Effects of tendon and nerve gliding exercises and instructions in activities of daily living following endoscopic carpal tunnel release

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Abstract: The effects of postoperative therapy on psychological function following endoscopic carpal tunnel release (ECTR) have not been sufficiently investigated. This study investigated the effectiveness of instruction in tendon and nerve gliding exercises and activities of daily living (ADL) as postoperative treatment for 49 patients with carpal tunnel syndrome. Patients were randomized into 2 groups (intervention and control). After surgery, tendon and nerve gliding exercises and instruction in ADL were performed only on the experimental group on the day of the surgery. All patients were examined preoperatively and again 5–13 days postoperatively. Outcomes of pain, numbness, sensation, range of motion (ROM), anxiety, ADL and quality of life (QOL) were compared between groups. Differences were seen in pain, static 2-point discrimination, ROM, anxiety, and QOL. Tendon and nerve gliding exercises and instruction in ADL after ECTR appear likely to accelerate recovery.

Keywords: carpal tunnel syndrome, endoscopic carpal tunnel release, tendon and nerve gliding exercises, ADL-instruction

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Introduction

Carpal tunnel syndrome (CTS) develops when the median nerve is compressed at the wrist. Symptoms such as numbness and sensory impairment of the fingers in the area of the median nerve, failure of thumb opposition, finger movement disorders, and pain are characteristic of CTS (Phalen, 1966). Cutting the transverse carpal ligament is the most effective treatment for CTS (Uchiyama et al., 2009). Open carpal tunnel release (OCTR) (Phalen, 1966) was the choice of surgery until 1987, when endoscopic carpal tunnel release (ECTR) (Okutsu et al., 1987) was introduced as a minimally

invasive alternative to OCTR using a smaller skin incision. ECTR avoids painful scarring, reduces the duration of hospitalization, and allows earlier recovery of movement. In addition, because postoperative external fixation is unnecessary, rehabilitation of patients can be accelerated (Okutsu, Ninomiya, Takatori & Ugawa, 1989).

Studies comparing the postoperative the results of ECTR and OCTR (Trumble, Diao, Abrams & Gilbert-Anderson, 2002; Tian, Zhao & Wang, 2007; Atroshi et al., 2009) showed that ECTR was associated with better improvements in muscle strength directly after surgery, but no differences in treatment results for subjective symptoms and activities of daily living (ADL) were reported. Agee et al. (1992) reported that post-ECTR tenderness caused a decrease in muscle strength, delaying ADL improvement. Atroshi, Johnsson, and Ornstein (1998) reported a strong correlation between ADL and postoperative patient satisfaction. There is therefore a need to improve early function and ADL

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after appropriate therapy.

Patient-perceived disability correlates as much or more with psychological distress as with objective impairment (Schiphorst Preuper et al., 2008). Correlations with psychological function are reported using Disability of the Arm, Shoulder, and Hand (DASH) scores (Niekel, Lindenhovius, Watson, Vranceanu & Ring, 2009), and Vranceanu, Jupiter, Mudgal & Ring (2010) stated that intervention for psychological function is important after surgery for CTS. In terms of psychological interventions, Inoue (2002) stated that a provision of objective and concrete information is effective. For physical intervention, finger exercises to prevent flexor tendon and neural adhesions must be prescribed (Yoshida, Okutsu & Hamanaka, 2008; Narazaki & Hashizume, 2008). Intervention effects on physical function have been examined, but intervention effects on psychological function have not been sufficiently investigated. The present study, therefore, sought to clarify the effects of interventions for physical and psychological functions on improvement of function, ADL, and quality of life (QOL) in patients treated using ECTR for CTS.

Methods

Subjects

From August 2010 until March 2011, a total of 86 patients (106 hands) diagnosed with CTS underwent ECTR at our institution. The content and purpose of the study were explained in advance to these patients, and consent to participate in this study was obtained from prospective subjects. Patients who had previously undergone carpal tunnel release (CTR) surgery, who had a combination of different upper limb disorders, or who had a medical or surgical history were excluded. In addition, patients with secondary CTS (caused by hemodialysis, wrist osteoarthritis, rheumatoid arthritis, or diabetes), upper limb numbness, pain, or sensory impairment (spine and spinal cord disorders, cerebrovascular disease) were excluded along with those who could not complete the questionnaire because of dementia, based on the judgment of the examiner. Subjects were randomly allocated to an intervention group or control group after preoperative evaluation according to sex, age, disease duration, severity (Hamada, Ide & Yamaguchi, 1985), and type of disorder, starting with patients with the earliest date of preoperative evaluation. Staff members not involved in the evaluation or treatment of these patients rolled a dice. When an odd number was rolled, the patient was assigned to the control group, and when an even number was rolled, the patient was assigned to the intervention group. During the intervention period, patients who refused to participate in the study, those

