The Meniscus Arrow® as a fixation device for the treatment of mallet fractures: results of 50 cases

Fenne L. M. Aarts · Rosalie Derks · Diederick B. Wouters

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Abstract

Background The treatment of mallet fractures is a controversial and challenging problem. Generally, mallet fractures are treated conservatively except those involving more than one third of the base of the distal phalanx. Many different surgical fixation techniques have been published. This paper describes a new fixation procedure using ultimate bioresorbable meniscal fixation nails (Meniscus Arrows®).

Methods Mallet fractures in 50 digits of 49 patients were fixed with this nail in an outpatient surgical procedure, mostly under local (Oberst-block) anaesthesia. The average operation time was 21 min.

Results According to the Crawford criteria, patient outcome was graded as excellent in 48 %, good in 22 %, and fair in 28 %. In one patient, the outcome was graded as poor, but the fracture was in a pre-existent arthritic joint. All fractures were consolidated without recurrent dislocation. Complications included one wound infection, which was successfully treated with antibiotics and without further consequences. No nail deformities occurred. Two times, the nail spontaneously and gradually dislocated during intensive use of the hand after, respectively, 3 and 6 months and could easily be removed under local anaesthesia without any functional sequelae.

Conclusion The bioresorbable meniscal nail fixation technique provides a fast and successful surgical treatment for mallet fractures with a minimum of adverse events.

Keywords Mallet fracture · Meniscus Arrow® · Biodegradable · Fracture fixation · Internal

Introduction

A mallet finger is a deformity caused by a hyperflexion trauma, usually during axial loading of the fingertip, which can result in a rupture of the extensor tendon of the distal phalanx or an avulsion fracture named a mallet fracture. While a tendinous mallet finger is, generally, treated conservatively with splints for 6 weeks with variable results, the management of mallet fractures is a more challenging problem. The treatment options range from only splinting to an operative fixation procedure most often followed by splinting [1–3, 6, 21].

Surgical treatment has been suggested for mallet fractures involving more than one third of the base of the distal phalanx [1, 2, 6, 14, 20, 26]. Many different surgical fixation techniques have been described in the literature, including Kirschner wires, tension band fixation, internal suture, screw fixation, mini-hook plates, and volar plate advancement arthroplasty [4, 5, 7–12, 15, 19, 22–25].

Our hypothesis was that given the lack of census about the various fixation procedures described in the literature for mallet fractures and the promising results of a pilot series with a bioresorbable meniscal fixation nail (BMFN) [17], applying this device could be a solution to the fixation problem. Therefore, the results of 50 mallet fractures involving more than one third of the base of the distal phalanx treated over a period of 5 years using these nails as a fixation device were analysed and described in this paper.

F. L. M. Aarts
IJsselland Hospital, Capelle aan de IJssel, Schieweg 73A, 3038
AG Rotterdam, The Netherlands

R. Derks
Deventer Hospital, Nico Bolkesteinlaan 75, 7416 SE Deventer, The
Netherlands

D. B. Wouters (✉)
Medical Centre Amstelveen, Burg. Haspelslaan 131,
1181NC Amstelveen, The Netherlands
e-mail: d.b.w.md@zonnet.nl

Materials and Methods

Between 2007 and 2012, 50 digits with mallet fractures in 49 patients were treated consecutively with a Meniscus Arrow® (BMFN, Conmed Linvatec Ltd. Tampere, Finland) as a fixation device. This device is composed of reinforced dextro-laevo-poly-lactic acid (DLPLA) 20/80 and is a barbed nail with a small, rounded, oval head, a core diameter of 1.0 mm, a barb-barb diameter of 1.1 mm and, for this application, a length of 10 mm (Fig. 1). One device costs about \$250. The instrument set contains a hand drill, a blunt pusher, and several shafts with different curves (Fig. 2).

All surgeries were performed by the same surgeon in an outpatient surgical procedure. The indications for operative treatment were mallet fractures involving a bony fragment of more than 30 % of the articular surface and less than a 4-week delay from the injury.

