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ORIGINAL REPORT

PERFORMANCE OF PRIORITIZED ACTIVITIES IS NOT CORRELATED WITH FUNCTIONAL FACTORS AFTER GRIP RECONSTRUCTION IN TETRAPLEGIA

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Objective: **To investigate the correlation between perceived performance in prioritized activities and physical conditions related to grip reconstruction.**
Design: **Retrospective clinical outcome study.**
Patients: **Forty-seven individuals with tetraplegia were included in the study. Each participant underwent tendon transfer surgery in the hand between November 2002 and April 2009 and had a complete 1-year follow-up.**
Methods: **Functional characteristics and performance data were collected from our database and medical records. Patients' perceived performances in prioritized activities were recorded using the Canadian Occupational Performance Measurement. Preoperative data included age at surgery, time since injury, severity of injury, sensibility and hand dominance. At 1-year follow-up, grip strength, key pinch strength, finger pulp-to-palm distance, distance between thumb and index finger and wrist flexion were measured. Correlation rank coefficient was used to test the possible relationship between physical data and activity performance.**
Results: **There were improvements in both functional factors and in rated performance of prioritized activities after surgery. There was no correlation between performance change and any of the physical functions, the factors known before surgery, or the functional outcome factors.**
Conclusion: **No correlation exists between a single functional outcome parameter and the patients' perceived performance of their prioritized goals in reconstructive hand surgery in tetraplegia.**

Key words: quadriplegia; hand strength; pinch strength; activities of daily living; tendon transfer; surgery.

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INTRODUCTION

Surgical reconstructions of grip functions in persons with tetraplegia have been performed and evaluated for decades. Outcome measurements focus primarily on body function dimensions, such as grip strength and a general activity dimension (1–4). It is concluded that the patients benefit from the surgery in both of these dimensions.

The overall goal of surgery is not only to strengthen the grip, but also to improve the individuals' everyday life. Hence, it is reasonable to apply the patients' perception of performance and satisfaction as an outcome parameter. Seventy percent of the patients undergoing reconstructive upper limb surgery report general satisfaction with the results and a positive impact on their lives (5). Interestingly, more complex activities tend to relate to a higher degree of satisfaction than basic activities such as traditional activities of daily living (ADL) activities (6). This observation highlights the usefulness of letting the individual choose the activities to evaluate in order to get a better appreciation of the benefits they experience from surgery.

A restored grip function expands the patient's opportunities in most activities. After hand trauma, a correlation between recovery of grip strength and overall hand function and activities has been demonstrated in daily living (7). However, Rice et al. (8) reported that grip strength measures alone are not sufficient predictors of hand function. Studies of individuals with tetraplegia reported problems in predicting grip ability and improvement in ADL based on grip strength (9, 10). Poor grip ability encourages the individual to develop skills to perform activities in an adapted way to compensate for lack of grip strength. After grip reconstruction, individuals have the opportunity to develop new skills due to their new functions. Nevertheless, patients are forced to perform their activities in a conformed manner, and remaining limitations may interfere with the way in which they can perform the activities. Since the tetraplegic person is forced to perform in adapted ways, it is unlikely that functional improvement automatically results in improved performance in important activities.

Before considering having surgery, patients often ask many and relevant questions about what to expect from the surgery and whether the anticipated gains are worth the risks and efforts. Therefore, the need to predict outcome is crucial for the patient before making the final decision as to whether to undergo surgery. A well-informed patient is essential for the decision-making process and to match the expectations of performance after surgery and rehabilitation with the patient's needs.

The aim of this study was to investigate the correlation between perceived performance in prioritized activities and physical conditions related to grip reconstruction. We wanted to investigate whether functional factors known before surgery can predict post-operative activity improvement.

