# The Effects of Sensorial Functions on Motor Functions and Functional Assessments in Patients with Chronic Stroke

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**Abstract:** *Background:* Sensory dysfunction following stroke is a common syndrome. Unless sensory dysfunction is assessed and defined, motor recovery will be limited due to focusing on motor performance during the rehabilitation and maximum outcomes will not be obtained for the treatment. *Objective:* To investigate the effect of sensory functions on motor function and functional status. *Method:* Sixty patients with chronic stroke hospitalized for rehabilitation of hemiplegia after stroke. Brunnstrom and Fugl-Meyer motor assesment scales to determine motor improvement were used, Functional independence measurement (FIM) was used for functional evaluation. Touching was used for superficial sensory assesment. Thumb localization and finger shift tests were used for deep sensorial assesment. Stereognosis and two-point discrimination tests were used for cortical sensory assesment. Partial localization-finger scrolling tests, stereognosis and two-point discrimination tests were evaluated for the deep sense and cortical senses of the patients. *Result:* Two point discrimination test result was 5-6 mm in 20 (33.3%) patient and 7 mm and abouve in 40 (66.7%) patients. Superficial sensory examination was found hipoesthetic in 50 patients (83.3%) and normal in 10 patients (16.7%). With the Two-point discrimination test, 20 patients (33.3%) were found to have a score of 5-to-6 mm' s, and 40 patients were found to have a score of 7- more mm' s. While proprioception was normal in 38 patients, in 22 patients was found to be mildly impaired by thumb localization test and finger shift test. 26 patients recognised 10 to 12 objects 15 patients recognised 7 to 9 objects and 19 patients recognised less than 7 objects by sterognazie assesment. There were statistically significant differences between superficial sense, Two-point discrimination, and sterognazie results and FIM, Brunnstrom upper-lower limb and Fugl-Meyer upper-lower values before and after hospitalization. Brunnstrom and Fugl-Meyer results were statistically significant according to Thumb localization test and finger shift test before and after hospitalization; however there was no difference according to FIM. *Discussion:* The findings of this study revealed that sensory dysfunctions were common after a stroke and affected motor and functional conditions of the patients. There is a significant relationship between motor functions and sensory functions in stroke patients. Assessment of sensory functions and early diagnosis will improve motor healing. *Conclusion:* A detailed examination of sensory functions and inclusion in the treatment program may be considered as an effective factor in improving motor function.

**Keywords:** Stroke, Sensory Function, Motor Function

## 1. Introduction

Stroke leads to motor paralysis, emotional, perceptual, mental, visual, language and speech disorders, and variations in the daily activities by influencing extremity and body on the side of the body contralateral hemisphere with lesion.

Sensory dysfunction following stroke is a common syndrome. The loss of sensory functions might be loss of only one sensory modality, such as light touch, or the entire loss of somatosensorial senses [1-3]. The primary somatosensory, cortex plays a role in motor control by individually or in combination with primary motor cortex [4]. Normal movement requires an intact motor system; however,

sensorial information must also reach to the cortex correctly during moving in space. If there is lack of body position awareness during the beginning of the movement or external variations cannot be sensed, it is not possible to perform a coordinated and effective movement [5].

Although somatosensory impairment is a common condition, it is mostly failed to notice. Rehabilitation focuses on motor abilities in the effected or weak extremities. However, it has been detected that somatosensory exercises appear with a significant improvement in somatosensory performance which also cause progress in the motor recovery eventually [4]. Studies showed that sensory recovery proceeded in the stroke patients in the chronic stage [6-8].

In the clinic, two-point discrimination, astereognosis, somatoagnosia, unilateral neglect, position sense and vibration arise in the lesions of primary somatic somatosensory cortex. Astereognosis is the most common sensory dysfunction following proprioception and impaired tactile sensation. Nevertheless, discriminative sensory dysfunction has been frequently reported, as well. The ratios of sensory dysfunction in stroke patients vary by way of defining and evaluating the sensory dysfunction. Therefore, sensory dysfunction following stroke variates between 11 and 100 according the limited number of studies [9, 10].

Somatosensory loss is a common condition in stroke patients. There are few studies available on this issue and the prevalence of sensory dysfunction is the wide range of 11-60%. Unless sensory dysfunction is assessed and defined, motor recovery will be limited due to focusing on motor performance during the rehabilitation and maximum outcomes will not be obtained for the treatment [11].

We investigated the effect of sensory functions on motor function and functional status in chronic stroke patients.