The patient group (Table 1) consisted of 34 men and 15 women with a mean age of 36 years (range 15–68 years). In 20 cases, the left hand was involved and in 30 the right (dominant) hand. The affected digits included the 5th finger in 17 cases, the 4th finger in 11, the 3rd finger in 13, the 2nd in 4, and the thumb in 5 cases. In one patient, two mallet fractures were found at the same time in one hand. The mean time from injury to surgery was 12 days (range 1–28 days). The injury mechanism was usually either sports-related ($n=21$) or a crush injury ($n=8$).

Post-operative immobilisation was accomplished by a mallet splint for 5 weeks, followed by 3 weeks of protecting the fracture with the splint during activities involving the hand. Consolidation and reduction of the fracture were confirmed by plain radiographs at 5 and 8 weeks post-surgery.

Primary outcome criteria included the extensor lag, which was scored using the Crawford criteria [3] (Table 1). Other criteria included consolidation, nail deformity, and wound healing disturbances.

Surgical Technique

The surgical treatment was performed by a single surgeon with special interest in hand surgery.

The surgical technique was local anaesthesia at the base of the injured finger (Oberst-block) and application of a finger tourniquet. A small dorsal incision of the distal interphalangeal (DIP) joint (Fig. 3a) was followed by undermining the skin adjacent to the incision, proximally and distally, over a small area with a small mosquito clamp or a pair of scissors (Fig. 3b). Then, the fracture fragment(s) were reduced, either by direct pressure or using a reposition forceps, if the fragments were greatly displaced (Fig. 3c). Drilling of a hole through a shaft of the instrument set with the hand drill (Fig. 3d) or a K-wire of 1 mm in diameter under image intensifier control (Fig. 4a) into the fracture and base of the

Fig. 1 The Meniscus Arrow®

distal phalanx was the next step. Subsequently, after removal of the K-wire drill or hand drill, the BMFN, 10 mm in length,

Fig. 2 The instruments: *on top* the hand drill

Table 1 Demography of included patients

Mallet fractures	50				
Average age (years)	36 (15–68)				
Sex					
Male	34				
Female	15				
Digit	I	II	III	IV	V
	5	4	13	11	17
Injury to operation interval (days)	12 (1–28)				
Average operation time (min)	21 (7–42)				

was inserted through the shaft into the drill hole by very gentle hammering. If necessary, the nail could be shortened by cutting it off with a pair of scissors in accordance with the diameter of the distal phalanx (maximal 3 mm). Thereafter, X-ray control was performed to verify the reposition and the primary fixation (Fig. 4b). Finally, the skin was closed with Ethilon® 4.0 (Johnson & Johnson, New Brunswick, NJ, USA; Fig. 4c) and application of a mallet splint (Fig. 4d) over Steri-Strips® (3M Corporate Headquarters, St. Paul, USA).

Results

The operation time ranged from 42 min for the first operation to 7 min in the last few patients (average 21 min). The final evaluation was performed at an average of 17 weeks (range 3–68 weeks).

According to Crawford's evaluation criteria (Table 2), 48 % were graded as excellent, 22 % good, and 28 % fair. In one patient, 2 % of the group with pre-existent polyarthrosis of

his finger joints, extension deficit of 30° was found. However, this was noted in several other DIP joints of his hands as well, so most probably an undetected deficit already existed before the trauma. The DIP joint demonstrated a mean range of motion of 70° (range 0–100) and 5° of extension loss (range 0–30). Bony union was achieved in all cases.

In one case, a superficial wound infection developed, which was treated with antibiotics. No removal of the nail was necessary in this case. No skin abnormalities were noted, except some dorsal soft tissue swelling over the DIP joint, which was tender to the touch for about 12 weeks in two cases.

Migration of the BMFN occurred in two cases, respectively, after 3 and 6 months. The fracture was already consolidated. The remnant of the device could easily be removed under local anaesthesia and this did not lead to any functional impairment.

Discussion

This study was designed to document the results of a new technique of closed reduction and internal fixation of mallet fractures using a BMFN. Mallet injuries, in general, are treated conservatively [1–3, 6, 21]. However, for avulsion fractures exceeding 30 % of the articular surface, non-operative treatment leads to poor results like loss of motion and degenerative changes of the DIP joint [18, 26].