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METHODS

Setting and patients

This study was set at National Centre of Reconstructive Hand Surgery in Tetraplegia, Sahlgrenska University Hospital, Gothenburg, Sweden. All tetraplegic patients who underwent tendon transfer surgery in the hand from November 2002 to April 2009 were included in the study. The combination of tendon transfers was individualized, but all had at least tendon transfer to restore thumb flexion (Table I). Patients who went through follow-ups of both their activity and physical status after one year were selected for analyses.

Rehabilitation began on the first day after surgery, with functional training. After 4 days, the patients were discharged from hospital and managed the training several times a day by themselves. A personalized exercise programme guided them. After 3–4 weeks, they returned to the clinic for 5 days of functional training as well as training in activities important for daily living. Additional follow-ups were performed at 3, 6 and 12 months.

Table I. *Demographics*

Sex	Earlier hand surgery	Age at surgery, years	Time since injury, years	ASIA[a]	Level of injury	IC[b]	Hand dominance	Sensibility	Type of surgery
M	No	46	11	A	C6	OCu4	Non-dominant	Sensibility	t, f, c, pi,
M	No	61	36	C	C6	OCu5	Dominant	Sensibility	t, f
M	No	31	16	A	C6	OCu3	Dominant	Sensibility	t, f, pi
F	No	59	2	D	C7	OCu5	Dominant	Sensibility	t, f, a, pi
F	No	53	4	A	C5	O1	Dominant	No sensibility	pof, c, pt
F	No	48	28	A	C5	O2	Dominant	No sensibility	pt, c
M	No	30	3	A	C3	O1	Dominant	No sensibility	t
M	No	65	21	B	C6	OCu4	Dominant	Sensibility	t, f, c, pi
M	No	50	28	A	C7	OCu5	Non-dominant	Sensibility	t, f, pi
M	No	36	2	A	C6	OCu4	Dominant	Sensibility	t, f, c, i
M	Yes	36	16	A	C7	OCu4	Non-dominant	Sensibility	t, f, c
M	No	32	12	C	C6	OCu5	Dominant	Sensibility	t, f, a
M	No	20	1	C	C6	OCu6	Dominant	Sensibility	t, f, a
F	No	45	3	A	C7	OCu8	Non-dominant	Sensibility	t, f, a, c, ai
F	No	49	21	A	C6	OCu4	Dominant	Sensibility	t, f, c, pi
M	No	25	5	A	C5	O2	Non-dominant	No sensibility	t, c
F	Yes	74	4	A	C6	OCu4	Non-dominant	Sensibility	t, f, c, pi
F	No	72	2	A	C6	OCu4	Dominant	Sensibility	t, f, a
M	No	33	12	A	C5	O3	Dominant	No sensibility	t
M	No	22	2	A	C6	O1	Dominant	No sensibility	t, f, c
F	No	31	5	B	C7	OCu7	Non-dominant	Sensibility	t, f, a
M	No	33	2	A	C5	OCu3	Dominant	Sensibility	t, f, pi
M	No	22	1	A	C5	OCu4	Non-dominant	Sensibility	t, f
M	Yes	23	2	A	C6	OCu5	Dominant	Sensibility	t, f, a, ai
M	No	39	3	C/D	C5	OCu7	Non-dominant	Sensibility	t, f, a, pi
M	Yes	32	3	A	C6	OCu4	Non-dominant	Sensibility	t, f
M	No	31	2	A	C6	OCu4	Dominant	Sensibility	t, f, c, pi
M	No	33	10	A	C6	OCu3	Dominant	Sensibility	t, f, c
M	No	26	5	A	C6	OCu4	Non-dominant	Sensibility	t, f, pi
M	No	51	16	A	C5	OCu4	Dominant	Sensibility	t, f
M	No	53	3	B	C7	OCu4	Dominant	Sensibility	t, f, c
M	No	21	3	A	C5	O1	Dominant	No sensibility	t, c
F	No	62	6	C	C5	O2	Dominant	No sensibility	t, a
M	No	40	9	A	C7	OCu4	Non-dominant	Sensibility	t, f, c, pi
F	No	26	1	A	C6	OCu4	Dominant	Sensibility	t, f, i, c
M	No	27	5	A	C6	O1	Dominant	No sensibility	top, c
M	Yes	29	7	A	C6	O1	Non-dominant	No sensibility	t, c
M	Yes	32	3	A	C5	OCu2	Dominant	Sensibility	t
M	No	31	2	A	C5	O1	Non-dominant	No sensibility	t
M	No	63	8	C	C6	O8	Non-dominant	No sensibility	t, f, a
M	No	59	3	A	C6	OCu4	Dominant	Sensibility	t, f, c,
M	No	43	20	C	C3	O3	Non-dominant	No sensibility	top, f, a,
M	No	64	3	A	C6	OCu4	Non-dominant	Sensibility	t, f
M	No	28	1	A	C7	OCu4	Dominant	Sensibility	t, f
M	No	45	14	C	C7	OCu6	Dominant	Sensibility	t, f, a, pi
M	No	28	3	A	C5	OCu4	Dominant	Sensibility	t, f
F	No	27	8	A	C5	OCu3	Dominant	Sensibility	top, f, c

