

Neurologic Outcome in Conservatively Treated Patients With Incomplete Closed Traumatic Cervical Spinal Cord Injuries

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Study design. The neurologic outcome in patients with conservatively managed incomplete closed traumatic cervical spinal cord injuries was evaluated using the motor scoring system and the Frankel classification.

Objectives. To show that the motor scoring of recovery system combined with functional Frankel grading will make the documentation of final neurologic outcome more accurate for future comparisons of various methods of treatment.

Summary of Background Data. The influence of surgical and pharmacologic methods of treatment on recovery remains debatable.

Methods. Sixty-three consecutive patients with incomplete cervical injuries who were admitted to the hospital within 2 days after injury were included. All patients were treated conservatively with 6 weeks of bed-rest and 6 weeks of mobilization with neck support.

Results. Five patients had neurologic deterioration, and all but one patient recovered without surgery. The evaluation of 44 patients who were observed for more than 12 months showed that the preservation of sharp sensation below the level of injury was an indicator of a good prognosis in patients whose injuries were classified as Frankel B, and the degree of recovery of these patients according to the motor score system was comparable with that of patients who were classified as Frankel C. All patients classified as Frankel C who did not deteriorate recovered in Frankel grade. All but one of the patients in the Frankel D group recovered full motor power. The degrees of motor deficit and recovery did not correlate with the mechanism or the degree of the injury of the spinal axis.

Conclusion. Conservative treatment remains a good option for patients with incomplete cervical cord injuries. It is hoped the current study will be a good basis for comparison of the neurologic outcomes of different

treatment modalities. [Key words: cervical-spinal cord injury, conservative treatment, incomplete paralysis, neurology] *Spine* 1996;21:2345-2351

Since the establishment of the comprehensive management of patients with spinal cord injuries, the prognoses of morbidity, mortality, and quality of life have been completely transformed.^{9,19} The prognosis of neurologic recovery also has improved as a result of better understanding of the physiological instability of the injured spinal cord and the untoward effects of complication arising from the associated multisystem impairment of neurologic functions.¹² To date, however, the influence of surgical and pharmacologic methods of treatment on recovery remains debatable.^{3-5,11,18,20,28-30} The inherent nature of the injury and the lack of sensitive scales for measuring small changes in neurologic progress are probably two of the many reasons why an assessment of the influence of treatment on recovery is difficult. The neurologic outcome of conservative management of cervical spinal cord injuries has been reported frequently.^{2,10,13,27} This study was designed to document the neurologic progress of patients with incomplete paralysis using a combination of measurement scales that will make future comparisons of outcomes with different methods of treatment easy and meaningful.

Materials and Methods

Sixty-three consecutive adult patients who had been admitted to the hospital between January 1983 and December 1992 with incomplete sensory sparing and with or without motor sparing were included in this study. The patients were admitted within 2 days after injury, and were treated conservatively. The authors excluded patients with double injuries of the spinal axis, roots or plexus injuries, skeletal injuries that interfered with accurate neurologic documentation, and 12 patients who underwent surgery for stabilization. The remaining 63 patients were evaluated retrospectively. All patients had some sensory sparing more than four segments below the last normal segment (LNS) with or without motor sparing, according to the

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Table 1. Causes of Injuries

Causes	Number of Patients
Road traffic accidents	29
Falls from heights	16
Diving	7
Horse riding	3
Falls on level ground	3
Rugby	2
Others	3
Total	63

American Spinal Injury Association (ASIA) classification.⁸ Twenty-eight patients were admitted on the day of injury, 25 patients were admitted on the day after injury, and 10 patients were admitted within 2 days after injury. There were 52 male and 11 female patients. The age of the patients at the time of the injury ranged from 16–80 years (average, 37.3 years of age), and the follow-up period ranged from 1–119 months (average, 33.0 months). The causes of their injuries are listed in Table 1.

