Acta Orthop. Belg., 2012, **78**, 473-478

ORIGINAL STUDY

Treatment of fractures of the proximal phalanx of long fingers with an isometric traction splint

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Treatment of fractures of the proximal phalanx of the long fingers remains difficult and challenging ; several options have been used. We report our experience with an isometric traction splint, modified from the Southampton design. A cohort of 32 patients with displaced fractures of a proximal phalanx was treated and assessed retrospectively after a short term (9 weeks after splint application). Traction splint was applied to realign the fracture and to control rotation. This construct was used for approximatively 5 weeks (mean : 36 days ; range : 21-44 days), considering the usual progression of fracture healing in closed phalangeal fractures and patient tolerance to the splint. Three weeks after splint removal, almost full range of motion was regained in the metacarpophalangeal and interphalangeal joints in all patients, except in 3 cases. Two of these three patients had a displaced fracture of the proximal phalanx as a result of a compression trauma. The combination of the trauma type with static traction splint led to a tenodesis effect with a severe active flexion deficit in the metacarpophalangeal and interphalangeal joints. Our results suggest that isometric traction splint is a valid treatment option for displaced fractures of the proximal phalanx, however compression type fractures should be excluded.

Keywords : fractures of the proximal phalanx ; long fingers ; traction splint ; Southampton ; compression injury.

INTRODUCTION

Fractures of the proximal phalanx are difficult to treat. Management depends on the type and location of the fracture, degree of displacement, and associated soft-tissue injury. Reduction is required when displacement exists. The anterior surface of the proximal phalanx forms the floor of the flexor sheath, so an anatomical reduction is very important for the tendon to glide normally. To maintain the reduction, traction splints can be considered as a valuable conservative alternative option, besides open procedures. However, screw, plate or K-wire fixation may be associated with damage to the soft tissue envelope, risk of infection and wire loosening (*1,6,7*).

Ligamentotaxis with isometric traction splinting was firstly described by Fitzgerald *et al* from Southampton and is simple, quick, inexpensive and non-invasive. The distal traction force on the periarticular ligaments results in maintaining fracture

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No benefits or funds were received in support of this study

reduction, restoring joint space and regaining functional motion. Furthermore, maintenance of the traction prevents contracture of the volar plate, collateral ligaments and other periarticular structures, thus reducing joint stiffness (*4*).

The present study was undertaken to determine the efficacy of the technique in a series of patients with proximal phalangeal fractures, and to evaluate possible factors which contribute to success or failure of the treatment.

MATERIALS AND METHODS

A cohort of 32 patients with displaced proximal phalangeal fractures was treated and assessed retrospectively after a short term (9 weeks after splint application). Four patients were lost to follow-up ; 28 patients remained for evaluation : 14 women and 14 men, with a mean age of 50.6 years (range : 10-91). The patients had a mean time of assessment of 67 months (range : 60-77) post splint application. Twenty patients were right-handed and 8 left-handed. Fifteen patients fractured a proximal phalanx of one of the long fingers in their dominant hand, 13 patients in their non-dominant hand.

The fracture originated from 22 blunt traumas after fall, 1 blunt trauma with a ball during sports, 2 torsion traumas, 1 dog bite and 2 compression traumas. The compression occurred with their hand hammered between the wall or a non-moving object and a second heavy moving object. We diagnosed the following displaced fracture patterns : 17 non intra-articular base fractures, 5 intra-articular base fractures, 1 Salter-Harris type 2 epiphyseal fracture and 5 diaphyseal fractures. All, except one (the dog bite) were closed fractures, with a non-endangered skin at the time of trauma. The dog bite resulted in a Gustilo-Anderson type 1 fracture without neurovascular damage.

In all these patients, closed reduction was performed and a Southampton traction splint was assembled, with initial radiographic improvement of fracture angulation and malrotation (Fig. 1).

