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Original Article

The relationship between proximal function of the upper extremity on the paralyzed side and upper extremity skills in daily life of subacute stroke patients

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ABSTRACT
Nakashima N, Miyasaka H, Kondo I, Iwata K, Uematsu H, Yamamura C, Sonoda S. The relationship between proximal function of the upper extremity on the paralyzed side and upper extremity skills in daily life of subacute stroke patients. Jpn J Compr Rehabil Sci 2017; 8: 44–50.
Objectives: The effects of proximal function of the upper extremity on the paralyzed side on daily life skills were examined in stroke patients.
Methods: One hundred and forty-seven stroke patients were evaluated using the Functional Skills Measure After Paralysis (FSMAP), the Finger-Function test (FF), and the Knee-Mouth test (KM) of the Stroke Impairment Assessment Set (SIAS). The FSMAP score for each subgroup of the SIAS-KM level was compared.
Results: The FSMAP score was significantly higher in patients with a KM score of 2/3 compared to patients with a KM score of 0/1 when SIAS-FF was 0/1A; in patients with a KM score of 2/3 compared to patients with a KM score of 0/1 and in patients with a KM score of 4/5 compared to patients with a KM score of 2/3 when SIAS-FF was 1B, 1C, or 2; and in patients with a KM score of 4/5 compared to patients with a KM score of 2/3 when SIAS-FF was 3, 4, or 5.
Conclusion: The cross-sectional study indicated that differences in the level of proximal function affect the upper extremity skills when the level of distal function is equivalent.
Key words: stroke, upper extremity function, activities of daily life, evaluation

Introduction

It is generally believed that post-stroke function of the upper extremity on the paralyzed side greatly improves within 8 weeks after stroke onset [1], and that the recovery of proximal and distal functions follows a similar course [2]. On the other hand, the functional outcome varies between proximal dominant and distal dominant paralysis depending on the location and size of lesions [3]. Moreover, the degree of functional recovery in stroke patients may vary, depending on several factors. Thus, upper extremity skills on the paralyzed side should be comprehensively assessed while providing training during rehabilitation.

Lang et al. investigated the relationship between functional impairment and upper extremity skills on the paralyzed side in stroke patients, and reported that proximal and distal functions mutually affect upper extremity functionality. The authors had found that the active range of motion of each segment of the upper extremity on the paralyzed side in stroke patients was highly correlated with the results of upper extremity functionality assessed using the Jebsen Test of Hand Function and the Action Research Arm Test [4]. In addition, Merians et al. provided robot-assisted training to improve the proximal and distal functions of post-stroke patients, and reported improvements in the outcomes of upper extremity skills, including improved proximal stability, smoothness, and efficiency of the movement path in concert with an improvement in distal function [5]. Thus, there are

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several studies reporting that proximal and distal functions are mutually correlated with upper extremity skills, such as grasping an object. However, the effect of proximal function alone on upper extremity skills has not been clarified.

While robot-assisted training is effective for improving proximal function of the upper extremity on the paralyzed side, its effect is unlikely to be reflected in the improvement of activities of daily life (ADL) [6, 7]. According to a review by Kwakkel et al., the effects of robot-assisted training on ADL have been studied using the Functional Independence Measure (FIM) [7]. However, it may have failed to precisely capture the effect because ADL and upper extremity functionality are different aspects. Moreover, the lack of a rating scale with high affinity for both proximal function of the upper extremity and ADL may also be a factor for this failure.

In this study, we assessed whether upper extremity skills are affected by the difference in proximal function of the upper extremity on the paralyzed side in stroke patients using the Functional Skills Measure After Paralysis (FSMAP) [8–10].

Subjects

This study included 147 patients with first-ever stroke who were admitted to the Fujita Health University Nanakuri Memorial Hospital (Table 1). The inclusion criteria were as follows: patients who had supratentorial lesions with paralysis in the unilateral upper extremity; and those who fully understood directions and were able to indicate their intention (FIM [11] not less than 4 points in comprehension, not less than 2 points in expression). The exclusion criteria were as follows: patients who had a history of functional impairment, such as fracture of the upper extremity on the paralyzed side or rheumatoid arthritis; and those with a serious comorbidity, as indicated by a score of 4 or higher on the Liu comorbidity index [12].

