Functional evaluation after primary flexor tendon repair in zone II

Ioannis GALANAKIS, Agisilaos ALIGIZAKIS, Pavlos KATONIS, Haris VAVOURANAKIS,
Kostantinos STERGIOPOULOS, Alexandros HADJIPAVLOU

The purpose of this prospective study was to evaluate the results of primary treatment of flexor tendon laceration in zone II according to Verdan's zone system. Special emphasis was given to the postoperative rehabilitation program. Nineteen patients (23 fingers) with laceration of the flexor tendons in zone II were treated operatively. Twelve males and seven females were included in the study. Their mean age was 28 years (range, 16 to 50 years). In 12 cases a concomitant laceration of the digital nerve was present. In all cases primary repair of all injured tendons and nerves was performed and a dorsal splint was applied. On the third to fifth postoperative day an exercise program commenced involving passive flexion-active extension of the injured fingers. Eighteen (22 fingers) of 19 patients completed the follow-up.

The results were evaluated according to Strickland's original classification system. The result was excellent in 15 cases, good in five and fair in two.

After primary repair of injured flexor tendons, a program of close follow-up, early protected motion and unrestricted motion of the interphalangeal joints offers the best chance of restoring optimal function to the hand.

INTRODUCTION

During the past 25 years, reestablishing satisfactory function after primary repair of lacerated flexor tendons in Verdan's zone II has been an insoluble problem. Flexor lacerations in the finger were found to show poor performance after primary repair and the digital sheath was referred to as 'no man's land' (17). Much investigation has been conducted in recent years into the appreciation of tendon structure, nutrition, function, biomechanical properties, and the biological response to injury and repair (5). As a result improved methods of tendon repair, flexor sheath restoration, and early motion stress have been applied (10).

The purpose of this prospective study was to estimate the functional results of primary repair of flexor tendons in zone II. Special emphasis has been given to the postoperative rehabilitation program.

MATERIAL AND METHODS

From January 1997 to June 2000, 19 consecutive patients (23 fingers) with traumatic flexor tendon lace-

From the University Hospital of Heraklion, Department of Orthopaedics, Crete, Greece.

Ioannis Galanakis, Orthopaedic Surgeon.

Agisilaos Aligizakis, Orthopaedic Surgeon.

Pavlos Katonis, Assistant Professor of Orthopaedics.

Haris Vavouranakis, Orthopaedic Surgeon.

Kostantinos Stergiopoulos, Associate Professor of Orthopaedics.

Alexandros Hadjipavlou, Professor of Orthopaedics.

Correspondence and reprints : Agisilaos Aligizakis, 9 Sorvolou street, 71305 Heraklion, Crete, Greece. E-mail : aligisak@med.uoc.gr.

Table I. — Distribution of flexor tendon and digital nerve laceration per digit

Fingers	Index		Median		Ring		Small	
Number of cases	Tendons 7	Nerve 3	Tendons 6	Nerve 3	Tendons 4	Nerve 2	Tendons 6	Nerve 4
Total	Tendons 23				Nerves 12			

ration in zone II were treated operatively in our department (table I). There were 12 males and seven females. The mean age of the study group was 28 years (range, 16 to 50 years). The sources of injury included knife cuts (seven cases) and broken glass cuts (16 cases). In 12 cases a concomitant laceration of a digital nerve was present (table I).

The flexor digitorum superficialis, the flexor digitorum profundus, and the associated digital nerve laceration were primarily repaired in all cases. All patients received general anesthesia or an axillary block. A nonsterile tourniquet was applied above the elbow, and a second-generation cephalosporin was administered before inflation. Operating loupes (x 4 magnification) were used for all tendon repairs. A palmar Brunner's zig-zag incision based on the original skin laceration was made. Pulleys were preserved where possible. Tendon suturing was performed through an appropriately designed L-shaped tendon sheath window created in its membranous portions (12). The sheath window was left unrepaired to avoid tendon constriction. Both profundus and superficialis flexor tendons were repaired in all cases using a 2-strand core stitch (modified Kessler) repair core suture of 4-0 nylon to reapproximate the tendon ends, while a 6-0 circumferential whip stitch of monofilament nylon was used to smooth out any jagged tendon ends. Associated digital nerve repair was performed finally by end-to-end coaptation, using 9-0 nylon suture, after tendon repair. Before wound closure, the tourniquet was deflated, and haemostasis was achieved with bipolar cautery. The skin was closed with 4-0 nylon vertical mattress sutures. A bulky compressive dressing and a dorsal splint extending from the tip of the fingers to the elbow, allowing full, unrestricted extension of the proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints was applied, with the wrist in 30° of palmar flexion, and the metacarpophalangeal (MCP) joints in 70°-90° of flexion (fig 1).