Southampton splint technique

A forearm cast with 10° wrist extension is applied as a base for the construction. Four longitudinal 30 cm long straps of adhesive elastic tape are firmly attached to each side of the finger, so that the tape ends provide a good traction tool. A one-side foamed metal splint has to be conformed to the volar side of the injured finger and in alignment with its longitudinal axis ; it is then fixed to the forearm cast. After fine adjustment, the splint can now support the injured finger. The fracture is ready to be reduced : traction is performed by pulling on the adhesive elastic tape ends. The tapes ends are then attached to the end of the splint. By gradual bending of the splint towards the forearm cast, supplementary traction is gradually added. When the splint is contoured and when the correct amount of manual traction is reached, the splint is fixed to the rest of the forearm cast. This leads to the neutral intrinsic plus position, based on differences in the shape of the metacarpal head, volar plate, and collateral ligament anatomy. The metacarpophalangeal (MP) joints are maintained in 60-70° of flexion, the interphalangeal (IP) joints in full extension and the wrist in 10°extension . Finally, the orientation of the finger tip is checked for rotational alignment and to ensure that there is no blanching of the tip of the pulp. A light supportive crepe bandage is then applied to steady the finger to the splint (Fig. 2).

Fig. 1. — 44-year-old male, compression trauma. AP, lateral and ¾ radiographs show a displaced angulated proximal phalangeal fracture.

The reduction is checked on radiographs after application (Fig. 3). During treatment, patients are encouraged to move the other fingers.

RESULTS

The splint was worn for 36 days on average (range : 21-47 days), based on the usual consolidation rate in closed phalangeal fractures. Secondary fracture displacement, bony union and malrotation were evaluated clinically and radiographically

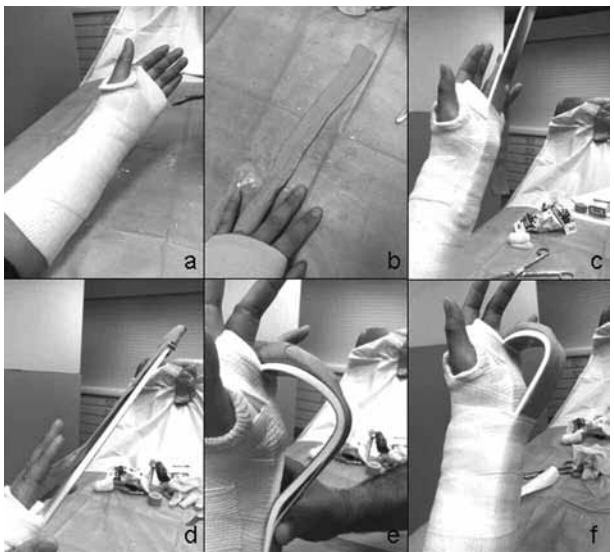

Fig. 2. — **a.** Southampton traction splint. Application of a forearm cast as construct foundation ; **b.** Southampton traction splint. Application of straps of adhesive elastic tape on the injured finger ; **c.** Southampton traction splint. Fixation of the precontoured one-sided foam metal splint on the forearm cast in alignment with the long axis of the injured finger ; **d.** Southampton traction splint. Fixation of the adhesive tape ends to the end of the splint after traction application through the tape ; **e.** Southampton traction splint. Bending of the splint to the volar side of the wrist thus adding additional gradual traction ; **f.** Southampton traction splint. Fixation of the splint to the forearm cast.

Fig. 3. — 44-year-old male, compression trauma. AP and lateral radiographs show reduction and realignment of a proximal phalangeal fracture after Southampton splint application.

(Fig. 4-5). Bony union was achieved in all patients. A residual malrotation of less than 10° was noted in one patient, and did not lead to any functional impairment in daily life. One splint construct loosened early after 3 weeks. The decision not to continue the splint and to immobilize by cast in intrinsic plus position without traction, did not result in an inferior function. In this case of a non intra-articular base fracture, immobilisation for three weeks was apparently sufficient to prevent secondary fracture angulation.

