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Original article

An outcome measure for patients with cervical myelopathy: Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ): Part 1

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Abstract

Background. An outcome measure to evaluate the neurological function of cervical myelopathy was proposed by the Japanese Orthopaedic Association in 1975 (JOA score), and has been widely used in Japan. However, the JOA score does not include patients' satisfaction, disability, handicaps, or general health, which can be affected by cervical myelopathy. The purpose of this study was to develop a new outcome measure for patients with cervical myelopathy.

Methods. This study was conducted in eight university hospitals and their affiliated hospitals from February to May 2002. The questionnaire included 77 items. Forty-one questions, which were originally listed by the authors, were for evaluation of the physical function of the cervical spine and spinal cord. The Medical Outcome Study Short-Form 36-Item Health Survey (SF-36) was used to examine health-related quality of life (QOL). Patients with cervical myelopathy and healthy volunteers were recruited at each institution. After analysis of the answers from patients and volunteers, irrelevant questions using the following criteria were excluded: (1) a question 80% of answers for which were concentrated on one choice, (2) a question whose answer was highly correlated with that of other questions, (3) a question that could be explained by other questions, and (4) a question for which the distribution of the answers obtained from the patients was not different from that obtained from the normal volunteers.

Results. The patients comprised 164 men and 86 women, and the healthy volunteers 96 men and 120 women. Thirteen items from the questions about the physical functions of the cervical spine and the spinal cord and 11 items from SF-36 remained as candidates that should be included in the final outcome measure questionnaire.

Conclusion. Twenty-four questions remained as candidates for the final questionnaire. This new self-administered questionnaire might be used to evaluate the outcomes in patients with cervical myelopathy more efficiently.

Introduction

Objective measurements such as health status, quality of life (QOL), patients' satisfaction, health care costs, and return to work are currently used to evaluate outcomes of medical practice. An outcome measure to evaluate the neurological function of patients with cervical myelopathy, was first proposed by the Japanese Orthopaedic Association in 1975[1] (JOA score) and has been used widely in Japan. After Hirabayashi et al. reported in *Spine* in 1981 the surgical results of patients with ossification of the posterior longitudinal ligament

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in the cervical spine using the JOA score,[2] the modified JOA score has been developed and used to evaluate cervical myelopathy in other countries.[3–5] In the JOA score, neurological function is emphasizes and is used by medical professionals including spine surgeons. However, the JOA score has several problems when used as an instrument to measure outcome. For example, the JOA score does not include patients' satisfaction, disability, handicaps, or general health (physical and mental health), which can be affected by cervical myelopathy.

A more specific outcome measure, in which patients' satisfaction, disability, handicaps, and general health can be evaluated, is necessary for cervical myelopathy. The first and most important long-term goal of the treatment for patients with cervical myelopathy is to improve their health status and QOL. Evaluation of QOL should include comprehensive assessment of the patient's health status specific to the disorder, such as evaluation of pain, a working status, and the patient's life satisfaction.[6] The second goal is to evaluate the status of decompression of the spinal cord and nerve roots, the alignment of the cervical spine, bony fusion in patients undergoing arthrodesis, adjacent segment diseases, and the range of motion in the cervical spine. These factors relate directly to the surgical strategy and can be easily evaluated by spine surgeons. However, these factors are not necessarily associated with the first goal of QOL improvement. The third goal is to develop an outcome measure to objectively assess the relationship between medical costs and the quality of a treatment. Therefore, the evaluation method that forms the basis of the instrument's items should be related to the outcome measures for patients with cervical myelopathy.

Based on current knowledge about the outcome measures of medical care, there is an urgent need to develop a new JOA score to evaluate cervical myelopathy. The purpose of this study was to develop a new outcome measure for patients with cervical myelopathy that can be used and understood by patients and health professionals. It is also important that this new outcome measure uses objective items, can be used clinically, and attaches a high value to respect for the patient. In this study (Part 1), the members of the Subcommittee on Evaluation for Low Back Pain and Cervical Myelopathy, who belonged to the Clinical Outcomes Committee of the Japanese Orthopaedic Association, devised a new questionnaire to evaluate the functional capacity of the cervical spine, physical function of the upper and lower extremities, and bladder function, which might be disturbed by cervical myelopathy. The authors listed, in the original questionnaire, items that were thought to be related to symptoms of cervical myelopathy. Using this original questionnaire, which was thought to be related to symptoms of cervical myelopathy, and the Medical Outcome Study Short-Form 36-Item Health Survey (SF-36, Japanese version),[7] which is used to evaluate health-related QOL, the authors performed a primary survey on healthy volunteers and patients with cervical myelopathy. The authors analyzed the responses to the questionnaire to devise a self-administered questionnaire, composed of a short list of the original questionnaire items, which fits into two pages of A4-size paper.

