# EVALUATION OF RESTORATION OF EXTENSOR POLLICIS FUNCTION BY TRANSFER OF THE EXTENSOR INDICIS

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**The aim of this study was to assess long-term results of extensor indicis (EI) to extensor pollicis longus (EPL) transfers and to assess donor site morbidity. A specific EI-EPL evaluation method (SEEM) was used to measure EPL function after transfer. The outcomes in 17 patients are presented. Results were assessed by the Geldmacher score, the SEEM, mobility and strength of thumb and index finger, pinch and grip strength, and a questionnaire, comparing the operated and non-operated hands. Based on the SEEM, the results were excellent to good in 11 of 17 patients. There was no marked loss of independent extension of the index finger and only a 38% loss of extension strength.**

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The long extensor of the thumb, the extensor pollicis longus (EPL), produces extension of the interphalangeal (IP), metacarpophalangeal (MP) and trapeziometacarpal (TM) joints of the thumb. At the TM joint the EPL also has an adduction moment.

Loss of the EPL function causes a so-called "dropped thumb", which is particularly obvious when there is a weak extensor pollicis brevis (EPB), when the EPL acts as the main extensor of the MP joint (Gelb, 1995). If the tendon is cleanly divided by a cut it can usually be repaired by primary suture. In many cases the EPL is disrupted secondarily, e.g. after a Colles' fracture or in rheumatoid arthritis, leading to a poorly vascularized segment of tendon adjacent to the dorsal tuberosity. In such cases primary tendon repair is not recommended and a tendon transfer is usually indicated (Noordanus et al., 1994).

The two tendons commonly used for transfers are the extensor indicis (EI) and the extensor carpi radialis longus (ECRL). On anatomical (Lieber et al., 1992) and mechanical grounds the first choice for EPL reconstruction is the EI muscle, because both the fibre length and the physiological cross-sectional area (PCSA) of the EPL and EI are similar, as is the line of pull. In choosing a motor it is sometimes assumed that, after EI transfer the independent extension of the finger is lost (Goldner, 1974; Nigst and Linder, 1989).

The aim of this study was to assess the long-term results of EI-EPL transfer and to assess any effect on the index finger.

To assess the results of EPL reconstruction objective methods that describe the function of the thumb have been used (Magnussen et al., 1990; Schneider and Rosenstein, 1983). The Geldmacher assessment scheme has also been used (Geldmacher et al., 1986; Hoch et al., 1988; Nigst and Linder, 1989; Noorda and Hage, 1994; Winckler et al., 1995). However, this scheme was designed to evaluate the results of extension after primary tendon repair. Radial abduction of the thumb is included in the Geldmacher scheme, although this is not a function of the EPL; on the contrary, the EPL is an adductor.

We suggest a modification in the assessment method and propose a specific EI-EPL evaluation method (SEEM) to measure the EPL function after EI transfer.

## PATIENTS AND METHODS

Between 1987 and 1994, 20 patients underwent EI transfer for EPL function loss, of whom 17 were available for assessment. There were 13 men and four women. The mean age was 40 years (range, 22–71). In nine patients the dominant hand was involved.

In nine cases the cause of the EPL injury was a direct injury, six were caused by glass, two by a knife, and one by a saw. The other eight tendons ruptured secondarily, three after a Colles' fracture (at a mean of 12 weeks after injury), two after steroid injections, two after a blunt injury and one spontaneously. None of the patients suffered from rheumatoid arthritis.

The mean time between rupture and surgery was 3.5 months (range, 1–9). The mean interval between surgery and evaluation was 49 months (range, 8–88).

### Technique

The surgical technique used for the EI-EPL transfer was based on the technique described by Schneider and Rosenstein (1983). Through a small transverse incision over the MP joint of the index finger, the EI was isolated and sectioned proximal to its insertion in the dorsal hood. At the level of the wrist, the EI tendon was pulled out through a transverse incision and brought through a subcutaneous tunnel to the EPL. Fixation was accomplished using the Pulvertaft technique. The tension in the transfer was tight, but flexion of the thumb was still possible with the wrist in neutral position. Immobilization in a plaster cast with the wrist and thumb in extension usually lasted 3 to 6 weeks, after which controlled mobilization was started in ten patients. In seven patients a dynamic extension splint was worn after 2 to 3 weeks immobilization.

## SCORING OF OUTCOME

The results were scored using the Geldmacher scheme, which is an objective evaluation system to classify the results of extensor tendon repair in general (Table 1). For the thumb, four functions must be scored: the radial abduction angle, the elevation deficit, the opposition distance and the flexion-extension deficit of the MP and IP joints. The Geldmacher grading scale is: excellent, 24 to 22 points; good, 21 to 17 points; satisfactory, 16 to 10 points; and poor, 9 to 0 points.

The results were also scored using the SEEM (Table 2), which includes the elevation deficit of the thumb, the combined flexion deficit of the thumb (opposition), and the ability to extend the index finger independently (MP and PIP joint deficits). With the SEEM a total of 100 points can be scored: 40 for elevation, 30 for opposition and 30 points for independent extension of the index finger. The SEEM grading scale is: excellent, 100 to 81 points; good, 80 to 61 points; satisfactory, 60 to 41 points; and poor, < 40 points.

