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A new technique to determine the tension in extensor pollicis longus reconstruction

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4) Key words

Extensor pollicis longus, tendon rupture, tendon transfer, extensor indicis, free
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1 **Abstract**

2 We present an original technique for determining the tension of the extensor pollicis
3 longus tendon after reconstruction. We treated 20 patients using this technique for
4 extensor pollicis longus tendon graft or extensor indicis tendon transfer and reviewed
5 the results. The tension of the reconstructed extensor pollicis longus was adjusted so
6 that the centre of the distal edge of the thumbnail was elevated 2 cm above the operation
7 table. The mean retropositional distance of the treated thumbs was 1.2 cm less than the
8 contralateral thumbs. The mean total active motion of the thumb was 90%. This
9 technique resulted in satisfactory thumb function.

10 Level of evidence: IV

11
12
13 **Introduction**

14
15 The surgical treatment for a rupture of the extensor pollicis longus (EPL)
16 tendon involves a tendon transfer or free tendon graft. The tendons recommended for

17 transfers include the extensor carpi radialis longus (ECRL) (Justan et al., 2009),
18 extensor carpi radialis brevis (ECRB) (Cui et al., 2017), abductor pollicis longus (APL)
19 (Chitnis and Evans, 1993) and extensor indicis (EI) (Magnussen et al., 1990), but the EI
20 tendon transfer has been the standard procedure in recent years. However, the
21 significant disadvantage in EI tendon transfer lies in sacrificing extension power and
22 producing an extensor lag in a normal index finger (Matter-Parrat et al., 2017).
23 Palmaris longus (PL) tendon grafting for EPL rupture is rarely done, because the graft is
24 avascular and requires two suture sites. However, the clinical results after PL tendon
25 grafting are comparable to that of EI tendon transfer (Pillukat et al., 2008; Saur et al.,
26 2003; Schaller et al., 2007). One of the key points for obtaining good results is that both
27 types of EPL reconstruction must be done with optimal tension. There are many
28 techniques for determining the degree of tension but no consensus has been established.
29
30 We have used both techniques for EPL tendon ruptures using a new technique for
31 determining the tension of the reconstructed EPL tendon. The purpose of this study
32 was to review the postoperative results.

33

Methods

34 Patients who underwent tendon reconstructions for a rupture of the EPL tendon more
35 than 4 weeks after injury between 2006 and 2014 were included in this study. We
36 excluded patients with arthropathic changes of the trapeziometacarpal and
37 scaphotrapeziotrapezoidal joints, and patients with rheumatoid arthritis. Three surgeons
38 (MH, SU, and HK) carried out the tendon reconstructions and used identical procedures
39 with either PL tendon grafting or EI tendon transfer, in addition to using the same
40 technique to determine the tension in the reconstructed EPL tendon.

41 We carried out PL tendon grafting for patients presenting with EPL rupture
42 within 3 months of injury with an intraoperative passive excursion of the proximal
43 stump of the EPL tendon of more than 1 cm, without an abnormal appearance of the
44 EPL muscle and in patients with weak EI muscle strength on manual muscle testing. In
45 the other patients, an EI tendon transfer was done.

46 At operation the proximal stump of the EPL tendon was gently pulled in a
47 distal direction to confirm its excursion. In patients treated with a PL graft, the distal
48 stump of the EPL tendon and the PL tendon were interwoven with each other by 4-0

49 Ethilon (Ethicon Incorporated, Somerville, NJ, USA). The PL tendon was passed
50 beneath the intact extensor retinaculum of the wrist. The PL tendon was then sutured to
51 the proximal stump of the EPL tendon using the same interlacing suture technique. In EI
52 tendon transfer patients, the distal stump of the EPL tendon was sutured to the EI
53 tendon with the same interlacing suture. and tension-determining technique as used in
54 PL tendon grafting patients.

