Single tendon transfer of the flexor carpi ulnaris for high radial nerve injury

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ABSTRACT

Purpose. To evaluate the outcome after single tendon transfer of the flexor carpi ulnaris (FCU) to the digital extensors for high radial nerve palsy.

Methods. Records of 10 patients aged 16 to 43 (median, 27) years who underwent single tendon transfer of the FCU to the digital extensors for high radial nerve palsy secondary to closed (n=4) or open (n=4) diaphyseal humeral fractures or deltoid injection (n=2) were reviewed. Two of the patients with open fractures also underwent treatment for non-union in a staged manner. Grip strength (power grip and precision grip) was measured monthly using an automated dynamometer. The range of motion of the wrist, and metacarpophalangeal joints of the thumb and fingers was measured monthly using a goniometer.

Results. All patients were followed up for at least one year. Preoperatively, the overall power grip strength of the injured hands was about 1/5 of the normal hands. At 12 months, the mean improvement was 202.5% for overall power grip strength and 32% to 37% for precision grip strength parameters. At 12 months, mean wrist extension was 50.4º, with about 10º lag in finger and thumb extension. The mean total active motion was 86.7º in the operated wrists and 128.1º in normal wrists. The decrease in wrist flexion and ulnar deviation was 7.8º and 6.8º, respectively.

Conclusion. Single tendon transfer of the FCU is a viable option to restore hand function and strength following high radial nerve injuries.

Key words: radial nerve; radial neuropathy; tendon transfer

INTRODUCTION

Transfer of a single healthy tendon for treatment of hand paralysis secondary to high radial nerve injury can restore wrist, finger, and thumb extension.1 Transfer of either the flexor carpi radialis (FCR) or flexor carpi ulnaris (FCU) tendon, along with the palmaris longus (PL) and pronator teres tendons—the triple tendon transfer—has been suggested for high radial nerve paralysis. A simpler procedure of single tendon transfer of the FCU to the digital extensors (including extensor pollicis longus [EPL]) can restore digital and thumb extension and wrist dorsiflexion.1

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This study evaluated the outcome after single tendon transfer of the FCU to the digital extensors for high radial nerve palsy.

MATeRIALS AND METHODS

Records of 10 patients aged 16 to 43 (median, 27) years who underwent single tendon transfer of the FCU to the digital extensors for high radial nerve palsy secondary to closed (n=4) or open (n=4) diaphyseal humeral fractures or deltoid injection (n=2) of the left (n=7) or right (n=3) side between December 2010 and January 2012 were reviewed. Two of the patients with open fractures also underwent treatment for non-union in a staged manner. Patients with associated ipsilateral injuries of the median or ulnar nerves, or with FCU power less than Medical Research Council grade 4 out of 5 were excluded.

Preoperatively, patients were given an external static cock-up wrist splint and encouraged to do physiotherapy to keep the wrist and hand joints supple. Surgery was performed under general or regional anaesthesia; a pneumatic tourniquet was applied after exsanguination of the limb. A volar longitudinal or J-shape incision was made over the ulnar aspect of the distal third of the forearm (Fig. a). The FCU was identified and transected just proximal to its pisiform insertion. The muscle was freed from its bed proximally, up to the junction of the proximal 1/3 and distal 2/3 of the forearm (Fig. b). A dorsal transverse or curvilinear incision was made in the distal forearm (Fig. c) to expose the extensor digitorum communis (EDC), extensor indicis proprius (EIP), and EPL, just proximal to the extensor retinaculum (Fig. d). The FCU was transferred to the dorsal wound around the ulnar border of the forearm through a subcutaneous tunnel. The wrist was held in 30\(^\circ\) extension and the metacarpophalangeal (MCP) and interphalangeal (IP) joints in full extension. The FCU tendon was interweaved with the EDC, EIP, and EPL tendons in an oblique direction, as distally as feasible (Fig. e). All the slack in the extensor tendons was pulled out dorsally and proximally. The FCU was sutured with these tendons midway between full tension and full relaxation (Fig. f). Non-absorbable sutures were used. In the first 6 patients, the FCU tendon passed through each tendon separately, each with a stay suture. In the next 4 patients, the FCU tendon passed through all tendons altogether. Tension was adjusted with passive wrist movements such that fingers came to within 2 cm of the palm with wrist in extension, while the digits extended on palmar flexion of the wrist. The tourniquet was deflated and meticulous haemostasis was achieved. The wound was closed in layers. An above-elbow plaster slab was applied with the wrist in 40\(^\circ\) extension and the MCP joints of the fingers and thumb in full extension (Fig. g). The distal

Figure (a) A volar J-shape incision is made over the ulnar aspect of the distal third forearm. (b) The flexor carpi ulnaris (FCU) is transected just proximal to its pisiform insertion. The muscle is freed from its bed proximally to the junction of the proximal 1/3 and distal 2/3 of the forearm. (c) A dorsal curvilinear incision is made. (d) The extensor digitorum communis (EDC), extensor indicis proprius (EIP), and extensor pollicis longus (EPL) are exposed, just proximal to the extensor retinaculum. (e) The FCU is transferred to the dorsal wound around the ulnar border of the forearm through a subcutaneous tunnel. The FCU tendon is interweaved with the EDC, EIP, and EPL tendons in an oblique direction, as distally as feasible. (f) The FCU is sutured separately with these tendons midway between full tension and full relaxation. (g) An above-elbow plaster slab is applied with the wrist in 40\(^\circ\) extension and the metacarpophalangeal (MCP) joints of the fingers and thumb in full extension. (h) Simultaneous extension of the MCP joints of the fingers and thumb extension at follow-up.
IP joints of the fingers were left free.