with missing data, and those who were absent on the date of evaluation were excluded. Consequently, 25 patients were included in the intervention group (34 hands) and 24 were included in the control group (30 hands). Mean ages in the intervention and control groups were 59.8 ± 14.2 and 63.2 ± 11 years, respectively. This study was conducted after approval had been obtained from the hospital ethics committee (approval number: 54).

Methods

During preoperative examination, the intervention and control groups received explanations and precautions regarding the surgery. Patients underwent surgery on an outpatient or overnight inpatient basis. All surgeries were performed using the Okutsu method (Okutsu et al., 1987) by a surgeon specializing in hand surgery. During medical examination on postoperative day 1, the bulky dressing was removed to facilitate free movement of the wrist and fingers. After surgery, intervention was limited to patients in the intervention group only on the day of the surgery, as described below. Nothing was performed besides a medical examination in the control group. All patients were examined preoperatively and again at 5–13 days postoperatively (mean, 8.1 ± 1.9 days).

Intervention

An occupational therapist provided instruction on finger exercises and ADL. Instructions on finger and tendon gliding (Wehbé & Hunter, 1985) and nerve gliding (Totten & Hunter, 1991) exercises were given to patients in the intervention group. Tendon-gliding exercises consisted of 5 types: finger stretches; hook fist; full fist; table top; and straight fist. Nerve gliding exercises included 6 types: 1) finger and thumb flexion with the wrist in a neutral position; 2) finger and thumb stretches with the wrist in a neutral position; 3) wrist and finger stretches with the thumb in a neutral position; 4) wrist, finger, and thumb stretches; 5) forearm supination while performing wrist, finger, and thumb stretches; and 6) thumb stretches with forearm supination. These exercises were performed with the head in the median line, the shoulder girdle in a neutral position, and the forearm placed on the table with the elbow flexed at a 90° angle. Each position was maintained for 5 s. Three sets of exercises were performed 10 times/day and continued until the first follow-up at 1 week after surgery. To avoid exacerbation of inflammation, patients were instructed to stop the exercises immediately if pain was experienced in the wound or the palm during exercise.

Taking into account the methods of Okutsu, Hamanaka, and Yoshida (2008) and Montgomery (1994), consultations were held between occupational therapists

and doctors regarding the content of ADL instruction to be provided as part of the postoperative intervention in this study. The occupational therapist taught the following contents about ADL instruction. Patients were instructed to start with a light load in the pain-free range and to gradually increase load. To prevent numbness and pain, patients were instructed to minimize flexion and extension of the wrist. To prevent palmar dislocation in the flexor tendon and nerves and pain, patients were asked to avoid applying pressure or gripping of heavy loads involving holding a stretch for 1 month after surgery. Patients received an explanation that there may not be early improvement of ADL, and the disappearance of numbness and pain could take a relatively long time. Furthermore, brochures containing instruction on ADL and exercise were distributed after these consultations.

Evaluation

Occupational therapists not involved in the treatment intervention and blinded to the group allocation process performed the evaluations before and after surgery. Mean day of postoperative evaluation was 8 ± 1.8 days postoperatively (range, 5–13 days) for the intervention group, and 8.3 ± 2 days (range, 5–13 days) for the control group. The same occupational therapists performed all evaluations for each subject. Upper limb function (pain, numbness, perception, and range of motion (ROM)), anxiety, ADL, and QOL were evaluated.

An 11-point numerical rating scale (Jensen, Turner & Romano, 1994) was used for the evaluation of pain and numbness. This evaluation method included quantification of the current stimulation level, with the maximum stimulation level ever experienced set as 10. Perception was evaluated using the Semmes-Weinstein monofilament test (SWMT) (Aulicino, 2002) and static 2-point discrimination test (s2PD) (Aulicino, 2002) for the ventral part of the numbest finger. ROM was evaluated using the total active motion (TAM) assessment scale for the index finger. The Japanese version of the State Trait Anxiety Inventory (STAI) (Nakazato & Mizuguchi, 1982) was used to evaluate anxiety. With an anxiety scale created from self-evaluation questionnaires, both the temporary emotional state due to current living conditions and trait anxiety showing individual character tendencies can be measured. The present study only measured state anxiety.