55 Before finally suturing the PL tendon to the proximal stump of the EPL tendon
56 suturing the EI tendon to the distal stump of the EPL the pneumatic tourniquet was
57 deflated. The assisting surgeon pressed the patient's hand flat on the operating table
58 with the forearm in pronation and wrist in neutral position. The tension of the
59 reconstructed EPL was adjusted so that the centre of the edge of the thumbnail was
60 elevated 2 cm above the operation table, and a temporary suturing was done (Figure 1).
61 After this temporary suturing, if the distance between the edge of the thumbnail and the
62 table was found to be less than 2 cm, the temporary suturing was removed and re-
63 sutured after adjusting the tension.

64 Postoperative rehabilitation consisted of either dynamic splinting or cast
65 fixation. Dynamic splinting was used if the patient was able to visit the hospital once a
66 week for follow-up by a surgeon. In other patients, the thumb was immobilized by a
67 thumb spica cast with the wrist in 45° extension and the thumb in a position of slight
68 adduction and extension. Passive extension and active flexion exercises were carried out
69 during the day with a rubber band 3 days after operation when a dynamic splint was
70 used. At night, the thumb was immobilized in a thumb spica splint. In both
71 postoperative rehabilitation protocols, active extension of the thumb was allowed 3
72 weeks after operation, and the thumb was placed in an extension position in the static
73 night splint until 6 weeks after operation . Use of the hands without restriction was
74 allowed at 12 weeks.

75 The active flexion and active extension movements of the thumb were obtained
76 by actively flexing and extending of the metacarpophalangeal (MP) and interphalangeal
77 (IP) joints simultaneously in the neutral wrist position. Patients were asked to maintain
78 the maximum retroposition of the thumb on the table, and the retropositional distance
79 from the tip of the thumbnail to the table was measured on both hands. The

80 retropositional distance of the contralateral thumb was subtracted from that of the
81 operated thumb, and the distance was defined as the elevation deficit (Figure 2). Total
82 Active Motion (TAM) in both thumbs was measured. Patients completed a Disabilities
83 of Arm, Shoulder and Hand (DASH) score questionnaire.

84 The Wilcoxon signed-ranked test was used to compare measured values before
85 and after surgery. The results after PL tendon grafting and EI tendon transfer were
86 compared using the Mann-Whitney U test. A *p*-value <0.05 was considered to be
87 significant.

88 The Ethics Committee of our institute approved this study (IEC No. 2369) and
89 informed consent was obtained from all patients.

90 **Results**

91 There were 25 patients with EPL tendon rupture, but five patients were
92 excluded: two with RA, one with STT arthritis and two due to loss of follow-up within
93 12 months. As a result, 20 patients were included in our study. Eight patients were male
94 and 12 patients were female. The mean age at the time of surgery was 59 (range 18-85)
95 years. The aetiology of the rupture was as follows: distal radial fracture, 17 patients;

96 trauma due to laceration, one; and unknown, two. The two patients with unknown
97 aetiology were a 27-year-old man and a 36-year-old man. Both were referred 2
98 months after they were aware of inability to extend the thumb. They had noticed wrist
99 pain 1 month before becoming unable to extend the thumb. We were unable to find any
100 other specific episodes or detect any abnormal findings, to explain the EPL tendon
101 rupture. All 20 patients could extend their index independently. Thirteen patients had an
102 operation within 3 months after injury. Among them, seven patients underwent PL
103 tendon grafting. In the remaining six patients, the EPL excursion was insufficient and
104 PL tendon grafting was changed to EI tendon transfer during surgery. Seven patients
105 had an operation at more than 3 months after injury. PL tendon grafting was done in
106 seven patients and EI tendon transfer in 13 patients. For postoperative rehabilitation,
107 nine patients followed the static splinting protocol and 11 patients underwent dynamic
108 splinting. The mean postoperative observation period was 44 (range 12-120) months.