## 2. Method

In the present study, 85 chronic stroke patients, who had hemiplegia after stroke and received inpatient rehabilitation, were evaluated. Nineteen patients with cognitive function impairment and aphasia, one patient who had stroke because of intracranial tumor and five patients with a second stroke were excluded from the study. The study included 60 patients. Approval was obtained from the ethics committee of the hospital for the study. Patient consents were taken by informing the patients about the study.

### 2.1. Inclusion Criteria

1) Hemiplegia or hemiparesis following the first stroke
2) Six-month post-stroke period
3) Psychosocial relevance
4) Age range of 40-80 years

### 2.2. Exclusion Criteria

1) Having comorbid diseases that might prevent rehabilitation
2) Patients having communication or significant cognitive and emotional impairment

3) Concomitant lower motor neuron or peripheral nerve lesion
4) Having aphasia and communication impairment
5) Having contracture and movement restriction on hemiplegic joints
6) Having movement disorders such as ataxia, dystonia or dyskinesia
7) Illiterate patients
8) Having the medical history of stroke
9) Having stroke due to a reason, except cerebrovascular condition

Sensory examination was performed in three sections; superficial, deep and cortical sensations. Tactile sensation was examined as superficial sensation. It was classified as normal and hypoesthesia. Examination was performed with a piece of cotton by comparing normal and abnormal areas. Deep sensation was performed as a proprioceptive sense by Thumb Localization Test and Finger Shift Test (*Up or Down test*). In the Thumb Localization Test, the patient was asked to localize the paralyzed side with normal hand and eyes closed, and the result was assessed as normal, impaired or slightly impaired. Finger Shift Test evaluated the awareness during up and down passive movement of the thumb proximal joint with eyes closed, and the patient's response was recorded as normal, impaired and slightly impaired [12, 13].

Cortical sensation was evaluated by considering stereognosis and two-point discrimination tests. Stereognosis was scored in three groups; 1) 10-12 objects, 2) 7-9 objects and 3) <7 objects. The patient was asked to close his/her eyes during the examination. Meanwhile, easily recognizable objects, such as key, pencil, lighter and glass, were placed in the patient's hand. During two-point discrimination test, patient's hand was supported, and patient was asked to close his/her eyes. The assessment was done from the palmar surface of distal phalanx of the thumb. A two-point discriminator was used for the test, and it was divided into two groups; 5-6 mm and >7mm [14, 15]. Brunnstrom and Fugl-Meyer motor assessment scales were used for motor functions of the patients [16, 17]. The Functional Independence Measurement (FIM) scale, of which the Turkish validity and reliability was performed by Kucukdeveci et al., was applied for functional assessment [18].

The FIM measures function in the areas of self-care, sphincter control, mobility, locomotor function, communication and social perception by using a 7-point scale for each activity. It consists of 13 motor and 5 cognitive items [19]. Totally 20 sessions of combined exercise program (conservative and neurophysiologic exercises) was applied to the patients once a day in the rehabilitation center. The findings of sensory examination were compared to the results of FIM, Brunnstrom upper-lower-hand, Fugl-Meyer upper-lower and spasticity while in hospital and post-discharge.

### 2.3. Statistical Assessment

SPSS 22.0 package program was used for statistical

analysis.. Kolmogorov Smirnov was used to decide whether the distribution of variables was normal. Chi-square test, Mann-Whitney-U test and one-way analysis of variance (ANOVA) were used to assess for significant differences between the demographic, clinic and SF-36 values of the patients, and t-test and Kruskal Wallis test were used for independent groups. Wilcoxon T test was performed to assess the input and output data between the groups, and t-test used was used for dependent groups. Frequency and percentages were calculated for the concomitant pathologies, patients' medical history, risk factors and complications.

# 3. Result

Fifty patients (83.3%) had hypoesthesia and 10 patients had normal sensory findings according to the superficial sensations. Patients were grouped according to the sensory features and there was no statistically significant difference between the demographic features of the patients and the duration of disease (p>0.05). Table 1 shows the general characteristics of the subjects.

**Table 1.** *Demographic characteristics, illness and length of stay in hospital according to superficial sense.*

| n=60 | hypoesthesia (n=50) | normal (n=10) | p value |
|---|---|---|---|
| Age (years) | 61.42±12.63 | 63.70±7.27 | 0.728 |
| Gender | | | |
| Female | 26 | 6 | 0.643 |
| Male | 24 | 4 | |
| Affected side | | | |
| Right | 24 | 6 | >0.050 |
| Left | 26 | 4 | |
| Etyology | | | |
| İschemia | 40 | 9 | 0.456 |
| Hemorrhage | 10 | 1 | |
| Duration of illness (month) | 11.84±7.33 | 13.8±7.08 | 0.618 |
| Duration of hospitalization (day) | 29.88±12.50 | 24.4±11.58 | 0.206 |

The values of motor and FIM were higher in patients with normal superficial sensation, and a statistically significant difference was detected between the groups (p<0.05).