Methods

1. Evaluation items

Evaluation items included the FSMAP, Knee-Mouth test (KM), and Finger-Function test (FF) of the Stroke Impairment Assessment Set (SIAS) [13], grip force, pinch force, and FIM. These items were evaluated at admission by an occupational therapist of the Fujita Health University Nanakuri Memorial Hospital.

2. FSMAP

FSMAP is used to assess functional skills of the upper extremity on the paralyzed side. Functional skills include those that support capability, for instance, the motion of drinking water from a cup is composed of a series of functional skills: reaching for the cup, holding the cup, carrying the cup to the mouth, and drinking the water. In the FSMAP, 15 items of ADL were assessed, and each item consisted of 3–5 functional skills. Each item on the FSMAP was rated as either possible (score 1) or impossible (score 0) with the total score being 65. Miyasaka et al. [14]

Table 1. Patient characteristics.

Age [years]	64.4 ± 13.5 [66]
Paretic side [right / left]	73 / 74
Gender [male / female]	81 / 66
Days from stroke onset [days]	35.4 ± 13.8 [35]
Lesion type	
Ischemic	75
Hemorrhagic	70
Subarachnoid hemorrhage	2
SIAS	
Knee-Mouth test (0 / 1 / 2 / 3 / 4 / 5)	45 / 32 /19 / 21 / 21 /9
Finger-Function test (0 / 1A / 1B / 1C / 2 / 3 / 4 / 5)	61 / 22 / 7 / 15 / 13 / 6 / 14 / 9
Grip force [kg]	
Paralyzed side	3.7 ± 6.7 [0]
Non-paralyzed side	25.4 ± 11.4 [25.0]
Pinch force [kg]	
Paralyzed side	1.4 ± 2.1 [0]
Non-paralyzed side	7.2 ± 4.9 [7.0]
FIM	
Motor item	49.8 ± 18.6 [50]
Cognitive item	26.2 ± 7.6 [28]

Mean ± Standard deviation [Median]; SIAS, Stroke Impairment Assessment Set; FIM, Functional Independence Measure.

performed a Rasch analysis of the FSMAP, and converted the raw score (65 points) to the corresponding value (scaled score), which ranged from 0 to 100 points. Therefore, the scaled score can be treated as an interval scale.

Evaluation items included in the FSMAP and an example of the evaluation content are shown in Table 2 and Figure 1, respectively.

3. Methods

In this study, SIAS-FF scores of 0/1A, 1B/1C/2, and 3/4/5 were defined as severe paralysis (individual movement is difficult), intermediate paralysis (slight individual movement is possible), and mild paralysis (individual movement is possible), respectively. To study the functional skills at each level of proximal function, the differences in functional skills at each KM level were compared according to the severity of paralysis in FF using the scaled score of the FSMAP.

Patient clinical characteristics were stratified by SIAS-FF and SIAS-KM and are shown in Table 3.

4. Statistical procedure

In this study, patients were stratified by the severity of paralysis. The Kolmogorov-Smirnov test was performed to determine data normality. Data was observed to be normally distributed for an FF score of 0/1A and a KM score of 2/3; FF score of 1B/1C/2 and KM score of 2/3; FF score of 1B/1C/2 and KM score of 4/5, and FF score of 3/4/5 and KM score of 2/3, while other combinations of scores did not exhibit data normality. A nonparametric test was performed for all combinations due to the small sample size of each group in this study.

The scaled FSMAP score was used for comparison. The Mann-Whitney *U* test was used for FF scores of 0/1A and 3/4/5, while the Kruskal-Wallis test was used for an FF score of 1B/1C/2. The significance level was set at 5%.