The evaluation of ADL utilized the DASH symptom scale (Imaeda *et al.*, 2005), published by the Japanese Society for Surgery of the Hand. The reliability, validity, and efficacy of the DASH scale have been confirmed (Imaeda *et al.*, 2005). In this study, only items regarding disability/symptom were considered. The DASH is a 30-

item disability/symptom scale concerning disability of the upper extremity. Scores for all items are then used to calculate a scaled score ranging from 0 (no disability) to 100 (most severe disability).

The Japanese version of the Euro QOL 5-Dimension scale (EQ-5D) (The Japanese EuroQol Translation Team, 1998) was used to evaluate QOL. The EQ-5D visual analog scale (VAS) evaluates health state on a scale from 0 to 100. Respondents indicate how they feel that day (with 0 as the worst and 100 as the best state). The EQ-5D describes health status according to 5 dimensions: mobility, self-care, usual activity, pain/discomfort, and anxiety/depression. Each dimension has 3 levels, namely, “no problems”, “some problems” and “sever problems”. Responses to the 5 dimensions are collectively expressed in the standard way as an EQ-5D score using the value set, which ranges from a for perfect health (no problems in any dimensions) to -0.111 for worst health (severe problems in all dimensions).

Statistical processing

SPSS for Windows version 16 (SPSS, Chicago, IL, USA) was used for statistical analyses. The χ^2 test and Mann-Whitney U test were used to compare data in the intervention and control groups. Wilcoxon's signed-rank test was used to compare data within groups before and after surgery. The significance level was established at 5% for all measures.

Results

Patient characteristics are shown in Table 1. No significant differences were observed between the control and intervention groups in terms of these characteristics. Tables 2 and 3 display the results of clinical parameters for both groups. No significant differences were evident in the preoperative comparison of all evaluation items between groups. Postoperative pain was significantly lower in the intervention group than in the control group, whereas TAM and EQ-5D (VAS) scores were significantly higher in the intervention group than in the control group ($p = .01$, $p = .02$, and $p = .01$, respectively).

In pre- and postoperative comparisons within each group, a significant increase in pain was only observed in the control group ($p = .001$). Both s2PD and STAI scores declined significantly in the intervention group after the intervention ($p = .002$, $p = .01$). The control group showed no significant change. Likewise, no significant change in EQ-5D (5 dimensions) was seen for either group, whereas the EQ-5D (VAS) score was significantly higher only in the intervention group ($p = .03$).

Table 1. Baseline characteristics of study patients

	Intervention (n = 25)	Control (n = 24)
Age (years)	59.8 ± 14.2	63.2 ± 11.0
Height (cm)	155.0 ± 7.1	157.4 ± 6.4
Weight (kg)	56.9 ± 10.4	59.9 ± 8.3
Women, n (%)	19 (76)	18 (75)
Bilateral symptoms, n (%)	9 (36)	6 (25)
Affected side (dominant), n (%)	18 (72)	17 (71)
Disease duration (days)	31.2 ± 40.7	36.3 ± 52.3
Baseline-opo (days)	17.3 ± 11.0	18.2 ± 16.5
Severity		
I	26	20
II	3	3
III	5	7

Values are given as mean ± standard deviation.

*: Significant difference between groups.

Table 2. Comparison of functional status before and after surgery

		Intervention (n = 34)	Control (n = 30)	
NRS (pain)	Pre	2.3 ± 3.1	1.7 ± 2.8	] †
	Post	2.5 ± 3.0*	3.7 ± 2.2*	
NRS (numbness)	Pre	6.7 ± 2.6	6.4 ± 3.0	] †
	Post	3.0 ± 3.0	2.3 ± 2.5	
SWMT	Pre	3.7 ± 0.6	3.6 ± 0.8	] †
	Post	3.2 ± 0.7	3.4 ± 0.5	
s2PD	Pre	5.8 ± 2.8	5.6 ± 3.1	] †
	Post	4.4 ± 2.9	4.6 ± 2.7	
TAM (°)	Pre	220 ± 20.7	213.8 ± 23.5	
	Post	218.8 ± 17.2*	204.7 ± 22.4*	

Values are given as mean ± standard deviation.