Postoperative rehabilitation was taught to the patients, which they carried out alone. Passive flexion–active unrestricted extension of the operated finger was initiated on the third to fifth postoperative day. The DIP joint was flexed first, followed by the PIP joint, and lastly the MCP joint (fig 2). Special emphasis was given to full interphalangeal joint extension using a dorsal elevation between the splint and the PIP joint creating sufficient room for full finger extension (fig 1). This exercise program was performed for 60-90 minutes daily. Digital nerve repair did not affect the time or type of postoperative rehabilitation.

The importance of passive flexion and full active extension was explained to the patients. At four and seven days after initiating rehabilitation, instruction application was checked. Six weeks postoperatively the splint was removed, and active flexion and extension exercises were permitted to each finger-joint separately, with simultaneous blocking of other hand joints (1). The patient was told to use the operated hand for exercise and general functions. Where stiffness of the proximal IP joint was present, a dynamic extension splint was applied between exercise periods and during the night,

Fig. 1. — Dorsal elevation between the splint and the PIP joint permits full unrestricted extension.

Table II. — Strickland's original grading system

Rating	PIP+DIP return	
	%	Degrees
Excellent	85-100	(150° +)
Good	70-84	(125°-149°)
Fair	50-69	(90°-124°)
Poor	< 50	(< 90°)
$\frac{\text{(PIP + DIP) flexion – (PIP + DIP) extension deficit} \times 100}{175}$ = % of normal active PIP+DIP motion		

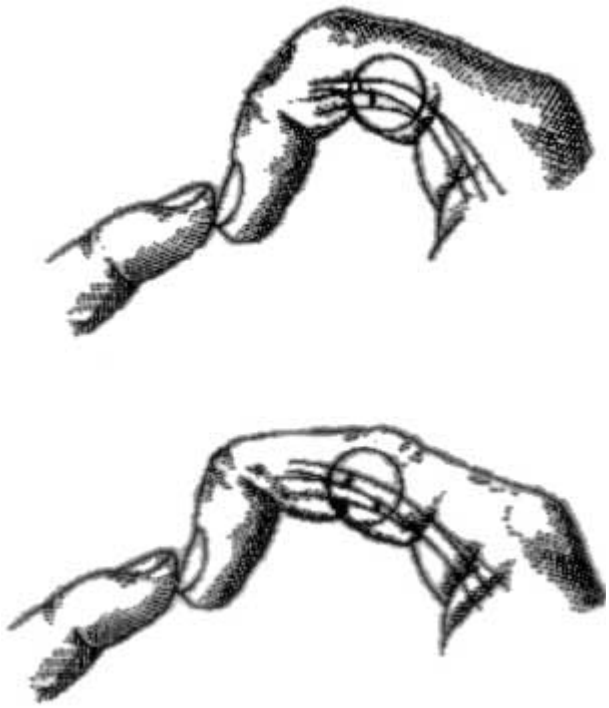

Fig. 2. — Passive flexion of the interphalangeal joints using the uninjured hand.

until full extension was achieved. Eight weeks after suturing limited activity was permitted. Full, unlimited activity depended on the patient's job, but it was usually permitted at 10 to 12 weeks together with strengthening exercises.

Functional evaluation of all digits was performed taking into account the range of motion in flexion as well as the extension lag in the PIP and DIP joint. Results were classified according to Strickland's original grading system (16, 18) (table II).