The excursion of the EI-EPL transfer was measured by a combined movement of all three thumb joints. The patient was asked to place both hands on a table and lift both thumbs as high as possible while keeping the fingers and palms flat on the table. For both hands, the distance (in mm) from the table to the top of the thumb was measured with a ruler (Fig 1). The difference in measurement between the injured and non-injured hands was designated the "elevation deficit".

For opposition, the patient was asked to move the tip of the thumb as far as possible along the little finger towards the distal palmar crease (Fig 2). The measured difference (in mm) between the injured and non-injured hands was called the opposition deficit by Geldmacher et al. (1986), but was designated the "flexion deficit" in the present study. The independent extension of the index finger was tested with the other digits held flexed.

The active range of motion (AROM) was measured at the IP and MP joints of the thumb and index finger in the operated and non-operated hands. The strength of thumb and index extension was measured with a hand-held dynamometer (Model 9520A.B; Aikoh Engineering Co. Ltd, Tokyo, Japan), which was pressed against the resisting finger or thumb (Schreu ders and Stam, 1996). Grip and pinch strengths were measured with a modified Jamar Dynamometer in conjuction with the Greenleaf Medical EVAL Hand and Upper Extremity Evaluation System (Greenleaf Medical, Palo Alto, CA). Each measurement was taken three times in all patients. Subsequently, the mean of these three measurements was calculated and the result expressed as a percentage of the strength of the non-operated hand.

**Table 1—Geldmacher evaluation scheme for scoring the results of extensor tendon repair**

| *Function* | | *Score* |
|---|---|---|
| Radial abduction range (angle between thumb and index finger) | > 70° | 6 points |
| | 51–70° | 4 points |
| | 31–50° | 2 points |
| | 9–30° | 0 points |
| Elevation deficit | 0.0–1.0 cm | 6 points |
| | 1.1–2.0 cm | 4 points |
| | 2.1–3.0 cm | 2 points |
| | > 3.0 cm | 0 points |
| Opposition distance (distance of thumb tip to MP of the little finger) | 0.0–2.5 cm | 6 points |
| | 2.5–4.0 cm | 4 points |
| | 4.1–6.0 cm | 2 points |
| | > 6.0 cm | 0 points |
| Flexion extension deficit (difference from non-operated hand) | 0–5° | 6 points |
| | 6–30° | 4 points |
| | 31–60° | 2 points |
| | > 60° | 0 points |

**Table 2—The specific EI-EPL evaluation method (SEEM) for scoring the results of EPL restoration using the EI transfer**

| *Function* | | *Score* |
|---|---|---|
| Elevation deficit (measured as distance between table and thumb) | 0–1 cm | 40 points |
| | 1–2 cm | 30 points |
| | 2–3 cm | 20 points |
| | 3–4 cm | 10 points |
| | > 4 cm | 0 points |
| Combined flexion deficit (measured as distance thumb tip to distal palmar crease of little finger) | 0–2 cm | 30 points |
| | 2–4 cm | 20 points |
| | 4–6 cm | 10 points |
| | > 6 cm | 0 points |
| Independent extension index finger: MP joint deficit | < 0° | 15 points |
| | 0° | 10 points |
| | 0–20° | 5 points |
| | > 20° | 0 points |
| Independent extension index finger: PIP joint deficit | 0–10° | 15 points |
| | 10–20° | 10 points |
| | > 20° | 0 points |

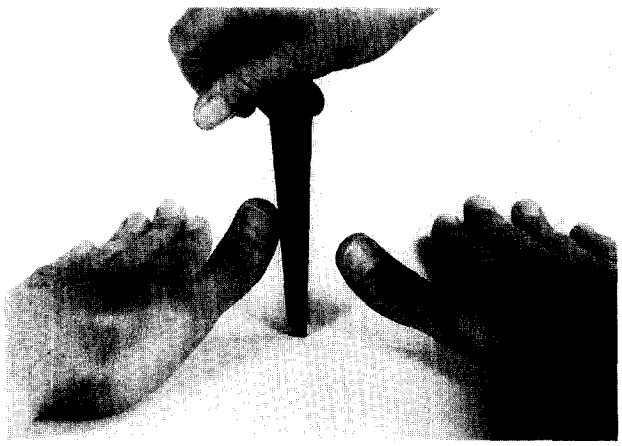

Fig 1 Measuring elevation.

Fig 2 Measuring opposition. The distance from the tip of the thumb to the distal palmar crease is measured in mm.

The subjective evaluation was obtained using a specially designed questionnaire in which patients reported on pain, strength, function, disability and general satisfaction with the result. A ten-point grading scale was used for the overall result: good result, 10 to 7 points; fair, 7 to 4 points; and poor, 4 to 0 points.

The Mann–Whitney test was used for statistical analysis.

## RESULTS

Table 3 presents the results according to the Geldmacher evaluation scheme and the SEEM.