Table 2. Category and subitems of Functional Skills Measure After Paralysis (FSMAP).

Category	Number of subitems
Use of a glass	5
Opening a PET bottle	4
Holding a PET bottle	4
Holding paper	3
Tearing newspaper	4
Folding paper	4
Turning over pages	3
Coin	5
Bowl	5
Spoon	5
Garment	5
Buttons	5
Pants	4
Washing face	4
Washing hands	5

Results

The maximum value, minimum value, quartile value, and median of the scaled score of the FSMAP for the SIAS-FF and SIAS-KM subgroups are shown in Figure 2. When the FF score was 0 or 1A, the scaled score was significantly higher in patients with a KM score of 2/3 compared to patients with a KM score of 0/1, while it was significantly higher in patients with a KM score of 2/3 and 4/5 compared to patients with a KM score of 0/1 and 2/3, respectively, when the FF score was 1B, 1C, or 2. When the FF score was 3, 4, or 5, the scaled score was significantly higher in patients with a KM score of 4/5 compared to patients with a KM score of 2/3. In this study, the scaled scores for functional skills were significantly higher in patients with a higher KM level when the SIAS-FF was equivalent.

Discussion

In this study, the effects of the difference in level of proximal function of the paralyzed-side upper extremity on functional skills were examined in stroke patients. When the level of distal function is comparable, functional skills are affected by the difference in level of proximal function.

Stabilization of proximal function has been reported

Table 3. Background data for subgroups stratified by severity of paralysis according to evaluation results with SIAS.

Finger-Function test	0, 1A		1B, 1C, 2			3, 4, 5	
Knee-Mouth test	0, 1	2, 3	0, 1	2, 3	4, 5	2, 3	4, 5
Number of patients	71	12	6	23	6	5	24
Age [years]	65.0 ± 13.0	57.9 ± 17.7	72.5 ± 9.9	62.4 ± 14.2	66.5 ± 4.8	58.0 ± 15.2	67.2 ± 13.2
Paretic side [right / left]	39 / 32	7 / 5	3 / 3	9 / 14	1 / 5	3 / 2	11 / 13
Gender [male / female]	40 / 31	6 / 6	3 / 3	9 / 14	3 / 3	1 / 4	10 /14
Days from stroke onset [days]	36.0 ± 15.3	38.2 ± 14.1	39.7 ± 14.1	35.4 ± 14.0	31.5 ± 7.9	26.8 ± 11.5	32.9 ± 9.8

Mean ± Standard deviation; SIAS, Stroke Impairment Assessment Set.

Washing hands

Notes
Patient is allowed a maximum of three attempts or trials for each task.
Position: Standing (Assisted standing is acceptable).
Patients who are unable to stand are not acceptable for this item.

Subitems

Rating (1 or 0)
(1) Moves paralyzed hand towards the sink, and soaks it in water for longer than 5 s.
(2) Puts hand soap on paralyzed hand (Use of non-paralyzed hand is acceptable).
(3) Fixes paralyzed hand and rubs it with non-paralyzed hand. Fixation is longer than 5 s.
(4) Washes non-paralyzed hand with paralyzed hand.
(5) Washes and rubs hands including washing between fingers.