Therefore, surgical treatment is generally advocated for those fractures, as it is for fractures with palmar subluxation [16]. The goal is to provide an accurate reduction and fixation of the fracture and to prevent secondary degenerative osteoarthritis, swan neck deformity, or a persistent extensor lag.

Fig. 3 **a** Place and configuration of the incision, the location determined by means of fluoroscopy. **b** Loosening of the skin over a distance of few millimetres to cover the head of the Meniscus Arrow after skin closure using a small mosquito clamp. **c** If necessary, the use of a small reposition clamp to reduce the fracture. **d** The aspect of the procedure: the hand drill exchanged for a nail and the pusher is in the shaft; the nail ready to be, very gently, hammered into place

Fig. 4 **a** The view under fluoroscopy. **b** The final view of the reposition and fixation; note that the Meniscus Arrow is not visible under visualisation with X-rays. **c** After closure of the incision. **d** Final aspect with splint

However, no consensus exists about the treatment, and no single treatment modality has yet consistently achieved excellent or good results [4]. Furthermore, this surgery has been considered to be demanding and difficult [8] as for closed and open fixation techniques.

Various methods have been described in the literature, involving open surgery, such as reduction and K-wire fixation [9, 22], hook plate fixation [24, 25], tension band wiring [5], and open reduction and screw fixation [15]. A K-wire compression technique has also been reported [7]. The Ishiguro technique is the most frequently mentioned and used closed fixation procedure [10–12, 19, 23].

Stern and Kastrup [21] described 53 % complications in a series of 45 surgically treated digits, with 76 % of these complications still present at a mean follow-up of 38 months after percutaneous trans-articular pin splintage, including complications like deep infection (4 %), joint incongruity (18 %), and nail deformity (18 %). In addition, seven patients (16 %) required reoperation, and all of these had an unsatisfactory result except that in one finger, the outcome was unknown. King et al. [13] reported marginal skin necrosis

on the dorsal aspect of the distal phalanx, with recurrent extension lag, permanent nail deformities, transient infections along the K-wires and pull-out steel wires, and osteomyelitis.

In contrast, in this series, three, only minor, complications were noted out of 50 treated fingers: one superficial skin infection, which was successfully treated with antibiotics, and two migrations of the nail after, respectively, 3 and 6 months, neither of which led to failure of fixation nor consolidation.

A drawback of this study is that it represents a retrospective series, and comparison can only be made with series in the literature. With this restriction, the results seem to be promising compared with the data in the literature. Second, the follow-up of between 3 and 68 weeks, with an average of 17, is too short to assess the incidence of osteoarthritis.

A few technical pitfalls can be associated with this procedure, such as insufficient loosening of the skin adjacent to the incision, leading to improper covering of the nail head and, theoretically, leading to a deep infection. Another is losing the location and/or direction of the drill hole, which prevents correct insertion of the nail.

Our technique allows sufficient reduction of the fracture, resulting in all patients in consolidation in the previously achieved fracture reduction without the need for a second, device removal procedure, except in two out of 50 fingers. Furthermore, it reduces the risk of degenerative osteoarthritis by avoiding pinning through the DIP joint. Finally, the ultimate small diameter of the nail decreases the risk of fragmentation. No fragmentation was noted in this series of 50 cases.

Table 2 Crawford's criteria

Excellent	Full distal interphalangeal joint extension, full flexion, no pain
Good	0° to 10° of extension deficit, full flexion, no pain
Fair	10° to 25° of extension deficit, any flexion loss, no pain
Poor	>25° of extension deficit or persistent pain

In conclusion, the BMFN fixation technique for mallet fractures provides a fast and successful treatment without the need for a second implant removal procedure in the vast majority of cases.

Conflict of interest Fenne L. M. Aarts declares that she has no conflict of interest.

Rosalie Derks declares that she has no conflict of interest.

Diederick B. Wouters declares that he has no conflict of interest.

Statement of Human and Animal Rights All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 [5]. Informed consent was obtained from all patients for being included in this study.

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