*: significant difference between groups; †: significant difference within group.

NRS, numerical rating scale; SWMT, Semmes-Weinstein monofilament test; s2PD, static 2-point discrimination test; TAM, total active motion.

Table 3. Comparison of STAI, DASH and EQ-5D scores before and after surgery

		Intervention (n = 25)	Control (n = 24)	
STAI	Pre	40.2 ± 8.9	38.1 ± 7.4	] †
	Post	34.7 ± 12.2	36.6 ± 9.9	
DASH	Pre	24.2 ± 18.1	24.3 ± 19.4	] †
	Post	41.7 ± 20.9	47.2 ± 22.5	
EQ-5D (5 dimensions)	Pre	0.750 ± 0.1	0.77 ± 0.1	
	Post	0.75 ± 0.2	0.74 ± 0.1	
EQ-5D (VAS)	Pre	66.6 ± 19.8	68.5 ± 15.6	] †
	Post	77.2 ± 16.9*	67.7 ± 16.3*	

Values are given as mean ± standard deviation.

*: significant difference between groups; †: significant difference within group.

STAI, State Trait Anxiety Inventory; DASH, Disability of the Arm, Shoulder and Hand; EQ-5D, Euro QOL 5-Dimension; VAS, visual analog scale.

Discussion

This study examined the effects of finger exercises and instruction in ADL on postoperative improvements in hand function, ADL, and QOL in patients with CTS treated using ECTR. Tendon and nerve gliding exercises are reportedly effective in the prevention and improvement of adhesions affecting the gliding of nerves and tendons in the hand (Cook, Szabo, Birkholz & King, 1995; Burke, Ellis, McKenna, Bradley & Dubin, 2003; Butler, 2000). These exercises are recommended as exercise therapy as part of conservative or invasive therapy in patients with CTS (Nathan, Meadows & Keniston, 1993; Cook et al., 1995). Gliding of the median nerve in such patients is decreased because of adhesions to surrounding tissue (Butler, 2000). Neurolysis is not performed because of technical difficulties and the narrow surgical field involved in the ECTR procedure (Hashizume, Nagoshi & Inoue, 1998). As a result, performing these exercises after ECTR may be necessary not only to prevent postoperative nerve adhesion, but also to encourage nerve gliding.

Perception tests convey information about nerve function. In this study, differences between the intervention and control groups were only seen in the results of the s2PD among the perception tests. Simsir, Sarsan, Akkaya, and Yildiz (2011) examined correlations between electrophysiological testing and perception tests and reported high correlations with s2PD scores, but not with SWMT scores. Katz, Gelberman, Wright, and Abrahamsson (1994) reported that because the s2PD reflects dysfunction of the median nerve, it is useful as a postoperative evaluation method. The results of the s2PD accurately reflect changes in the median nerve and this intervention may accelerate nerve recovery. Training in nerve-gliding exercises may therefore have positive effects on the recovery of nerves and surrounding tissue after ECTR.

When tissue is damaged as a result of injury or surgery, swelling and pain can occur. Mechanical stimulation during acute inflammation can lead to chronic inflammation and prevent normal healing (Gary, 2005). ECTR does not require extensive recovery time after surgery, so use of the hand may begin at an early stage. However, excessive activity may exacerbate hand dysfunction and delay recovery. Patients require a thorough explanation of how to resume postoperative ADL. In this study, occupational therapists provided individual intervention regarding postoperative ADL to patients in the intervention group. By instructing patients to increase the use of their hand in a step-by-step manner while performing ADL, excessive loads can be decreased and exacerbation of inflammation prevented.

Postoperative pain was significantly higher in the control group, whereas no significant changes were seen in the intervention group, suggesting that the postoperative restrictions on hand usage imposed for the ADL instruction in this study facilitated pain prevention in ECTR patients. Postoperative limits to ROM were also better in the intervention group than in the control group, but this result can be attributed to lower pain levels in the intervention group. Pain relief at an early stage is crucial to the retention of good postoperative hand function.