Rating standard

Starting position and instrument arrangement.
The sink is positioned at a height between the mid-thigh and navel.
The patient may turn the tap with the non-paralyzed hand.
The paralyzed arm should not contact the sink.
(1) Moves paralyzed hand towards the sink, and soaks it in water.
For a score of 1, the patient must raise his/her paralyzed hand, reach the tap water, and wet his/her paralyzed hand for longer than 5 s, regardless of the size of wet area; otherwise, the score is 0. The paralyzed upper arm can contact the side of the trunk. The paralyzed arm should not contact the sink.
(2) Puts hand soap on the paralyzed hand.
For a score of 1, the patient must put hand soap on the paralyzed hand; otherwise, the score is 0.
The patient separates the paralyzed hand from the trunk and maintains the space, and operates the push pump with the non-paralyzed hand.
In addition, the push pump may be held either in the air or on the sink.
(3) Fixes paralyzed hand and rubs it with the non-paralyzed hand.
For a score of 1, the paralyzed hand must be fixed and the non-paralyzed hand rubs it under running water; otherwise, the score is 0.
If the paralyzed hand cannot be fixed for longer than 5 s and it moves with the movement of the non-paralyzed hand, or it contacts the sink, the score is 0.
The paralyzed hand can contact the side of the trunk.
(4) Washes non-paralyzed hand with paralyzed hand.
For a score of 1, the paralyzed hand must wash the dorsal side and palm of the non-paralyzed hand; otherwise, the score is 0.
If the paralyzed hand contacts the sink and/or there is compensatory movement of the non-paralyzed arm and hand, the score is 0.
The paralyzed upper arm may contact the side of the trunk.
When it is difficult to judge, the rater may hold the non-paralyzed arm.
(5) Washes and rubs hands including washing between fingers.
For a score of 1, the patient must wash the paralyzed hand including between the fingers with cooperative movement of the non-paralyzed hand; otherwise, the score is 0.
When washing only partially between the fingers, the score is 0.
Holding the paralyzed arm against the trunk is not acceptable.

Instruments
Liquid hand soap (Push pump system 500 ml).

Figure 1. Evaluation manual in the FSMAP (Washing hands).
Washing hands consisted of 5 functional skills (subitems). The rater scores each subitem as either 1 (possible) or 0 (impossible) according to the rating criteria.
Precautions and goods to be used are specified; thus, evaluation can be done by anyone by using the manual.

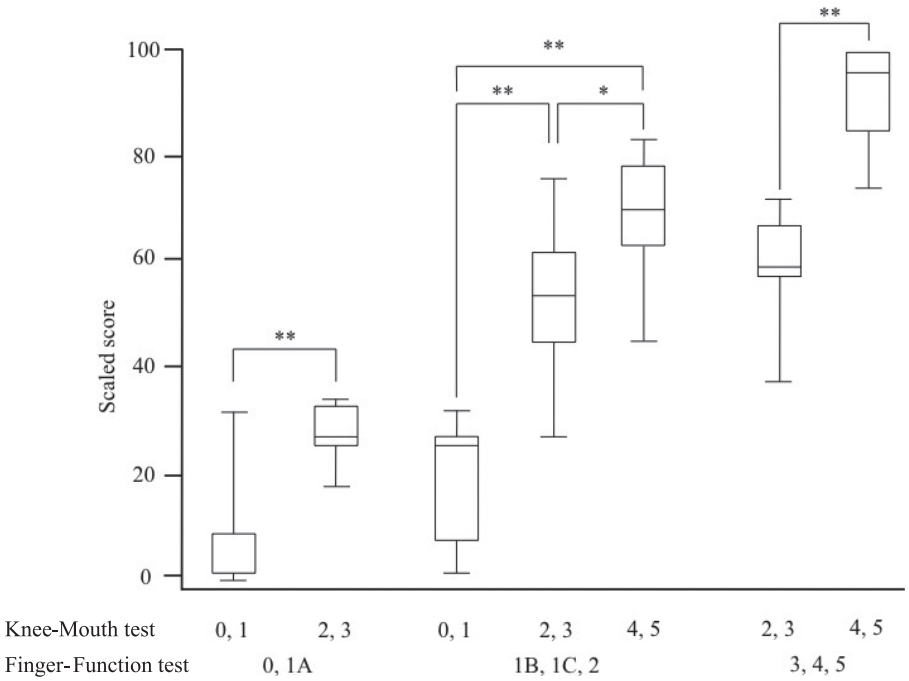

Figure 2. Scaled score of FSMAP grouped according to the severity of paralysis.
Scaled score of FSMAP for each subgroup of SIAS-FF and SIAS-KM. Scaled score of FSMAP is rated on a 100-point scale. The Mann-Whitney *U* test was used for FF scores of 0/1A and 3/4/5, while the Kruskal-Wallis test was used for an FF score of 1B/1C/2.
Box plots present the minimum value, lower quartile, median, upper quartile, and maximum value in ascending order.
** p Represents significance level < 0.01; * p Represents significance level < 0.05.