[a]Neurological Classification according to the American Spinal Injury Association.
[b]International Classification; McDowell et al., 1986 (14).
M: male; F: female; t: thumb flexion reconstruction; f: finger flexion reconstruction; c: first carpometacarpal arthrodesis; pi: passive intrinsic reconstruction; ai: active intrinsic reconstruction; top: combined thumb flexion and pronation reconstruction; pof: combined pronation and finger flexion reconstruction; pt: passive thumb flex/ext; a: thumb abduction reconstruction.

Outcome measurements

The patients' activity goals and their perceived performance were measured using the Canadian Occupational Performance Measurement (COPM) (11). This instrument detects a person's self-perception of activity performance over time. As the COPM interviews were orientated towards grip reconstruction, the individual described problems associated with hand function experienced in his or her daily life. The patients were encouraged to select the 5 most important activity limitations. In our clinic, we use the perceived activity limitations as goals in the surgery. Finally, the individual rated the prioritized goals for current level of performance on a scale ranging from 1 to 10 (1 = not able to perform the activity, 10 = able to perform the activity extremely well). At 12 months postoperatively, the patient was asked to rate the performance of the prioritized activities again. The difference between the preoperative and postoperative ratings for each patient indicated the changes in activity performance after surgery. In order to make group analysis of the activity change, the differences were divided *a posteriori* into 3 groups; unsure improvement (–0.7–2.0 points), improvement (2.1–4.0) and major improvement (4.1–8). The author of COPM claims that a scale difference of 2 is a "clinically important change" (12). Therefore the "unsure improvement" group included individuals with ≤ 2 points improvement. In order to analyse the type of goals, each goal was classified according to the International Classification of Functioning, Disability and Health (ICF) (13).

Functional characteristics and performance data were collected retrospectively from our database and from medical records. Data known before surgery included age at surgery, time since injury, severity of injury according to international classification (14), sensibility as measured by 2-point discrimination (a distance of more than 10 mm between the 2 points in the thumb is considered "no sensibility") and hand dominance at time of surgery. Factors analysed at 1 year follow-up were: ability to close the hand (reflected by grip strength (kg) (Jamar Hand Dynamometer, North Coast Medical, Gilroy, USA), key pinch strength (kg) (Preston Pinch Gauge, North Coast Medical, Gilroy, CA, USA, finger pulp-to-palm distance (cm)) and ability to open the hand (reflected by maximal distance between thumb and index finger (cm), joint range of motion and muscle strength of wrist flexion).

Statistical analysis

All values are reported as means and ranges. Ordinal data are also reported with median. To detect differences in activity performance between pre- and post-surgery, a Wilcoxon signed-rank test was used. Spearman's rank correlation coefficient was used to test the possible relationship between physical data and performance. Individuals with surgery on both sides were excluded during correlations testing at second surgery to avoid bias. Because of the unequal magnitude of variance in the 3 different performance groups, data are presented in figures and no statistical tests were performed to detect possible differences between the groups. Statistical tests were performed using SPSS (version 17.0).