The authors protocol of conservative treatment consisted of bedrest with skull traction for 6 weeks (average, 44.7 days) followed by mobilization in a brace for 6 weeks. Patients with hyperextension injury without bone injury usually were treated with 4 weeks of bedrest. Anticoagulant therapy and H₂-receptor antagonist medication were administered to almost all patients. Closed reduction with slow incremental weights, with or without manipulation, was attempted in 11 patients within 48 hours after the injury; only four of these patients required general anesthesia. Methylprednisolone was not used for any of these patients. The stability of the cervical spine was assessed radiographically by dynamic views at 6 weeks and 12 weeks after injury. One patient underwent anterior discectomy and fusion because of neurologic deterioration and was downgraded from Frankel C to Frankel B. One patient died because of preexisting constrictive lung disease. thromboembolic disease developed in two patients. Another two patients went into cardiac arrest during recumbency; both recovered uneventfully. The average total hospitalization period from injury to discharge after rehabilitation was 181.0 days (range, 45–337 days) for the patients in the Frankel B group, 132.0 days (range, 49–251 days) for those in the Frankel C group and 58.9 days (range, 39–77 days) for those in the Frankel D group.

Neurologic status was recorded according to the original Frankel classification and ASIA motor score.^{8,17} The motor score was calculated from the summation of the grade of the strength of five key muscles in each extremity on a six-point scale ranging from 0 to 5, and totaling as much as 100 for a full score (Tables 2 and 3).⁸ For further quantification of the motor deficit and recovery, the motor deficit percentage (MDP) and the motor recovery percentage (MRP) were identified as fol-

Table 3. Key Muscles in the ASIA Motor Scoring System

Segment	Muscles
C5	Elbow flexors (biceps, brachialis)
C6	Wrist extensors (extensor carpi radialis longus and brevis)
C7	Elbow extensor (triceps)
C8	Finger flexors (flexor digitorum profundus) to the middle finger
T1	Small finger abductors (abductor digiti minimi)
L2	Hip flexors (iliopsoas)
L3	Knee extensors (quadriceps)
L4	Ankle dorsiflexors (tibialis anterior)
L5	Long toe extensor (extensor hallucis longus)
S1	Ankle plantar flexors (gastrocnemius, soleus)

lows: $MDP = (1 - \text{summation of initial motor score below LNS} \div \text{full motor score of these segments}) \times 100 (\%)$; $MRP = (\text{follow-up motor score} - \text{initial motor score}) \div (100 - \text{initial motor score}) \times 100 (\%)$.¹⁴

The skeletal injuries were classified using the criteria of Allen et al.¹ The bony stenosis at the site of injury was measured at the time of admission and during the follow-up examination on the plain radiographs as described by Donovan et al.¹⁰ The percentage of stenosis was calculated, and the degree of kyphosis at the follow-up examination was measured.¹⁰ The patients whose skeletal injuries were not diagnosed from plain lateral radiographs but were diagnosed from computed tomographs were excluded from the measurements. The levels of the skeletal injuries are listed in Table 4.

■ Results

The 63 patients were classified according to the severity of their injuries at the time of admission as follows: 28 patients as Frankel B, 25 patients as Frankel C, and 10 patients as Frankel D. Mean MDP values were 96.4% (range, 76.7–100%) in the Frankel B group, 75.5% (41.3–97.8%) in the Frankel C group, and 23.6% (4.4–48.9%) in the Frankel D group. The MDP for each type of skeletal injury is listed in Table 5.

Neurologic Deterioration

Spontaneous neurologic deterioration was recorded in six patients. Another patient with ankylosing spondylitis in the Frankel B group lost sacral sensory sparing after reduction. Two patients deteriorated from Frankel C to Frankel B on the first day after injury. The motor score in

Table 4. Levels of Skeletal Injuries Who Were Followed for More Than 12 Months

Level of Skeletal Injuries	Number of Patients
C 3–C 4	7
C 4	2
C 4–C 5	3
C 5	0
C 5–C 6	17
C 6	3
C 6–C 7	5
C 7	3
Undetermined	4
Total	44

Table 2. A Six-Point Scale on Motor Testing of Key Muscles

0 = Total paralysis
1 = Palpable or visible contraction
2 = Active movement, full range of motion (ROM) with gravity eliminated
3 = Active movement, full ROM against gravity
4 = Active movement, full ROM against moderate resistance
5 = (Normal) active movement, full ROM against full resistance