After splint removal, 16 patients (57%) were encouraged to mobilise their finger with aid from a trained physiotherapist . Three weeks after splint removal, average active extension was -3.5° (range : 0-20°) in the MP joint, -2.5° (range : 0-30°) in the PIP joint and -0.5° (range : 0-10°) in the DIP. Average active flexion in the MP joint was 88° (range : 64-90°), in the PIP joint 112° (range : 40-120°) and in the DIP joint 76° (range : 40-80°). The average distance between the finger pulp and the distal palmar crease during active flexion was 0.6 cm (range : 0-5 cm) (Fig. 6).

Only 2 patients (7%) experienced some residual pain at the fracture site. Normal daily life and professional activity were regained after 58 days or 9.5 weeks (range : 54-80 days).

A mild pulp ischaemia of the fingertip after 5 weeks of splinting was noted in 3 patients (10.7%), but had recovered 3 weeks after splint removal. Two patients (7%) developed a scintigraphically confirmed complex regional pain syndrome. One of the two recovered completely with local and oral analgetic instructions and physiotherapy, the other displayed joint stiffness with a flexion tenodesis.

Three patients (10.5%) had an unsatisfactory range of motion with an average distance between the finger pulp and the distal palmar crease of 5 cm during active flexion. Joint stiffness was due to a tenodesis of the flexor tendons around the fracture site. Unlike in the other patients, the original fracture mechanism in two of these patients was a compression trauma and one of them developed a

Fig. 4. — 44-year-old male, compression trauma. AP and lateral radiographs show a proximal phalangeal fracture with callus formation and with correct alignment, 5 weeks after splint application.

Fig. 5. — 44-year-old male, compression trauma. AP, lateral and ¾ radiographs show consolidation of a proximal phalangeal fracture, 3 weeks after splint removal.

complex regional pain syndrome. Flexor tendons had to be tenolysed surgically in order to improve motion.

Technique of surgical tenolysis

Under locoregional anaesthesia with a continuous catheter around the axillary plexus, the affected finger was incised on the volar side starting from the A1 pulley site to the A4 pulley site with a Brunner incision. After meticulous dissection with exposure of the tendon sheath, the strongly thickened tendon sheath, the pulley A1, C1, A3 and C2

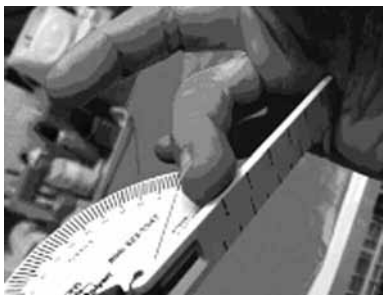

Fig. 6. — Measurement of the pulp – distal palmar crease distance in cm.

were removed, with careful preservation of A2 and A4 in order to prevent subsequent flexor tendon bowstringing. Fibrous tissue overgrowth of the flexor tendons was debrided. Specific fibrous adhesions were found to have developed between the flexor digitorum profundus tendon and the fracture site ; they were carefully removed by sharp and blunt dissection using the appropriate tools (knife, 2/0 Ethilon® thread and Morel Fatio). After tenolysis, the flexor tendons were noted to glide freely in their pulley sheath during passive mobilisation of the finger (Fig. 7). No interposition was added to prevent recurrence.

Three weeks after tenolysis and intensive physiotherapy, the average distance between the finger pulp and the distal palmar crease during active flexion, reduced to an acceptable 2 cm.

DISCUSSION

We believe that the Southampton traction splint is an effort-demanding treatment for the patient as well as for the orthopaedic surgeon, since 12.5% of the patients were lost to follow-up. Regular follow-up at the clinic is mandatory : once a week during the first two weeks, to check the radiological alignment and the splint construct, then every two weeks to check the splint construct (splint damage, skin problems, loosening of the strap) and to support patient splint tolerance and compliance to wear the splint as long as needed. Our data support the fact that this type of conservative treatment is applicable to individuals in a wide age range.