to improve upper extremity function in some studies [4, 5]. However, subgroups were not stratified by the severity of paralysis and differences in level of proximal function were not examined in these studies. The results of the present study demonstrated that the FSMAP score varied depending on the level of proximal function despite the equivalent level of finger-function on the paralyzed side. In particular, patients with an SIAS-KM score of 2/3 were able to reach over and hold an object even though their SIAS-FF score was 0/1A and their ability to perform voluntary distal functions was poor. Generally, rehabilitation of the upper extremity on the paralyzed side is performed to facilitate movement of the upper extremity on the paralyzed side. Stewart et al. indicated that patients with severe upper extremity paralysis have difficulty using the upper extremity on the paralyzed side in daily life [15]. On the other hand, Thielman et al. reported that the improvement of coordination of elbow-shoulder motion may affect upper extremity functionality in patients with low motor function [16]. Patients with severe paralysis in this study were able to perform more gross tasks using proximal functions while they experienced difficulty performing the gripping and pinching tasks using distal functions.

It has been reported that the severity of upper extremity motor paralysis is correlated with trunk compensation during reaching movements in stroke patients, and that a trunk compensatory strategy is used for more severe motor paralysis to compensate for reaching movement [17, 18]. In the FSMAP used in this study, trunk compensation was not limited. As a result, the object reaching tasks and tasks that required holding the upper extremities in space were performed by the effective use of trunk compensation, and this may have contributed to the results of this study.

Several studies have reported a correlation between proximal function and distal function, and that motor activity in the upper extremity is controlled by the complementary action of both proximal and distal functions of the upper extremities [4, 19−22]. Finger extension and individual movements are observed in patients with an SIAS-FF score of 1B, 1C, or 2. Patients at these levels are assumed to be capable of performing an object grasping task. Therefore, distal dominant functional skills are acquired when proximal function is poor, while difficult proximal functional skills, including performing an object reaching task and holding the upper extremity of the paralyzed side in space, increase with proximal function improvement. Therefore, greater stabilization of proximal function may affect the ability to perform distal functions.

Montgomery et al. reported that the trunk and

proximal upper extremity muscles are innervated by the ipsilateral cerebral cortex [23]. Thus, proximal function experiences greater improvement compared to distal function due to bilateral innervation in stroke patients. Hence, rehabilitation of proximal function should be actively performed, and it may be useful for improvement of upper extremity skills.

Study limitations

This study has some limitations.

First, the sample size was small. The SIAS was used for classification of the severity of paralysis in this study. While the SIAS is clinically easy to use, it is limited by a distribution bias as its categorical structure does not allow for equal distribution. Therefore, since only five patients were included in the smallest group in the study, it is important to be cautious when interpreting our results.

Second, patients during the recovery phase were enrolled in this study. As function following paralysis begins to recover in stroke patients, patients may not yet be able to perform tasks that require the upper extremity on the paralyzed side as residual, but not yet compensatory, function is available. Conversely, skills requiring coordinated movements involving compensatory upper extremity on the non-paralyzed side may be acquired in patients with chronic stroke because spontaneous recovery of the upper extremity on the paralyzed side is reduced. It is necessary to investigate functional skills in patients with chronic stroke to study the differences in functional skill recovery following stroke onset in the future.

Finally, patients included in this study were inpatients at the same hospital, and sampling biases, such as days from stroke onset and the paralysis side, were eliminated when possible. Therefore, the results of this study are considered to be generally reliable. However, we cannot determine a causal relationship between changes and rehabilitation as the data was collected in a cross-sectional manner. In the future, a longitudinal study is required to examine the effects of improvement of proximal function on upper extremity functionality.

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