Postoperatively, finger movements were started as soon as the patient was comfortable. Skin sutures were removed at 2 weeks. The plaster slab was removed at 4 weeks and replaced with a removable cock-up splint. Active wrist and finger mobilisation to restore grasp and release was allowed. Finger extension exercises were started with the wrist in a neutral position and gradually progressed to wrist dorsiflexion.

Grip strength (power grip in 5 object sizes and precision grip) was measured monthly using an automated dynamometer. The precision grip included tip pinch, key pinch, and palmar pinch. The range of motion of the wrist and the MCP joints of the thumb and fingers was measured monthly using a goniometer and included: (1) wrist flexion, extension, radial and ulnar deviation; (2) finger extension with wrist extended and neutral; and (3) thumb extension.

RESULTS

All patients were followed up for at least one year. The mean tourniquet time was 88.6 (range, 67–116) minutes; it was 98.4 minutes for the first 5 patients and 78.8 minutes for the next 5 patients.

Preoperatively, the overall power grip strength of the injured hands was about 1/5 of the normal hands. At 12 months, the mean improvement was 202.5% for overall power grip strength, 43% for key pinch, 46% for key pinch, and 57% for palmar grip (Table). Compared with the normal hands, the mean deficit of the operated hands was 39% for overall power grip strength, 33% for tip pinch, 32% for key pinch, and 37% for palmar pinch.

Preoperatively, compared with the normal hands, the mean finger extension lag was 77.2° with the wrist extended and 74.3° with the wrist in neutral, and the mean thumb extension lag was 59.8°. No patient was able to extend the wrist up to neutral. At 12 months, the mean lag improved to about 10° for finger and thumb extension and 33.6° for wrist extension. The mean total active motion was 86.7° in the operated wrists and 128.1° in normal wrists. The decrease in wrist flexion and ulnar deviation was 7.8° and 6.8°, respectively (p=0.005).

DISCUSSION

The treatment goal for high radial nerve palsy is to restore grip strength and wrist extension. Conventionally, triple tendon transfer has been used to reconstruct wrist, fingers, and thumb extension separately. Single tendon transfer of the FCU is technically simpler and results in better cosmesis and is of particular use in patients with multiple injuries or scarred limbs, with less choice of tendons available for transfer. In 108 patients who underwent single tendon transfer of the FCU to the EDC, EIP, and
EPL, with no separate transfer for wrist extension, improvement in power grip strength and range of motion of the wrist and digits was significant after a mean follow-up of 4 years.1

Nonetheless, single tendon transfer of the FCU remains controversial,2–4 because (1) the FCU is a stronger muscle than the extensors of the wrist and fingers; (2) the excursion of the muscle is smaller than these extensors; and (3) the FCU is a prime stabiliser of the wrist in ulnar deviation and hence too important to be sacrificed.2,5 The loss in wrist flexion and ulnar deviation is significant. Thus, major of the FCR or the flexor digitorum superficialis (FDS) tendon is suggested instead.

In a long-term study of various transfers in 15 patients, the mean wrist extension and flexion was 38° and 28°, respectively. 12 patients achieved full finger extension, and 13 achieved full thumb extension.6 Single tendon transfer of the FCR rather than the FCU was recommended for finger extension,6 as part of the Tsuge procedure (pronator teres to extensor carpi radialis brevis tendon, FCR to EDC tendon, PL to EPL tendon, and tenodesis of abductor pollicis longus to brachioradialis tendon).7

Transfer of the FCU did not differ significantly from transfer of the FCR in terms of functional outcome, with the power grip strength of the operated hands being 58% and 39% of the normal hands, respectively.8 No major functional disability was noted after transfer of the FCU, and a functional range of motion and grip strength for all activities of daily living were maintained.8,9 The FDS can act as an ulnar wrist stabiliser in the absence of the FCU.9

Based on measurements using an electrogoniometer, the average activities of daily living require 5° flexion, 30° extension, 10° radial deviation, and 15° ulnar deviation of the wrist.10 20° wrist extension and 20° wrist flexion has been considered functional.6,10 In our patients, the deficits of 7.8° in wrist flexion and 6.8° in wrist ulnar deviation should not have affected the patients’ daily activities. As the FCU was also sutured to the EPL, the loss of independent thumb extension is theoretically possible. However, our patients were able to make a thumb-up position with simultaneous MCP joint extension. No patient complained of any functional disability due to this altered pattern of thumb extension (Fig. h), although the power of independent thumb extension was weaker than that in the normal side.

Although the FCU may be too strong a muscle to restore finger extension as part of a triple tendon transfer, when used alone, this force is dissipated over the wrist as well. In addition, the excursion of the FCU is improved when acting upon multiple joints serially. The passive tenodesis wrist extension after single tendon transfer of the FCU is sufficient to enable the finger flexors to improve grip strength and function. As wrist and finger extensions are coupled, the finger flexors are preloaded across the digital joints and able to contract more forcefully.

Limitations to this study were the small sample size and short follow-up period.

CONCLUSION

Single tendon transfer of the FCU is a viable option to restore hand function and strength following high radial nerve injuries.

DISCLOSURE

No conflicts of interest were declared by the authors.

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