Table 5. Types of Cervical Injuries and the Motor Deficit Percentage

	Number of Patients	Motor Deficit Percentage
Compressive flexion	25	66.1 (6.7–100)
Distractive flexion	13	84.1 (4.4–100)
Distractive extension or no apparent injury	14	72.2 (25.6–100)
Compressive extension	6	93.3 (76.7–98.9)
Vertical compression	2	96.7 (93.3–100)
Unclassified (ankylosing spondylitis)	3	86.7 (76.7–92.5)
Total	63	

one of these patients dropped from 14 to 13, and he recovered to Frankel D with a motor score of 70 at a follow-up evaluation 17 months after injury. Disc protrusion was suspected from radiographs in the other patient whose motor score dropped from 42 to 6 and was decompressed anteriorly within 24 hours after deterioration. At a 2-year follow-up examination, this patient remained in the Frankel B group, and his motor score improved to 32. The third patient in the Frankel C group deteriorated within the same Frankel grade 3 days after injury with a drop in motor score from 29 to 17. This patient recovered to Frankel D over a period of 20 months with a motor score of 73. Two patients in the Frankel B group with blunting of pin-prick sensation in the sacral area only and one patient with light-touch sensation in his body lost sensation below the level of injury 1 day after injury. The former two patients recovered their sensation within 16 days after deterioration. The condition of the latter, who also had ankylosing spondylitis, deteriorated after closed reduction, but recovered some of the sensation 1 year after deterioration. None of these three patients, however, recovered motor power in the lower limbs, although the motor score in the upper limbs improved from 15.0 to 25.3 on average. A fourth patient in the Frankel B group lost one segment of zonal motor power and recovered to Frankel C within 19 months after injury with a final motor score of 64. Condition did not deteriorate in any of the patients in the Frankel D group.

Neurologic Recovery

Neurologic improvement was evaluated in 44 patients who were observed for more than 12 months after injury (mean time from injury to follow-up examination, 44.6 months). The neurologic improvement of these patients was documented using the Frankel classification system and the motor score (Figures 1 and 2).

Of 21 patients presenting in the Frankel B group at the time of admission, five patients remained in the Frankel B group, eight patients improved to Frankel C, six patients improved to Frankel D, and two patients improved to Frankel E. Six of the eight patients who had sacral sensation (S3 to S5) in response to pin-prick (sharp or dull)

		Frankel grade at follow-up				
Frankel grade on admission		A	B	C	D	E
	B	0	5 14.2/22.4	8 11.0/50.4	6 16.8/85.8	2 25.0/100
	C	0	1 42/32	0	15 27.8/84.1	1 47/100
	D	0	0	0	3 77.7/98.7	3 74.7/100

Figure 1. The progress of the neurological status in Frankel grade of 44 patients from the time of hospital admission to follow-up examination more than 12 months after injury. The upper half of each cell indicates the number of the patients in each category, and the lower half of the cell indicates the progress in motor score of the patients (mean motor score on admission ÷ mean motor score at follow-up).

and sharp sensation in response to pin-prick between the level of injury and the sacral segment recovered to Frankel D or E. Only two of the 13 patients who had different modalities of sensory sparing, however, recovered to Frankel D. There was a statistically significant difference between the MRPs of these two groups of patients presenting as Frankel B (80.2% vs. 35.0%; $P < 0.001$; two-tailed unpaired t test).

Of 17 patients presenting in the Frankel C group on admission, 16 patients recovered to Frankel D or E. One of the two patients who deteriorated to Frankel B remained in the Frankel B group. The average motor score recovery in each Frankel grade is shown in Figure 1. There was no statistically significant correlation between the MDP (78.9% on average) and the MRP (79.6% on average) among the patients who presented in Frankel C on admission and recovered ($P > 0.1$, Pearson's coefficient of correlation; Figure 3).

All six patients who presented in Frankel D on admission had central cord syndrome. No patient's condition deteriorated and three recovered to Frankel E. All but

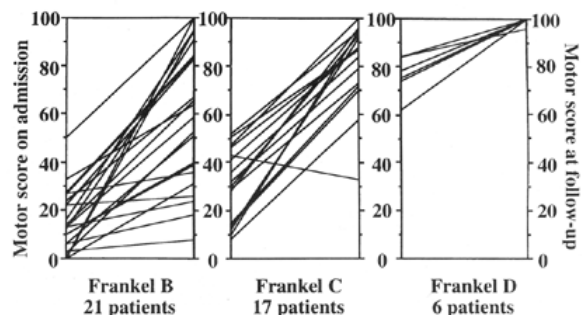


Figure 2. The progress in motor score of 44 patients classified by each Frankel grade who were observed for more than 12 months after admission.