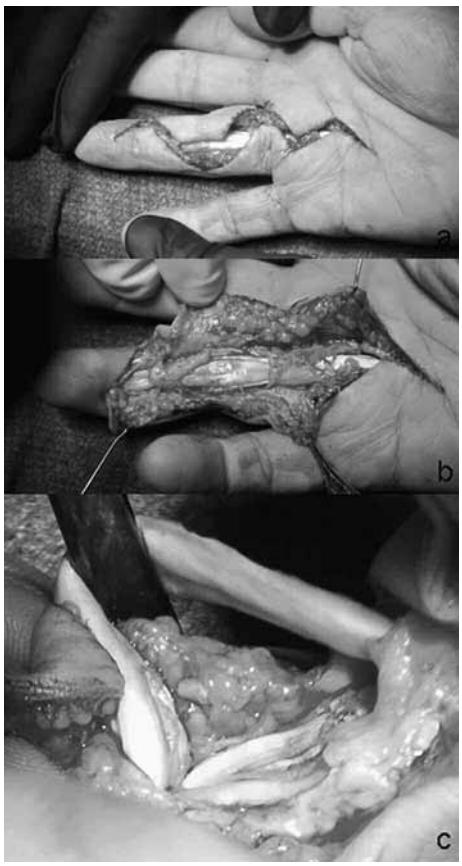

Fig. 7. — **a.** Tenolysis. Brunner incision on the affected finger ; **b.** Tenolysis. The pulley system is exposed : A1 and A3 are excised, A2 and A4 are preserved ; **c.** Tenolysis. Fibrous adhesions develop between the flexor profundus tendon and the volar plate.

Practically all patterns of displaced fractures can be treated with the Southampton traction splint. According to Ashok *et al*, even an open fracture is not a contraindication to splint application. The wounds can be closed and the splint can be applied after the first dressing change. As no hardware is added in the fracture environment, this approach is safer even for grossly contaminated wounds after thorough debridment and closure (*1*).

Bony union is achieved in all cases and malrotation seldom occurs if correct alignment is achieved at splint construction. Most of the patients healed without residual pain (93%), were happy with their cosmetic result and regained nearly complete range of motion (88.5%). Seven percent developed a complex regional pain syndrome.

Joint stiffness was diagnosed in 10.5% of the patients due to flexor tenodesis. According to our data, we assume that this complication is mainly related to the type of trauma. Furthermore, we suggest that in cases of displaced fractures after compression trauma, primary open reduction and internal fixation should be preferred to isometric traction splinting. As two of the three patients with flexor tenodesis were known to be regular smokers, we cannot exclude that smoking may be another confounding factor in their problematic healing process. When needed, a secondary open tenolysis procedure results in a much improved range of motion.

Our design differs from the original Southampton splint and the modification of Collins *et al* or Habib *et al*. By bending and fixing the metal splint towards the wrist, a more stable fixation of the splint is created. We believe that this modification improves the durability of the construct and patients' comfort in activities of daily living (*3,4,5*).

The splint of Ashok *et al* uses traction on the injured finger with a hook glued on the nail plate. This appears less simple and swift than our technique. According to these authors, nail avulsion rarely occurs (*1*).

In summary, all of these described splints use the same theoretical principle of isometric traction splinting, but differ only in design details.

A traction splintage was also described by Baier *et al*. Their traction is maintained throughout a tracking arc instead of a static metal splint. This would ensure early "dynamic" restricted motion and could theoretically reduce joint stiffness. In our opinion, this technique is more demanding for correct positioning and requires more specific and costly material (*2*).

We believe that the Southampton traction splint can also be implemented in displaced middle phalanx fractures, but in these cases the Suzuki dynamic splint is an interesting alternative as described by Majumder *et al*. The Suzuki splint construct requires maybe more training skills than our splint design, requires access to operating theatre facilities and more postoperative pin tract care. Furthermore, the Suzuki splint is not applicable in fractures of the proximal phalanx (*6*).

We conclude that the Southampton traction splint is a low-cost, simple, quick and non-invasive design which can be applied even in the emergency department. It provides excellent results as treatment in displaced fractures of the proximal phalanx. The isometric traction and contact to the surface of the splint moulds the fracture into correct alignment. Exclusion criteria exist for cases of compression trauma, where the combination of splinting and the origin of the injury leads to joint stiffness due to flexor tendon tenodesis in the fracture callus.

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