RESULTS

Subjects

Forty-seven grip reconstructions with tendon transfers were performed on 41 individuals (36 men and 11 women). Mean age at surgery was 40 years (20–74) and mean time since injury was 8 years (1–36). No hand had normal sensation, 72% had some sensibility in the thumb and 28% had no sensibility in the entire hand. Sixty-four percent of the surgery was performed on the dominant hand and 36% on the non-dominant hand. Six persons had had surgery on the contralateral hand.

The combinations of operations necessary to restore grip function were addressed individually. All participants underwent restoration of thumb flexors. In 77% of the hands, both the finger flexors and thumb flexors were reconstructed (Table I).

The participants produced a total of 220 prioritized activity goals. There is a wide spread of activities represented, which simulates the person's life situation (Fig. 1). Self-care, including personal care and dressing and eating, is the largest group (45%). Goals related to leisure represent 7% of the expressed goals.

General improvements

Pinch and grip strengths after 1 year were 2.1 (0.2 to 5.6) and 6.6 (2 to 20) kg, respectively. The maximal distance between the thumb and index finger at opening of the hand was 5.0 (0 to 14.5) cm. The gap between the fingertips and palm was less than 1 cm when flexing the fingers. There were significant mean and median improvements in performance, of 3.3 (–0.7 to 7.0) points, 2.7 (1.2 to 5.3) points before surgery and 6.0 (2.5 to 9.8) 1 year after reconstruction.

General correlation

There was no correlation between performance change and any of the physical functions, the factors known before surgery (sensibility, hand dominance, age, years after injury, severity of injury, type of surgery), or the functional outcome factors (grip and pinch strength, pulp to palm distance, opening, wrist flexion active or passive). The correlation coefficient never exceeded 0.2.

Specific group analysis

There were 8 arms in the "Unsure improvement" group (–0.7 to 2.0 points), 21 in "improvement" group (2.1 to 4.0 points) and 18 in the "great improvement" group (4.1 to 8 points).

Pinch strength after surgery ranged from 1.9 to 2.4 kg and grip strength ranged from 5.9 to 7.5 kg between the 3 groups (Fig. 2).

The absence or presence of sensibility did not discriminate between the different groups of performance improvement. Patients without sensibility displayed similar results to those with sensibility (Fig. 3). Opening ability and hand dominance did not predict the outcome in performance. The non-dominant hand showed similar results to the dominant hand (Fig. 3).

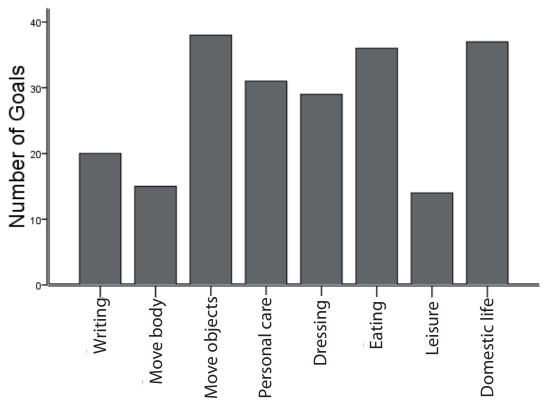

Fig. 1. Total number and distribution of prioritized goals (n = 220) between different areas in 47 individuals with tetraplegia undergoing reconstructive hand surgery.