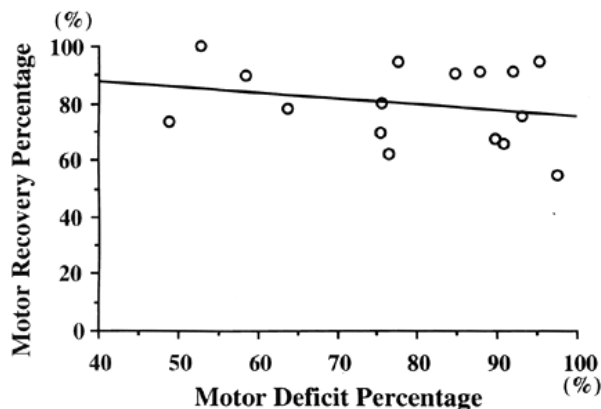


Figure 3. Scatter diagram showing the relationship between the motor deficit percentage and the motor recovery percentage in the patients who presented as Frankel C on admission and were observed for more than 12 months. One patient whose condition deteriorated to Frankel B and who did not recover was excluded from the diagram. There was no statistically significant correlation ($r = 0.24$; $P > 0.1$).

one recovered full motor score and one patient recovered from a motor score of 84 to 96. The motor score improvement of those patients who improved to Frankel E and of those who remained in Frankel D are shown in Figure 1.

There was no significant correlation between the MDP and the initial skeletal stenosis ($P > 0.1$; Pearson's coefficient of correlation; Figure 4). There were no statistically significant differences in MRP among patients with different types of axial injuries ($P > 0.1$; ANOVA; Table 6). MRP did not show significant correlation with the degree of stenosis at the time of admission (Figure 5), nor during follow-up examination (Figure 6). There was

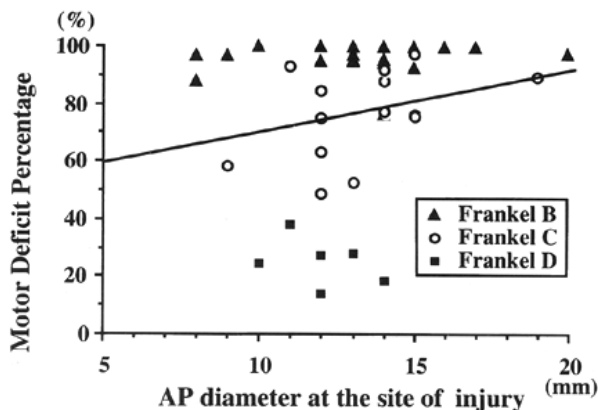


Figure 4. Scatter diagram showing the relationship between the motor deficit percentage of the patients who were observed for more than 12 months and the antero-posterior diameter at the site of injury on the initial lateral radiograph. There was no statistically significant correlation among all the patients nor among the patients in each Frankel group on admission. The regression line in the diagram is drawn from all the patients ($r = 0.23$; $P > 0.1$).

Table 6. Type of Cervical Injuries and the Neurologic Improvement in the Motor Recovery Percentage

	Number of Patients	Motor Recovery Percentage
Compressive flexion	21	70.5 (5.2–100)
Distractive flexion	6	53.2 (12.3–94.1)
Distractive extension or no apparent injury*	7	82.2 (31.0–100)
Compressive extension	4	68.8 (52.0–90.8)
Vertical compression	2	87.5 (75.0, 100)
Unclassified (ankylosing spondylitis)	3	40.1 (5.1–65.2)
Total*	43	

* One patient who deteriorated and did not recover was excluded.

also no significant correlation between MRP and residual kyphosis (Figure 7) using Pearson's coefficient of correlation ($P > 0.1$).