Anxiety may also exacerbate pain. Vranceanu *et al.* (2010) reported a correlation between acute postoperative pain and preoperative anxiety after minimally invasive surgery for CTS. In medical and physiological stress models, anxiety represents a psychological reaction caused by stress and perceiving a stressor as a threat causes anxiety (Spielberger, 1983). Preoperative anxiety is caused by daily stimuli such as thinking about or experiencing surgery. These feelings then become a stressor and may have large implications on recovery. In this study, anxiety showed no postoperative improvement in the control group. On the other hand, anxiety did show postoperative improvement in the intervention group. Inoue (2002) stated that objective and concrete information must be communicated in order to enhance feelings of control and alleviate anxiety and tension. Sustaining an uncomfortable psychological and physical state after surgery can be stressful. Objective information about the causes of pain and numbness and receiving instructions in coping methods can affect perception and may explain the differences in anxiety between the two groups in this study. When such information was clearly communicated to patients in previous studies (Hall & Stride, 1954; Langer, Janis & Worfer, 1975), pain and anxiety were alleviated. Instruction on ADL as utilized in this study should thus combine subjective and objective information to effectively alleviate anxiety and avoid the stress that delays complete postoperative recovery.

In this study, a brochure was distributed to patients in the intervention group to encourage the completion of postoperative exercises and communicate instructions for resuming ADL. In a study using a questionnaire on post-ECTR surgery, Yoshida *et al.* (2008) stated that patients reporting anxiety had received insufficient explanation from the medical staff and had demonstrated a lack of understanding of their condition. Visualization through a brochure makes the content of the instructions easier to understand and facilitates confirmation and repetition. Patients using the brochure can perform postoperative exercises and follow instructions on ADL more effectively. In this study, the intervention had a positive effect on the early improvement of postoperative physical and psychological function.

Objective evaluation indices such as the SWMT and tests of nerve conduction velocity have long been used to determine the therapeutic effects of interventions for CTS. In recent years, however, the importance of subjective evaluation indices has also come to be recognized (Itsubo *et al.*, 2009). The present study used the DASH scale and EQ-5D as subjective measures to evaluate ADL and QOL.

The DASH scale is a questionnaire that allows self-evaluation of the symptoms and abilities of the hand, and has been reported as a useful index for evaluating improvement in disorders resulting from CTS (Kameda *et al.*, 2007). A significant decrease in ADL for both groups was observed both pre- and post-operatively. Mackenzie, Hainer, and Wheatley (2000) reported that after ECTR, 2 weeks were required for grip and pinch strength to improve to preoperative levels. Muscular strength was not measured, but muscular strength may not have been sufficiently improved when patients completed the DASH scale. The presence of pillar pain may be another factor influencing postoperative recovery in CTS patients (Feinstein, 1993). Pillar pain has not been clearly defined, but pain in the thenar and hypoth- enar areas of the palm that appeared for 3 months after surgery is presumably caused by postoperative tendon synovitis and palmar cutaneous nerve injury (Ludlow, Merla, Cox & Hurst, 1997). Hunt and Osterman (1994) reported that pillar pain occurring in the early postoperative period delays the time until reinstatement or reuse of the hand and may result in decreased postoperative ADL. No differences in ADL were observed between groups after surgery. Responses to the DASH are supposed to be based on the state in the preceding week, not on the day of measurement. Good results were seen in the intervention group for physical and psychological function, but there is a possibility that these were not reflected by the DASH. Further investigation in consideration of the measurement time might therefore be warranted.

The EQ-5D is a comprehensive scale commonly used for the evaluation of changes health status. Differences in VAS scores were seen between the two groups in our study. The VAS score was increased only in the intervention group. Kuroda and Kanda (2007) reported a high correlation between the 5 dimensions evaluated on the EQ-5D and VAS scores, but suggested that subjective symptoms and mental state had a considerable effect on the latter. In this study, pain and anxiety were improved in the intervention group. These differences in postoperative pain and anxiety may have influenced the VAS scores.

This study had several limitations that need to be considered when interpreting the results. First, no de-

tailed study was performed to determine the compliance of the intervention group with regard to performing the exercises and following the rehabilitation instructions at home after discharge. Differences in the degree of implementation of these exercises and instructions thus remain unclear. Second, the sample size was small. Third, only anxiety was evaluated among many possible contributory psychological factors. The connection between psychological perception and pain must be evaluated in greater detail and should include factors such as depression and self-efficacy. Future studies will focus on these issues.

Conclusion

This study examined whether prescribed tendon and nerve gliding exercises and instruction in ADL accelerated improvements in hand function, ADL, and QOL after ECTR for CTS. Our results suggest that successful encouragement and description of the expected course of improvements in physical and mental function through tendon and nerve gliding exercises and instruction in ADL can enhance QOL at an earlier stage after ECTR.

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