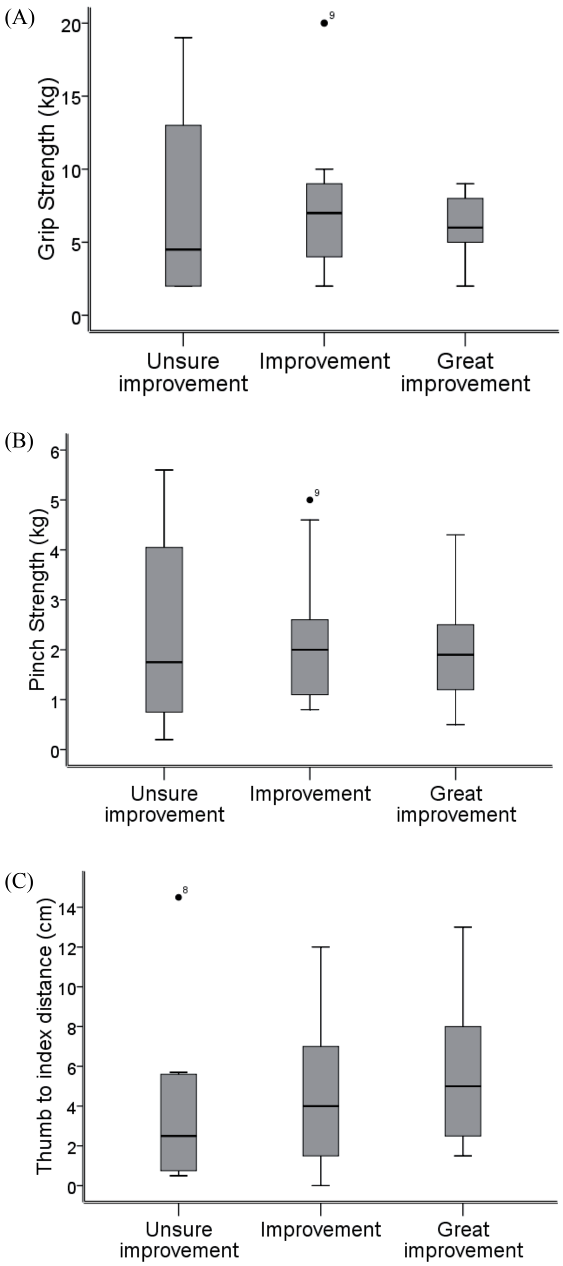

Fig. 2. Functional characteristics measured as (A) grip strength, (B) key pinch strength, and (C) opening of the hand (maximal distance between thumb and index finger) for different levels of perceived improvement of performance. Note that the magnitudes were essentially the same across different improvement groups.

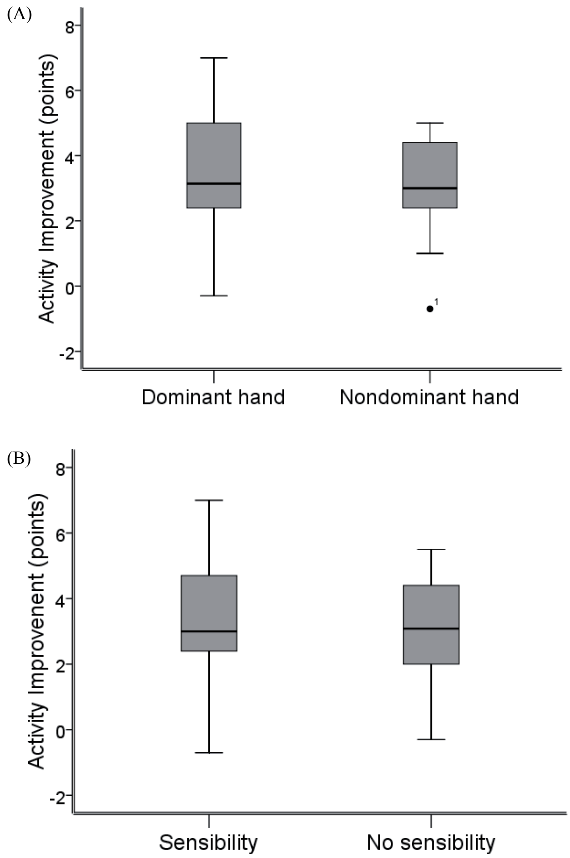

Fig. 3. Magnitude of the improvement of activity performance measured as difference between pre- and post-operative assessments relative to (A) hand dominance and (B) sensibility.