109 All 20 patients were directly examined by the first author (FK), who was not
110 involved in any of the surgical procedures. There were no complications that required
111 surgical revision. Table 1 shows the clinical results. The active extension degrees of the

112 thumb interphalangeal joint were significantly improved. There were no significant
113 differences in postoperative degrees of active flexion at thumb IP joint. The mean TAM
114 of the thumb after tendon reconstructions showed a significant improvement. The
115 DASH score was significantly improved. Overall, there were no significant differences
116 in the postoperative assessments between PL tendon grafting and EI tendon transfer
117 (Table 2). There were no significant differences in results between the static splinting
118 and dynamic splinting groups.

119 **Discussion**

120 This tension assessment technique that we describe resulted in satisfactory
121 thumb function regardless of three different operators, the different techniques for EPL
122 reconstruction and the different postoperative rehabilitation protocols.

123 Most techniques to determine the proper tension of the EI tendon transfer for
124 EPL reconstruction have relied on a combination of reference angles of the wrist and
125 thumb after suturing the tendon (Table 3). With these methods, the proper tension is
126 difficult to determine and their reproducibility is questionable. However our technique
127 for determining the tension is simple, quantitative, and offers low inter-operator

128 variability. Furthermore, this technique can easily show whether the tension is too tight
129 or loose. If an appropriate tension is not obtained, the operator can easily re-suture and
130 re-assess the tension.

131 The peak strength of active muscle contraction is when the muscle is
132 approximately in the middle of its total range from maximum stretch to full contraction
133 (Elftman, 1966). The mean retropositional distance of the non-operated thumb in the
134 present study was 3.9 (SD 1.0) cm, compared to the 5.4 cm reported in another study
135 (Lemmen et al. 1999). Therefore, we adopted 2 cm, which was approximately half the
136 distance from neutral to maximal retroposition, as the distance for determining optimal
137 tension in the EPL tendon reconstruction.

138 If there is restriction of flexion in the IP joint of the thumb after EPL tendon
139 reconstruction, the ability to pinch and achieve a full grip function would be
140 compromised. In this series any restriction of flexion gradually improved, and the
141 restriction of flexion of the IP joints in the neutral wrist position was only 5° at the final
142 follow-up (Table 1). In this situation, full flexion is made possible by extending the
143 wrist and no patients complained of hindrances to activities of daily living. The patient

144 with the greatest restriction of flexion of the thumb in this series could flex the IP joint
145 of the thumb to 45° and his DASH score improved postoperatively.

146 There were no differences in the results of PL tendon grafting and EI tendon
147 transfer operations. We believe that PL tendon grafting should be the first-choice
148 procedure for patients with EPL tendon ruptures, provided that their time from injury to
149 reconstruction is within 3 months and an excursion of approximately 1 cm is confirmed
150 by pulling the proximal tendon stump of the EPL.

151 There were some limitations to the present study. It was not a randomized trial,
152 and we were unable to make a prospective comparison with other classical tension
153 assessment techniques. The distance from the operating table was standardized to 2 cm,
154 without accounting for individual variations in the thumb or hand function such as the
155 size of the hand and the ranges of motion of the MP or IP joints of the thumb (Sato et
156 al., 2011 and 2012). In theory the retropositional distance of the thumb to the operating
157 table should be decided by considering that of the contralateral thumb. Two patients
158 with a relatively short postoperative follow-up period of 12 months were included.
159 There were two different early postoperative rehabilitation protocols. However, other

160 studies have reported no differences in the results between these two rehabilitation

161 protocols (Germann et al., 2001; Wood et al., 2013).

