallet fractures according to the Crawford classification while Pegoli et al. rated just 78% as excellent *(13,20)*. It is difficult to compare our patient related functional results to previous studies, because these studies used the Crawford classification to quantify objective functional outcome based on the measurement of loss of extension of the injured finger *(7)*.

The outcome data were based on patient self report by mailed questionnaires, rather than clinical or radiological follow-up results. Even though validated, patient reported measures of function should obviate the need for objective measurement of functional impairment *(10)*. However,

comparing joint movements of the injured finger (e.g. Crawford classification) and patient reported outcome scores could be interesting for further research of bony mallet injuries.

The percutaneous technique provides stable fracture fixation using closed fracture reduction with no secondary displacement in our study group. We demonstrated that surgery under loco-regional anaesthesia of the finger is a well-tolerated and safe procedure; none of the locally anesthetized patients were converted to general anaesthesia. By cutting off the used k-wires subcutaneously after percutaneous insertion, in combination with a removable thermoplastic splint, the associated risk for skin problems and deep infection was minimised. Our complication rate was low and comparable to previous reports focusing on percutaneous techniques *(13)*. Most open techniques require more exposure, probably resulting in higher complication rates *(2,15)*.

One of the strengths of this study is the generalisability of the results. After introduction of the technique, surgery was done by (residents under supervision of) different trauma surgeons with a variable experience level in fracture care. There was no difference in functional outcome and complication rate between the level of expertise of the surgeon. With a mean follow-up of more than 2.5 years and a 75% follow-up rate, we are able to report substantial mid-term functional results.

A limitation is the retrospective nature of this study. Nine patients were lost to follow-up lacking mid-term PRWHE results. Therefore, results of the PRWHE questionnaire should be interpreted with caution.

The indication for surgical treatment is based on strict criteria and none of the patients matching these criteria received conservative treatment. Therefore, our retrospective observational cohort study lacks the ability to provide information about conservative treatment. Despite our promising results, the optimal treatment strategy for these injuries remains unclear. Future research is needed to determine the effectiveness of this technique in relation to conservative treatment for patients with these specific bony mallet injuries.

In conclusion, the results of our study support the use of the k-wire extension blocking technique for large displaced bony mallet injuries. The k-wire extension blocking technique is easy to learn, quick, safe and results in excellent mid-term functional outcome.

REFERENCES

1. **Aarts FLM, Derks R, Wouters DB.** The Meniscus Arrow?? as a fixation device for the treatment of mallet fractures: results of 50 cases. *Hand* 2014 ; 9 : 499-503.
2. **Alla SR, Deal ND, Dempsey IJ.** Current concepts: Mallet finger. *Hand* 2014 ; 9 : 138-44.
3. **Bendre AA, Hartigan BJ, Kalainov DM.** Mallet finger. *J. Am. Acad. Orthop. Surg* [Internet]. 2005 ; 13 : 336-44.
4. **Botero SS, Jose J, Diaz H, Benaïda A, Collon S, Facca S** *et al.* Review of Acute Traumatic Closed Mallet Finger Injuries in Adults. *Arch. Plast. Surg* 2016.

5. **Cheung JPY, Fung B, Ip WY.** Review on Mallet Finger Treatment. *Hand Surg* 2012 ; 17 : 439-47.
6. **Clayton RAE, Court-Brown CM.** The epidemiology of musculoskeletal tendinous and ligamentous injuries. *Injury* 2008 ; 1338-44.
7. **Crawford GP.** The molded polythene splint for mallet finger deformities. *J. Hand Surg. Am.* 1984 ; 9 : 231-7.
8. **Doyle JR.** Extensor tendons-acute injuries. In:Green DP, Hotchkiss RN, Pederson WC (Eds) *Green operative hand surgery* (4th ed). Philadelphia, PA: Churchill Livingstone. 1999.
9. **Dripps R.** New classification of physical status. *Anesthesiology* 1963 ; 24 : 111.
10. **Goodchild L, Chuang L, Hewitt C, Torgerson D, Trial P.** Surgical vs Nonsurgical Treatment of Adults With Displaced Fractures of the Proximal Humerus The PROFHER *Randomized Clinical Trial* 2017 ; 1037-47.
11. **Gurnani N, Hoogendoorn J, Rhemrev S.** [Mallet finger: surgery versus splinting]. Ned. Tijdschr. Geneeskd. [Internet]. 2014;158:A6941. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24618239
12. **Handoll HHG, Vaghela MV.** Interventions for treating mallet finger injuries. Cochrane Database Syst. Rev. 2004 ; CD004574.
13. **Hofmeister EP, Mazurek MT, Shin AY, Bishop AT.** Extension block pinning for large mallet fractures. *J. Hand Surg. Am* 2003 ; 28 : 453-9.
14. **Ishiguro T, Itoh Y, Yabe Y, Hashizume N.** Extension block with Kirschner wire for fracture dislocation of the distal interphalangeal joint. Tech. *Hand Up. Extrem. Surg* 1997 ; 1 : 95-102.
15. **King HJ, Shin SJ, Kang ES.** Complications of operative treatment for mallet fractures of the distal phalanx. *J. Hand Surg. Br* 2001 ; 26 : 28-31.
16. **Kumar K, Simon F, Resident J.** The Ishiguro Technique for the Treatment of Mallet Finger Fracture 2013 ; 279-81.
17. **Lee SK, Kim KJ, Yang DS, Moon KH, Choy WS.** Modified extension-block K-wire fixation technique for the treatment of bony mallet finger. *Orthopedics* 2010 ; 33 : 727-32.
18. **MacDermid JC, TurgeonT, Richards RS, Beadle M, Roth JH.** Patient Rating of Wrist Pain and Disability: A Reliable and Valid Measurement **Tool. J. Orthop. Trauma** [Internet]. 1998 ; 12 : 577-86.
19. **El Moumni M, Van Eck ME, Wendt KW, Reininga IHF, Mokkink LB.** Structural Validity of the Dutch Version of the Patient-Rated Wrist Evaluation (PRWE-NL) in Patients With Hand and Wrist Injuries. Phys. Ther [Internet]. 2015.
20. **Pegoli L, Toh S, Arai K, Fukuda a, Nishikawa S, Vallejo IG.** The Ishiguro extension block technique for the treatment of mallet finger fracture: indications and clinical results. *J. Hand Surg. Br* 2003 ; 28 : 15-7.
21. **Smit JM, Beets MR, Zeebregts CJ, Rood A, Welters CFM.** Treatment options for mallet finger: a review. *Plast. Reconstr. Surg* 2010 ; 126 : 1624-9.
22. **Wada T, Oda T.** Mallet fingers with bone avulsion and DIP joint subluxation. *J. Hand Surg. Eur. Vol* [Internet]. 2015 ; 40 : 8-15.