Methods

The Clinical Outcomes Committee of Japanese Orthopaedic Association conducted this study together with various medical institutions with the aim of preparing an instrument to objectively evaluate patients with cervical myelopathy. This study was conducted in eight university hospitals and their affiliated hospitals from February to May 2002. A member of the Subcommittee on Low Back Pain and Cervical Myelopathy Evaluation from each hospital administered the questionnaire to more than 30 patients with cervical myelopathy.

Questionnaire

The questionnaire included 77 items (Tables 1, 2). Forty-one questions, which were originally listed by the authors, were for evaluation of the physical function of the cervical spine and spinal cord (Table 1). A respondent recalled his or her physical condition during the last week and circled the item number of each of the questions that best applied to his or her condition. If a respondent's condition changed depending on the day or the time, he or she circled the item number of "your worst condition." Each item in this questionnaire related to items C-1 to C-41. The SF-36 was used to examine health-related QOL (Table 2) and related items QOL-1 to QOL-11-4. The JOA score revised in 1994 (revised 17-point method; Table 3),[8] in which the evaluation of nerve root function was supplemented, was used and evaluated by a medical professional in the present study.

Survey of patients with cervical myelopathy

Patients answered each question by themselves. This study included patients with cervical myelopathy secondary to cervical disc herniation, spondylosis, ossification of the posterior longitudinal ligament, calcification of the ligament flavum, spinal cord tumor, and developmental spinal canal stenosis. Patients with the following disorders were excluded: cervical spondylotic amyotrophy, cervical radiculopathy, disorders of the upper cervical spine such as atlantoaxial subluxation, spinal tumor, vascular lesions of the cervical spinal cord,

Table 1. A questionnaire about the physical function of the cervical spine and the spinal cord

C-1 Can you fasten the front buttons of your blouse or shirt using both hands?
C-2 Can you fasten the buttons of your blouse or shirt using only the right hand?
C-3 Can you fasten the buttons of your blouse or shirt using only the left hand?
C-4 Can you fasten the uppermost button of your blouse or shirt?
C-5 Can you fasten the cuff buttons of your blouse or shirt?
C-6 Can you turn the pages of a book or a newspaper?
C-7 Can you eat a meal using a spoon or a fork with your right hand?
C-8 Can you eat a meal using a spoon or a fork with your left hand?
C-9 Can you eat a meal using a pair of chopsticks?
C-10 Can you remove fish bones using a pair of chopsticks?
C-11 Does your right hand reach your mouth?
C-12 Does your left hand reach your mouth?
The items of a reply to these questions from C-1 to C-12 are below:
1) I can do it without difficulty.
2) I can do it if I spend time.
3) I cannot do it.
0) I am not sure.

C-13 Can you raise your right arm?
C-14 Can you raise your left arm?
The items of a reply to these questions are below:
1) I can raise it straight upward.
2) I can raise it upward when flexed a little.
3) I can raise it halfway (up to shoulder level).
4) I cannot raise it.

C-15 Can you remain sitting on a chair without leaning on the backrest?
1) I can do it for the time necessary to have a meal.
2) I can do it for the time necessary to change clothes.
3) I can do it for the time necessary to use a toilet (evacuation of bowels).
4) I cannot do it.
0) I am not sure.

C-16 Can you stand up from the sitting position (on your own), without the assistance of other people, or without the support of a handrail or a stick?
1) I can do it without difficulty.
2) I can do it if I take time.
3) I cannot do it.
0) I am not sure.

C-17 Can you keep standing (on your own), without the assistance of other people, or without the support of a handrail or a stick?
1) I can do it for a while (more than 3 minutes).
2) I can do it for a short time (about a minute).
3) I cannot do it.
0) I am not sure.

C-18 Can you walk on a flat surface?
1) I can do it without difficulty.
2) I can do it slowly.
3) I can do it with support (of a handrail, a stick, or a walker).
4) I can do it only slowly even with support.
5) I cannot do it.
0) I am not sure.

C-19 Can you go up the stairs without holding the handrail?
C-20 Can you go down the stairs without holding the handrail?
The items of a reply to these questions are below:
1) I can do it without difficulty.
2) I can do it if I take time.
3) I cannot do it.
0) I am not sure.

C-21 Can you stand on your right leg without the support of your hand?
C-22 Can you stand on your left leg without the support of your hand?
The items of a reply to these questions are below:
1) I can do it for more than 10 seconds.
2) I can do it for less than 10 seconds.
3) I can hardly do it.
0) I am not sure.