Discussion

There are many reports that describe the neurologic outcome of various types of management of cervical spinal cord injuries. In general, the decision to operate on the cervical spine usually is based primarily on biomechanical considerations to preserve cord function.¹⁰ Some studies have failed to demonstrate any neurologic advantage of surgical decompression and/or stabilization over conservative management.^{10,27}

Many classifications have been proposed to evaluate functional outcome.^{21,24,25} The Frankel classification system is still the most commonly used measure of neurologic outcome.⁷ The final functional status of patients, however, is influenced by the quality of rehabilitation and physical, social, and psychological factors. To evaluate the neurologic outcome, therefore, it is necessary to use scales that are minimally affected by other factors. A

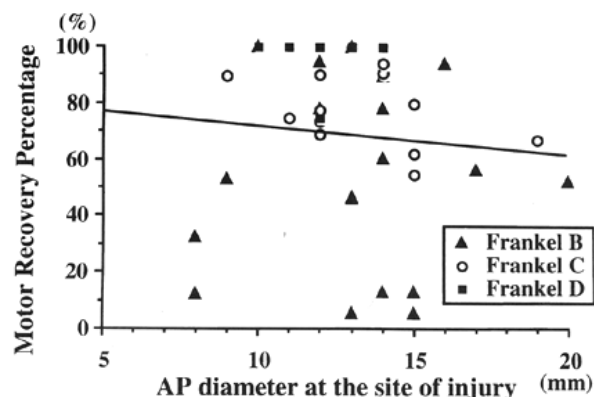


Figure 5. Scatter diagram showing the relationship between the motor recovery percentage of the patients and the antero-posterior diameter at the site of injury on the initial lateral radiograph. No statistically significant correlation was detected among all the patients or among the patients in each Frankel group on admission. The regression line represents all the patients ($r = 0.08$; $P > 0.1$).

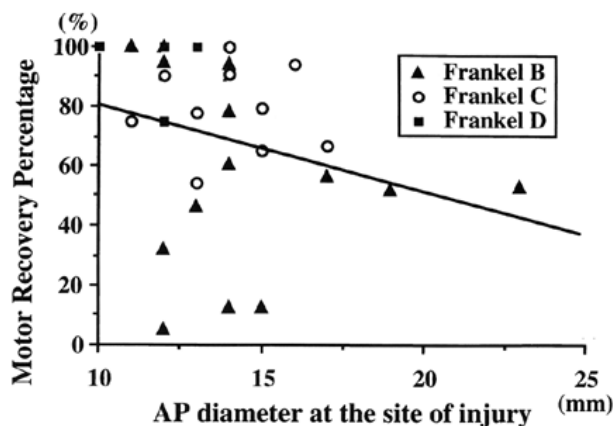


Figure 6. Scatter diagram showing the relationship between the motor recovery percentage of the patients and the anteroposterior diameter of the site of injury at the follow-up examination. There was no statistically significant correlation among all the patients nor among the patients in each Frankel group on admission. The regression line represents all the patients ($r = 0.24$; $P > 0.1$).

combination of the Frankel classification and a numerical motor scoring system is likely to be a method that will result in a more precise qualitative and quantitative description of neurologic impairment and progress for retrospective and prospective studies.¹⁴

Spontaneous neurologic deterioration with a decline in Frankel grade occurred in four of 63 patients in this study (two in the Frankel B group and two in the Frankel C group). All but one of these patients recovered to initial neurologic status with conservative treatment. The patient whose condition deteriorated from Frankel C to Frankel B and did not recover had anterior decompression and fusion on the day of the deterioration. Two other patients whose condition deteriorated according to

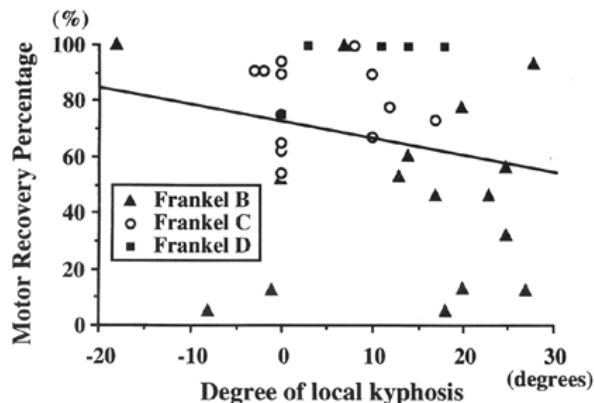


Figure 7. Scatter diagram showing the relationship between the motor recovery percentage and the degree of local kyphosis at the follow-up examination. There was no statistically significant correlation among all the patients nor among the patients in each Frankel group on admission. The regression line represents all the patients ($r = 0.23$; $P > 0.1$).

motor score but not in Frankel grade recovered in Frankel grade (from Frankel C to D). The incidence of spontaneous neurologic deterioration in this study was similar to that in a study of patients with complete cervical injuries (four of 54 patients).²² The four patients whose condition deteriorated spontaneously in the latter study also recovered to the initial neurologic status with conservative treatment.