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Figure



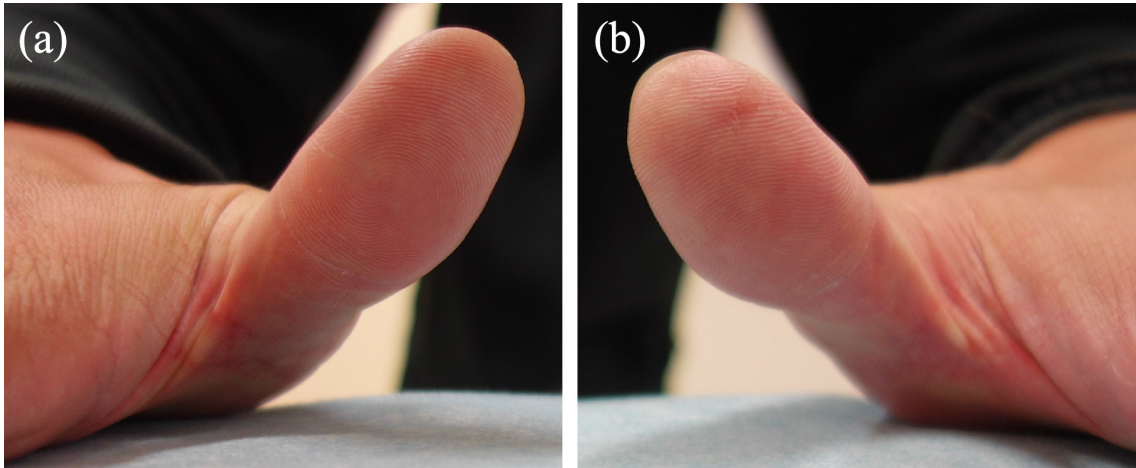
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213 Figure 1. A photograph after extensor indicis tendon transfer. The centre of the distal

214 edge of the thumbnail is elevated 2 cm above the operating table with the forearm in

215 pronation and the wrist in the neutral position.

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217

218 Figure 2. Photographs 70 months after tendon transfer; the measured elevation of the
219 repaired left thumb (b) is compared to the non-operated right thumb (a). The elevation
220 deficit is 0.5 cm.

Table 1. Summary of functional results ($n=20$). Values given as mean (SD).

Clinical results	Before tendon reconstruction	After tendon reconstruction	<i>p</i> -value
Active extension IPJ (°)	-29 (16)	8 (10)	<0.001
Elevation deficit (cm)	-	1.2 (1.0)	-
Active flexion IPJ (°)	65 (12)	61 (13)	0.10
TAM (%)	50 (15)	90 (12)	<0.001
DASH	28.5 (21.0)	7.7 (8.0)	<0.001

IPJ: interphalangeal joint; SD: standard deviation; TAM: Total Active Motion; DASH: Disabilities of the Arm, Shoulder and Hand

Table 2. Comparison of the results of the two types of EPL reconstruction. Values given as mean (SD).

Clinical results	PL tendon graft (<i>n</i> = 7)	EI tendon transfer (<i>n</i> =13)	<i>p</i> -value
Active extension IPJ (°)	9 (12)	8 (9)	0.96
Elevation deficit (cm)	1.1 (0.8)	1.2 (1.2)	0.84
Active flexion IPJ (°)	61 (13)	60 (13)	0.84
TAM (%)	93 (7)	88(14)	0.59

EPL: extensor pollicis longus; IPJ: interphalangeal joint; PL: palmaris longus tendon graft; EI: extensor indicis; SD: standard deviation; TAM: Total Active Motion

Table 3. Tension-determining techniques in EPL tendon reconstruction and their results

Reference	Tendon, reconstruction method	Tension-determining technique	Mean elevation deficit (cm)
Chitnis and Evans. (1993)	APL TT	Thumb in full abduction and extension	1.3
Cui et al. (2017)	ECRB TT	Thumb in full abduction and extension in 20° WE	1.3
Jung et al. (2014)	EI TT	Thumb in full extension in WN	1.0
Jung et al. (2014)	EI TT	Thumb in full extension in 30° WF	2.0
Lemmen et al. (1999)	EI TT	Tight, but possible flexion of the thumb in WN	2.4
Magnussen et al. (1990)	EI TT	Tight, but possible flexion of the thumb in WN	1.4
Present Study	PL TG or EI TT	Thumbnail elevated 2 cm above the operation table in WN with the forearm in pronation	1.2

EPL: extensor pollicis longus; EI: extensor indicis; APL: abductor pollicis longus; ECRB: extensor carpi radialis brevis; PL: palmaris longus; TT: tendon transfer; TG: tendon graft; WN: wrist neutral; WE: wrist extension; WF: wrist flexion