DISCUSSION

In this study there was no correlation between a single functional outcome parameter and the patients' perceived performance in their prioritized goals in reconstructive tetraplegia hand surgery. Furthermore, there was a disconnection between most of the factors traditionally judged as appropriate indicators of successful reconstructions in tetraplegia and self-rated outcome. Hand function in tetraplegia is usually evaluated by measurement of finger pulp sensibility, number of muscles available for surgery, joint range of motion and hand dominance. This study does not confirm previous postulations of the importance of sensibility (4, 18, 19) and the necessity of performing the surgery on the dominant side. Patients can reach their activity goals independent of sensibility, age or hand dominance.

Body functions, including, for example, grip strength and range of motions, are of course important factors for the ability to perform various activities. Functional training is needed to optimize the activation of the transferred muscle (16). Even if no single body function correlates with activity improvement, these functions need to be optimized in order to achieve better activity performance. The weak correlation between function and activity performance indicates the need for both functional and activity training to ensure optimal results. Improvement in activity dimension is a complex process relying on many factors. To develop new skills and to ensure that the new function integrates optimally with daily activities, specific activity training is necessary to transform the improved functions into activity skills (16). Except for learning new motor programmes, there are also personal factors, such as self-assurance, habits, and willingness to relearn, as well as the physical environment and social support that probably influence the results in activities. To gain desired improvements in activity and attain new function in daily living, it is important to be aware of these resources and/or barriers to the rehabilitation process.

In some cases expectations about the surgery might be unrealistic. It is difficult for caregivers to predict the exact activity outcome, and even a well-informed patient may have difficulty in envisaging the results. Forner-Cordero (10) reported that 57.2% of the patients expected more from the surgery and were somewhat disappointed in spite of the functional improvement. Even if the patient has good functional improvement, it will not correlate with expected activity improvements if the expectations are unrealistic. As a clinical tool, the COPM is useful to detect patients' activity expectations and a well-informed patient is therefore essential. The results of this study do not indicate the use of any single physical factor known before surgery as a general predictor of activity performance. However, the discussion with the patient is essential in order to clarify whether specific needs could be met by the surgery.

The dominant hand naturally receives more activity training because the brain is programmed to use this hand in activity. The non-dominant hand use is less automated and requires active thinking to a much greater extent. Although there were no differences in improved performance between the 2 hand dominance groups, the pre-experienced skills are not the same for the non-dominant hand as for the dominant hand. However, when setting differentiated goals depending on hand dominance, activity training can give as good results in the non-dominant hand as in the dominant hand.

Moberg (17) stated that hand function depends on its mobility and sensibility, and some authors argue that patients with no sensibility should not be submitted to tendon transfer (4, 18, 19). Forner-Cordero (10) affirmed the lower result in ADL in the group of patients with zero sensibility, indicating the importance of sensibility as a predictor for general activity results. The results of this study, however, also indicate that patients with no sensibility experience improvements in their prioritized goals similar to those in the hands with sensibility. We therefore suggest that patients with hands lacking sensibility should be considered as surgery candidates, since they gain from the surgery to the same extent as those who have hands with some sensibility. A hand without sensibility is more useful with a grip than without active grip ability.

In conclusion, it is currently impossible to produce an algorithm that predicts the success or failure or lack of success according to the patient's prioritized goals even if a general improvement is measured (6). Activities of daily living rely on several and complex sensi-motor processes, and it is not surprising that no single physical change can explain the improvement.

Further investigations of larger populations, preferably in the setting of multi-centre studies, are needed ultimately to determine the power of different factors used to predict outcome. Since the functional factors alone could not explain activity improvement, attempts need to be made to define factors that facilitate or prevent patients from reaching their activity goals.

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