Patients completed the thumb localization test were defined as 'normal' proprioception, and those could not complete the test were defined as 'slightly impaired' proprioception. Thirty-eight patients (63.3%) completed the test and twenty-two patients (36.7%) could not complete the test. The in-hospital and post-discharge values of Brunnstrom upper-lower-hand, Brunnstrom recovery and Fugl-Meyer upper-lower were significantly different in patients with 'normal' proprioception in comparison to those with 'slightly impaired' proprioception (p< 0.05) (table-2).

**Table 2.** *Motor and functional independence measurements of patients according to superficial sense.*

| n=60 | Hipoestezik (n=50) | Normal (n=10) | P değeri |
|---|---|---|---|
| FIM baseline | 81.58±22.85 | 104.3±22.28 | 0.006* |
| FIM after | 90.32±22.45 | 113±12.93 | 0.001* |
| FIM difference | 8.74±7.56 | 8.70±12.34 | 0.989 |
| Brunnstrom upper baseline | 3.26±1.35 | 5.20±1.32 | 0.001* |
| Brunnstrom upper after | 3.46±1.33 | 5.60±0.70 | 0.001* |
| Brunnstrom upper difference | 0.20±0.40 | 0.40±0.96 | 0.282 |
| Brunnstrom lower baseline | 3.28±1.14 | 4.60±1.65 | 0.018* |
| Brunnstrom lower after | 3.52±1.13 | 4.90±1.20 | 0.002* |
| Brunnstrom lower difference | 0.24±0.47 | 0.30±0.48 | 0.718 |
| Brunnstrom hand baseline | 3.1±1.28 | 5.60±1.26 | 0.001* |
| Brunnstrom hand after | 3.32±1.35 | 5.90±0.32 | 0.001* |
| Brunnstrom hand difference | 0.22±0.42 | 0.30±0.95 | 0.668 |
| Fugl-meyer upper baseline | 24.8±21.38 | 51.9±15.95 | 0.001* |
| Fugl-meyer upper after | 28.72±20.1 | 56.7±4.95 | 0.001* |
| FIM baseline | 3.92±6.65 | 4.80±12.44 | 0.747 |
| FIM after | 15.9±6.61 | 24.8±6.36 | 0.001* |
| FIM difference | 17.62±6.7 | 26.2±5.45 | 0.001* |
| Brunnstrom upper baseline | 1.72±1.95 | 1.40±1.83 | 0.636 |
| Brunnstrom upper after | 26.66±1.84 | 26.90±2.23 | 0.717 |
| Brunnstrom upper difference | 17.720±9.13 | 13.00±9.22 | 0.142 |

According the Finger Shift Test, the patients completed the test was defined as 'normal' proprioception, and those could not complete the test were defined as 'slightly impaired' proprioception. Thirty-eight patients (63.3%) completed the test and twenty-two patients (36.7%) could not complete the test. The in-hospital and post-discharge values of Brunnstrom upper-lower-hand, Brunnstrom recovery and Fugl-Meyer upper-lower were significantly different in patients with 'normal' proprioception in comparison to those with 'slightly impaired' proprioception (p< 0.05) (table-3).