C-23 Can you jump on your right leg?
C-24 Can you jump on your left leg?
The items of a reply to these questions are below:
1) I can do it ( ) times. (Put the number of times in the blank).
2) I can hardly do it.
0) I am not sure.

C-25 Can you walk at a quick pace?
C-26 Can you trot? (By "trot" we mean moving fairly fast at a speed between walking and running, taking small quick steps.)
The items of a reply to these questions are below:
1) I can do it without difficulty.
2) I cannot do it.
0) I am not sure.

C-27 Do you need a catheter (an artificial tube) insertion to void urine (for urination)?
1) I do not need it.
2) I usually do not need it.
3) I sometimes need it, sometimes not.
4) I usually need it.

C-28 Do you have urinary incontinence?
1) No.
2) I have it when I sneeze or strain myself.
3) I have it when I do not release urine over a period of more than two hours.
4) Frequently.
5) Always.

C-29 Can you void urine without strain?
1) I can do it.
2) I cannot do it without strain.
3) I cannot do it by myself.

C-30 How often do you go to the bathroom (to void urine) at night?
1) Hardly ever
2) Once or twice.
3) Three times or more.

C-31 Do you have a feeling of residual urine even after voiding of urine (urination)?
1) I rarely have such a feeling.
2) I sometimes have such a feeling, and sometimes not.
3) I usually have such a feeling.
0) I am not sure.

Table 1. *Continued*

C-32 Can you void urine immediately in the toilet?
1) I almost always can do it immediately.
2) I sometimes can do it immediately, and sometimes not.
3) I usually cannot do it immediately.
0) I am not sure.

C-33 Do you have bowel movements (evacuations) every day?
1) I have more than one movement almost every day.
2) I have a movement almost every day.
3) I have a movement about every other day.
4) I have a movement about every three days.
5) I have a movement more than every three days.

C-34 [Question for men]. Have you ever been told at a urology department that you had prostate hypertrophy?
1) No.
2) Yes, but I have not had treatment.
3) Yes, I have. I underwent medical treatment and it was cured.
4) Yes, I have. I have been undergoing medical treatment.

C-35. While in the sitting position, can you look up at the ceiling by drawing your head directly backward?
1) I can do it without difficulty.
2) I can do it with some effort.
3) I cannot do it.

C-36. Can you gargle?
C-37. Can you drink a glass of water in one gulp?
C-38. Can you see your feet when you walk down the stairs?
C-39. While in the sitting position, can you turn your head toward the person seated on your right side without moving your body?
C-40. While in the sitting position, can you turn your head toward the person seated on your left side without moving your body?
The items of a reply to these questions from C-36 to C-40 are below:
1) I can do it without difficulty.
2) I can do it with some effort.
3) I cannot do it.
0) I am not sure.

C-41. Can you turn your head when you back your car?
1) I can do it without difficulty.
2) I can do it with some effort.
3) I cannot do it.
0) I am not sure. I do not drive a car/I do not drive these days.

Table 2. A questionnaire to assess health-related quality of life (QOL)

The following are questions on your daily life during the last week (unless otherwise specified). For each question, circle one of the items numbered 1–5 that best describes your condition.

QOL-1 What is your present health condition?
1) Excellent
2) Very good
3) Good
4) Not very good
5) Poor

QOL-2 What is your present health condition as compared with that of a year ago?
1) Much better
2) A little bit better
3) Almost the same
4) Not as good
5) Much worse

QOL-3 The following are ordinary daily activities. Please indicate if you have difficulty doing them because of your poor health condition and, if so, how difficult you think it is to do them. Circle the item number that most applies.

1. Engaging in hard activities
(Such as running fast, lifting a heavy object, doing intense exercise)
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

2. Engaging in moderate activities
(Such as cleaning the house, taking care of the yard, taking a one- or two-hour walk)
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

3. Lifting or carrying moderately heavy objects
(Such as a shopping bag)
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

4. Climbing the stairs to higher floors
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

5. Climbing the stairs to one floor above
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

6. Bending forward, kneeling, and stooping
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

7. Walking a kilometer
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

8. Walking a few hundred meters
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

9. Walking a hundred meters
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

Table 2. *Continued*

10. Taking a bath or changing clothes without the support of others
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

QOL-4 When you engaged in your work or daily activities (including housework) during the last month, did you have any of the problems listed below because of your physical condition? (Circle the item number in each topic that best applies.)

1. I decreased the number of hours of working or daily activities.
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

2. I could not do my work or daily activities as well as I expected.
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) I was able to do my work or daily activities as well as I expected.