The presence of sacral sparing is an important clinical sign of an incomplete lesion and is useful for prognosis.^{26,29} The importance of the various sensory modalities of sparing as prognostic indicators has been also documented.^{6,15,16,23} The importance of sacral sparing in prognosis was confirmed statistically by evaluation using the MRP in this study. Patients in the Frankel B group who had sacral sparing with preservation of sharp sensation between the level of injury and sacral dermatomes at the time of admission to the hospital showed significantly better MRPs (80.2%) than all other patients in Frankel B (35.0%). The MRP of the former patients was not different from that of patients in the Frankel C group (79.6%) ($P = 0.93$; two-tailed unpaired t test). Final motor score in lower limbs also was not significantly different between these two groups (40.3 in patients in the Frankel B group and 43.0 in patients in the Frankel C group; $P = 0.23$; two-tailed unpaired t test).

All patients in the Frankel C group with motor power in the lower limbs recovered to Frankel D or E regardless of how small the motor score in the lower limbs was at presentation. Because of the potential subjective difference in the definition of Frankel C and D, the motor score at presentation and at follow-up examination and the motor recovery percentage is essential in comparing the condition of individual patients and groups of patients. In this study, patients classified as Frankel C showed an average motor score of 29.0 at presentation and of 85.1 at the follow-up examination. The MRP for these patients was 79.6%.

Three of six patients presenting as Frankel D remained in the Frankel D group; the other three improved to Frankel E. In this study, the average motor score of the patients who remained in the Frankel D group was 77.7 on admission and 98.7 at the follow-up examination; the average MRP for these patients was 91.7%. In the three patients who moved from Frankel D to Frankel E, the average motor score was 74.7 on admission and 100 at the follow-up examination; the average MRP for these patients was 100%.

It was interesting to note that the motor deficit percentage (MDP) did not correlate with the degree of stenosis of spinal canal (Figure 4) or with the mechanism of injury (Table 4). It was also interesting to note that the MRP did not correlate with the degree of stenosis of the spinal canal, mechanism of injury, or degree of kyphosis (Figures 5, 6 and 7; Table 5). Bohlman and Anderson³ reported that if there is residual compression to spinal cord or motor roots, neurologic recovery can be achieved

by delayed anterior decompression and stabilization after neurologic recovery has reached its plateau. The severity of the initial neurologic deficit, however, which was indicated as the important determinant of neurologic recovery, was not specified in their study.³ In the present study, 15 of 16 patients who were classified as Frankel C recovered to functional ambulation without treatment with high-dose methylprednisolone or surgical decompression and stabilization, regardless of the severity of motor sparing in their lower extremities. It was suggested in the Second National Acute Spinal Cord Injury Study⁴ that treatment with very high doses of methylprednisolone resulted in recovery of segmental and long-tract neurologic function in patients. Evidence concerning the efficacy of timing or the value of surgery on neurologic recovery, however, was not demonstrated clearly in that study.¹¹

The authors of the present study concluded that the preservation of pin-prick sensation in the sacral dermatomes and sharp pin-prick sensation between the level of injury and the sacral dermatomes was an indicator of a good prognosis for patients who were classified as Frankel B on admission. Almost all patients with initial motor sparing recovered to functional ambulation. In these patients, there was no significant correlation between the degree of the skeletal injury and neurologic recovery. It seems that in the majority of patients the maximum damage to the spinal cord occurs at the time of the accident, and that the great majority of patients with incomplete cervical spinal cord injury will recover if their physiologically unstable spinal cord is protected from further mechanical and nonmechanical damage.¹² Containment of the biomechanical instability can be achieved equally well by conservative and surgical means. Containment of the physiological instability of the spinal cord can be achieved only by thorough patient care and prevention of complications from the multisystem impairments in these patients.

The authors believe that the roles of pharmacologic agents, surgical decompression and/or stabilization, and conservative management in neurologic recovery require further careful assessment and comparison using standard, sensitive scales for evaluation.

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