**Table 3.** *Measurements of motor and functional independence with thumb finger localization test.*

| n=60 | normal (n=38) | Mild affected (n=22) | P value |
|---|---|---|---|
| FIM baseline | 89.76±26.8 | 77.77 ±17.99 | >0.050 |
| FIM after | 97.75±24.95 | 87.77±17.00 | >0.050 |
| FIM difference | 8.00±8.42 | 10.00±8.45 | 0.379 |
| Brunnstrom upper baseline | 33.84±14.47 | 31.23±17.33 | 0.105 |
| Brunnstrom upper after | 39.68 ±12.29 | 39.14±13.67 | 0.393 |
| Brunnstrom upper difference | 5.84±5.80 | 7.90±7.17 | 0.228 |
| Brunnstrom lower baseline | 4.29±1.43 | 2.36±0.66 | 0.001* |
| Brunnstrom lower after | 4.58±1.24 | 2.5±0.74 | 0.001* |
| Brunnstrom lower difference | 0.29±0.61 | 0.14±0.35 | 0.287 |
| Brunnstrom hand baseline | 3.82±1.43 | 2.9545±0.9 | 0.028* |
| Brunnstrom hand after | 4.03±1.28 | 3.27±1.03 | 0.027* |
| Brunnstrom hand difference | 0.21±0.41 | 0.31±0.57 | 0.401 |
| Fugl-meyer upper baseline | 4.4±1.35 | 2.01±0.9 | 0.001* |
| Fugl-meyer upper after | 4.74±1.08 | 2.05±0.21 | 0.001* |
| Fugl-meyer üst difference | 0.34±0.63 | 0.04±0.21 | 0.036* |
| Fugl-meyer lower baseline | 41.68 ±18.07 | 7.95±11.69 | 0.001* |
| Fugl-meyer lower after | 45.53±14.72 | 12.41±12.42 | 0.001* |
| Fugl-meyer lower difference | 3.84±8.35 | 4.45±6.85 | 0.772 |
| FIM baseline | 19.34±7.12 | 14 ±6.52 | 0.005* |
| FIM after | 20.71±6.88 | 16.18±7.04 | 0.018* |
| FIM difference | 1.36±1.55 | 2.18±2.40 | 0.116 |

Depending on the findings of two-point discrimination test, the distance was 5-6 mm and >7 mm in twenty (33.3%)

and forty (66.7%) patients, respectively. Motor and FIM values was higher in patients with TPD of 5-6 mm in comparison to those with TPD of >7 mm (p<0.05) (table-4).

***Table 4.*** *Motor and functional independence measurements of patients according to two point discrimination.*

| n=60 | 5-6 mm | ≥7 mm | p value |
|---|---|---|---|
| | (n=20) | (n=40) | |
| FIM baseline | 99.3± 24.63 | 78.4± 20.87 | 0.010* |
| FIM after | 108.6± 19.72 | 86.85± 20.75 | 0.000* |
| FIM difference | 9.30±10.43 | 8.45±7.33 | 0.716 |
| Brunnstrom upper baseline | 5.1± 1 | 2.83± 1.13 | 0.000* |
| Brunnstrom upper after | 5.4± 0.6 | 3.03± 1.09 | 0.000* |
| Brunnstrom upper difference | 0.30±0.73 | 0.20±0.40 | 0.498 |
| Brunnstrom lower baseline | 4.15± 1.6 | 3.18± 1.06 | 0.006* |
| Brunnstrom lower after | 4.4± 1.35 | 3.43± 1.06 | 0.030* |
| Brunnstrom lower difference | 0.25±0.44 | 0.25±0.49 | 1 |
| Brunnstrom hand baseline | 5.3± 0.92 | 2.63± 0.95 | 0.000* |
| Brunnstrom hand after | 5.6± 0.5 | 2.83± 0.98 | 0.000* |
| Brunnstrom hand difference | 0.30±0.73 | 0.20±0.41 | 0.498 |
| Fugl-meyer upper baseline | 51.5± 11.6 | 18.23± 18.6 | 0.000* |
| Fugl-meyer upper after | 54.6± 5.5 | 22.77± 17.87 | 0.000* |
| Fugl-meyer üst difference | 3.10±8.81 | 4.55±7.27 | 0.501 |
| Fugl-meyer lower baseline | 21.55± 7.5 | 15.30± 6.36 | 0.010* |
| Fugl-meyer lower after | 23± 7.4 | 17.07± 6.35 | 0.020* |
| Fugl-meyer lower difference | 1.45±1.64 | 1.77±2.07 | 0.543 |

Twenty-six patients (43.3%) exactly recognized 10-12 objects in stereognosis assessment. Fifteen patients (25%) had moderate stereognosis impairment and they could recognize 7-9 objects. Patients with severe stereognosis impairment could identify less than 7 objects and there were 19 (31.7%) patients in this group. The in-hospital and post-discharge values of FIM, Brunnstrom upper-lower-hand, Fugl-Meyer upper-lower and Brunnstrom recovery were significantly different in these three patients (p< 0.05) (table-5).