Measurements of the extension and flexion deficit of thumb and index finger are given in Table 4.

Table 5 shows the strength measurements in the present study and compares them with other studies. In our study the pinch and grip strength was normal in the operated hand.

Independent extension of the index finger after EI transfer was possible in 15 of the 17 patients.

Based on the questionnaire, the results of the transfer were scored by 14 patients as good, by one patient as fair, and by two as poor.

In patients with an EI transfer in the dominant hand the outcomes assessed by SEEM were significantly better ($P < 0.05$) than in patients with a transfer in the non-dominant hand.

**Table 3—Results after EI transfer for restoration of EPL function in 17 patients evaluated by the Geldmacher scheme and SEEM**

| | *Geldmacher* | *SEEM* | *Other studies** |
|---|---|---|---|
| Excellent | 7 | 8 | 23–56% |
| Good | 4 | 3 | 18–54% |
| Satisfactory | 5 | 5 | 9–55% |
| Poor | 1 | 1 | 0–4% |

*Hoch et al. (1988), Nigst and Linder (1989), Noorda and Hage (1994) and Winckler et al. (1995).

## DISCUSSION

The results in the present study using the Geldmacher scheme agree well with data from other studies (Hoch et al., 1988; Nigst and Linder, 1989; Noorda and Hage, 1994; Winckler et al., 1995).

However, this scheme was not designed specifically to evaluate results after tendon transfer, but rather to measure the extension after tendon repair in general. The Geldmacher scheme includes the radial abduction of the thumb, which is not a function of the EPL.

The SEEM scoring system is as simple and quick as the Geldmacher scheme but places more emphasis on the most important function of the EPL, i.e. the elevation of the thumb. The opposition distance is an indicator of the flexion deficit of the thumb.

**Table 4—Active range of motion measurements. The deficit is calculated as the difference between the mean value of the operated and non-operated finger and thumb**

| | *Non-operated mean (range)* | *Operated mean (range)* | *Mean deficit* |
|---|---|---|---|
| Thumb IP ext. | –29° (–49° to 7°) | –18° (–60° to 26°) | 11° |
| fl. | 76° (60° to 97°) | 69° (47° to 86°) | 7° |
| MP ext. | –14° (–38° to 8°) | 5° (–28° to 48°) | 19° |
| fl. | 58° (45° to 77°) | 51° (29° to 67°) | 7° |
| Elevation | 54 mm (35 to 70) | 30 mm (0 to 68) | 24 mm |
| Index PIP ext. | – 7° (–25° to 7°) | –5° (–13° to 8°) | 2° |
| fl. | 103° (84° to 113°) | 101° (76° to 117°) | 2° |
| MP ext. | – 7° (–34° to 21°) | –7° (–31° to 32°) | 0° |
| fl. | 81° (69° to 92°) | 82° (73° to 96°) | 1° |

**Table 5—Strength measurements as percentage of corresponding values in the non-operated hand**

| | *Present study mean (range)* | *Other studies** |
|---|---|---|
| Extension thumb | 81% (29–108%) | 51% |
| Extension index | 62% (29–104%) | 49–64% |
| Pinch strength | 98% (52–130%) | 90–92% |
| Grip strength | 101% (81–125%) | 87% |

*Magnussen et al. (1990) and Noorda and Hage (1994).

The SEEM also assesses the donor site of the EI transfer, by grading independent extension of the index finger. Some are convinced that extension of the index finger is not possible after EI transfer, although this has been shown to be incorrect (Moore et al., 1987). In the present study, independent extension of the index finger after EI transfer was possible in 15 of the 17 patients. Furthermore, the extension loss in the index finger at the PIP and MP joints was 2° and 0°, respectively (Table 4). This is in accordance with the suggestion of others, that if the extensor hood is kept intact, an extension lag will be prevented (Browne et al., 1979; Moore et al., 1987; Noorda et al., 1994).

There is some loss of range of motion in the thumb. Thumb extension at the IP and MP joints is about 10 to 20° less than in the uninjured hand. The mean elevation deficit was 24 mm and although this seems to be a significant loss, there was little limitation to hand function.

Strength measurements of thumb and index extension show that the average strength of the transfer was 81%, considerably better than the 51% strength reported by Magnussen et al. (1990). Grip and pinch strengths in the injured and uninjured hands were comparable. The average loss of extension strength of the index finger was 38%, which is in accordance with the results of Noorda et al. (1994).

When comparing the subjective opinion of the patients (based on the questionaire) with the objective results of the SEEM, the only poor SEEM result coincides with one of the two poor subjective results. In this patient the transfer was too slack and a further operation was refused. The other poor subjective result scored "good" on the SEEM; in this patient the transfer was too tight and a secondary tendon lengthening procedure was done with a good result. The only fair subjective result coincides with one of the five satisfactory SEEM results. The other four satisfactory SEEM results scored "good" in the subjective analysis. The remaining two "good" and eight "excellent" SEEM results coincide with the remaining "good" subjective results. A high SEEM score appears to be related to patient satisfaction with the results, which indicates that the SEEM is a valid method for assessing EPL function.

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