RESULTS

The follow-up period was 20 weeks (range, 12 to 35 weeks). Range of motion of the injured finger was evaluated in all cases at 12 weeks postoperatively (table III). Fifteen of the 22 cases with zone II flexor tendon laceration were classified as excellent, five cases as good, and two as fair (one had become infected). Sixteen out of 19 patients (20 fingers) classified as excellent or good were absolutely satisfied with the final result. All patients returned to their employment between the tenth and twelfth week postoperatively depending on their job.

Complications were observed in two of the 19 patients. There was one rupture of a tendon repair two weeks postoperatively, which was reoperated ; however the patient did not appear for follow-up and was excluded from the study. In one case the result was fair because wound infection resulted in interphalangeal flexion decrease as well as extension lag of both DIP and PIP joints. The two patients with a fair result denied any further operation to improve their range of motion, and they considered the result as adequate for their everyday demands.

DISCUSSION

The issue of recovery of satisfactory digital motion after flexor tendon repair has long challenged hand surgeons. Flexor tendon lacerations in zone II particularly require a full understanding of the local anatomy and atraumatic repair. Adhesion formation of the surrounding tissues during the healing process of the flexor tendons would lead to

Table III. — Classification of results according to Strickland's classification

Results	PIP + DIP return	Cases
Excellent	(150° +)	15
Good	(125° – 149°)	5
Fair	(90°- 124°)	2
Poor	(< 90°)	0
Total		22

restriction of movement and poor functional results. Tendon and tendon sheath laceration, during injury or during operative reconstruction, tendon ischemia, sheath diminution, immobilization, and suturing gap formation, all favor adhesion formation (17).

Predisposing factors for adhesion formation can be limited with meticulous exposure of the tendon stumps, preservation or repair of the sheath, atraumatic tendon suturing (2) and strength repair (8, 13, 19). Early postoperative mobilization of the tendon ensures rapid healing and satisfactory gliding, while protecting the repair from rupture throughout the healing process (5, 6, 10).

It has been found that repaired tendons subjected to early motion stress will develop fewer adhesions, more rapidly increasing strength and gliding capacity, and smoothing of any jagged tendon ends. The more frequent, intense, and longer in duration the load stress, the faster the tendon heals (17).

Flexor tendon primary repair in zone II should employ an early motion protocol to avoid adhesion formation. There are three protocols for early motion : a) passive flexion and active extension achieved with the use of the original Kleinert splint (9) or modifications of the Kleinert splint, b) passive motion achieved by the patient himself with the help of the other uninjured hand (4, 11), and c) the last one, applied in 1989 in Belfast, where the patients were permitted active flexion and active extension of the operated tendons (3, 15). The use of a four- or six-strand core stitch repair instead of two, combined with a running-lock circumferential epitendinous stitch and the Belfast rehabilitation protocol should increase the strength of the repair in cooperative patients (5).

In the current study, with the use of classic methods of tendon repair and rehabilitation satisfactory results were achieved. This study confirms the results of previous studies (7, 14). The dorsal splint application at the beginning of rehabilitation, which permits full unrestricted extension in the PIP and DIP joint, is of great importance, because it lessens the possibility of extension stiffness. A modified Duran and Hauser protocol (11) was used, because passive flexion using the uninjured hand encourages the patient to be more cooperative and permits improved movement of the DIP joint and better gliding of the flexor digitorum profundus, which is extremely important in rehabilitation (20). However the patient was not permitted active flexion of the finger.

Ideal operating conditions (satisfactory general anesthesia, tourniquet, and operative loupe magnification), and atraumatic operative technique are also of great importance in the successful rehabilitation of a flexor tendon laceration in zone II. The restoration of function to a digit following flexor tendon interruption and repair is long and arduous. A strong relationship must develop between the surgeon, the patient, and the therapist. The surgeon needs to spend considerable time explaining the inherent problems to the patient, the likelihood of achieving success, the importance of the rehabilitation protocol to avoid adhesion formation, the diminished danger of tendon suturing rupture, and tendon strengthening.

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