***Table 5.*** *Motor and functional independence measurements according to stereognazia.*

| n=60 | 5-6 mm | ≥7 mm | P value |
|---|---|---|---|
| | (n=20) | (n=40) | |
| FIM baseline | 99.3± 24.63 | 78.4± 20.87 | 0.010* |
| FIM after | 108.6± 19.72 | 86.85± 20.75 | 0.000* |
| FIM difference | 9.30±10.43 | 8.45±7.33 | 0.716 |
| Brunnstrom upper baseline | 5.1± 1 | 2.83± 1.13 | 0.000* |
| Brunnstrom upper after | 5.4± 0.6 | 3.03± 1.09 | 0.000* |
| Brunnstrom upper difference | 0.30±0.73 | 0.20±0.40 | 0.498 |
| Brunnstrom lower baseline | 4.15± 1.6 | 3.18± 1.06 | 0.006* |
| Brunnstrom lower after | 4.4± 1.35 | 3.43± 1.06 | 0.030* |
| Brunnstrom lower difference | 0.25±0.44 | 0.25±0.49 | 1 |
| Brunnstrom hand baseline | 5.3± 0.92 | 2.63± 0.95 | 0.000* |
| Brunnstrom hand after | 5.6± 0.5 | 2.83± 0.98 | 0.000* |
| Brunnstrom hand difference | 0.30±0.73 | 0.20±0.41 | 0.498 |
| Fugl-meyer upper baseline | 51.5± 11.6 | 18.23± 18.6 | 0.000* |
| Fugl-meyer upper after | 54.6± 5.5 | 22.77± 17.87 | 0.000* |
| Fugl-meyer üst difference | 3.10±8.81 | 4.55±7.27 | 0.501 |
| Fugl-meyer lower baseline | 21.55± 7.5 | 15.30± 6.36 | 0.010* |
| Fugl-meyer lower after | 23± 7.4 | 17.07± 6.35 | 0.020* |
| Fugl-meyer lower difference | 1.45±1.64 | 1.77±2.07 | 0.543 |

## 4. Discussion

The findings of this study revealed that sensory dysfunctions were common after a stroke and affected motor and functional conditions of the patients.

Sensory dysfunction is common disorder after a stroke. A defect in somatosensorial system blocks feedback received from sensory system and prevents to acquire new motor skills. Unless sensory dysfunction is assessed, motor recovery will be limited due to focusing on motor performance during the rehabilitation and maximum outcomes will not be obtained for the treatment [19, 20]. In this study, the ratio of superficial sensory impairment was 83.3% and the ratios of impairment according to the thumb localization and finger shift test, stereognosis and two-point discrimination tests were 36.7%, 56.7% and 66.7%, respectively. The ratios of sensory impairment varied according the results of sensory tests performed in this study. These results might be due to the subjective assessment of the sensory analysis, loss in any body region and variety of the applied methods. Debbie et al. stated that motor and proprioceptive deficits resulted in a worse functional outcome in stroke patients. If motor deficit was predominant in the patients and sensory loss was not apparent, patients showed better recovery [21]. These results were compatible with findings of this study; motor and functional outcomes were better in patients with normal or near-normal test results. The inhibitory mechanisms of nervous system, such as spinal cord, subcortical structure and cerebral cortex, promote the mechanism of two-point discrimination. Two-point discrimination is related to the fine motor activities of the hand. Therefore, it is a classical test to measure functional sensitivity. Motor and functional outcomes were better in patients with normal or near-normal two-point discrimination test results [22, 23].

The detailed sensory examination has a significant importance after stroke. The results of this study indicated that the outcomes of post-stroke motor and sensory assessment at the acute stage were better indicators in the prediction of prognosis. In the study of Connell et al., the sensory outcomes at 6 months after stroke were found to be correlated to the degree of post-stroke sensory impairment at the acute stage [10]. Stephanie et al. evaluated muscle strength and two-point discrimination in 50 patients at the 5th day of the acute stroke to predict the clinical appearance at 6 months after stroke. They stated that the values of two-point discrimination and muscle strength obtained at the end of the first month were good indicators to predict the progress at 6 months after stroke. They detected that this condition was not relevant to the localization and severity of the stroke [24]. The patients of this study were at the chronic stage and we could not make a prediction about the prognosis. These studies that we had encountered during literature scanning were only recommendation to the rehabilitation physicians for approaching sensory assessment of stroke patients at the acute and chronic periods.

In a study investigating the course of sensory impairment in stroke in 5 stroke patients with initial tissue loss, somatosensorial impairment was detected at the 1 week, 3 months and 12 months after the stroke.

Weight discrimination or stereognosis provided better recovery in 3 months; however, passive tests, such as tactile sensing threshold test, graphesthesia and two-point discrimination test, showed better recovery even after 3 months. Certain methods (graphesthesia impairment and motion perception) were evaluated as deteriorated meanwhile after first recovery [25].

## 5. Conclusion

Sensory dysfunction is a common disorder after stroke and it is equivalent to other post-stroke impairments in terms of recovery time. Motor, sensory and cognitive functional inabilities were assessed in detail at both acute and chronic stages of stroke patients, and patient-oriented treatments should be designated, and multidisciplinary approaches should be performed.

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