3. I could not do some kinds of work or daily activities.
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) I was able to do any kind of work or daily activities.

4. I had difficulty in engaging in my work or daily activities (e.g., I needed more effort to do it).
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

QOL-5 When you engaged in your work or daily activities (including housework) during the last month, did you have any of the problems listed below because of psychological reasons? (Circle the item number in each topic that best applies.)

1. I decreased the number of hours of working or daily activities.
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

2. I could not do my work or daily activities as well as I would like.
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) I was able to do my work or daily activities as well as I expected.

3. I could not concentrate on my work or daily activities as hard as I can normally.
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) I was able to concentrate on my work or daily activities as hard as I can.

QOL-6 How severely were your relations with your family, friends, neighbors, and other acquaintances hindered because of physical or psychological reasons?
1) Not at all
2) A little
3) Slightly
4) Fairly
5) Greatly

QOL-7 How severe was your pain during the last month?
1) None
2) Very mild
3) Mild
4) Moderate
5) Severe
6) Very severe

QOL-8 How severely was your work (including housework) hindered during the last month because of the pain?
1) Not at all
2) A little
3) Slightly
4) Fairly
5) Greatly

QOL-9 The following are questions about your feelings during the last month (circle the item number of each question that best applies).

1. Were you full of good spirits?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

2. Were you rather nervous?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

3. Were you desperately depressed?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

4. Were you comfortable and peaceful?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

Table 2. *Continued*

5. Were you full of physical power and life?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

6. Were you discouraged and depressed?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

7. Were you exhausted?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

8. Did you feel pleasant?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

9. Did you feel tired?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

QOL-10 During the last month, how often were your relations with other people (for example, visiting your friends or relatives) hindered because of physical or psychological reasons?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Never

QOL-11 Circle the item number of each of the following topics that best applies to your condition.

1. I think I am more likely to become ill than other people.
1) Completely yes.
2) Almost yes.
3) I am not sure.
4) I hardly think so.
5) I do not think so.

2. I am in decent health.
1) Completely yes.
2) Almost yes.
3) I am not sure.
4) I hardly think so.
5) I do not think so.

3. I feel my health will get worse.
1) Completely yes.
2) Almost yes.
3) I am not sure.
4) I hardly think so.
5) I do not think so.

4. My health condition is excellent.
1) Completely yes.
2) Almost yes.
3) I am not sure.
4) I hardly think so.
5) I do not think so.

cervical hemangioma, syringomyelia, multiple sclerosis, motor neuron disease, myelitis, and spinal cord injury. Patients with disturbances of the central nervous system such as cerebral infarction, combined cervical and thoracic spine lesions, orthopedic disorders other than cervical myelopathy, and cognitive disorders, and patients who could not complete the questionnaire because of defects of the arm, fingers, or foot, were also excluded. Patients whose condition resulted from occupational accidents, traffic accidents, or injuries were excluded.

The investigation period was 4 weeks from the start of the present study at each institution. All patients were asked to participate in the survey and were told that the questionnaire would be used to develop a new JOA score. Only patients who agreed to join the study answered the questionnaire.

Survey of healthy volunteers

Healthy volunteers were recruited at each institution during the same period. They were self-supporting and required no medical assistance. Individuals being treated with alternative medicine such as acupuncture, cautery, massage, or chiropractic were included.

The healthy volunteers were grouped by sex and age by decade from 20 to 80 years. More than 15 healthy individuals from each institution within each age decade and from each sex were surveyed. Medical professionals were excluded from participating as healthy volunteers.

This study design was reviewed and approved by the institutional review board in each institution, and informed consent was obtained from each patient or volunteer.

Selection of questions to develop the short list of questions

After analysis of the answers from patients and volunteers, the authors excluded irrelevant questions using the following criteria:

Table 3. Japanese Orthopaedic Association (JOA) score for patients with cervical myelopathy

Motor function Upper extremity The thumb and fingers	Sensory function Upper extremity
0 [Complete disturbance] The patient cannot use chopsticks or a spoon/fork, and cannot fasten a button on his or her own.	0 [Severe disturbance] Complete sensory loss (touch sensation, pain sensation)
1 [Severe disturbance] The patient cannot use chopsticks or write, and can barely use a spoon/fork.	(0.5 Partial sensory loss ≤5/10 (touch sensation, pain sensation); intolerable pain or numbness)
2 [Moderate disturbance] The patient can pick up a large object with chopsticks but can hardly write. He/she can fasten a large button.	1 [Moderate disturbance] Partial sensory loss ≥6/10 (touch sensation, pain sensation); numbness and hypersensitivity.
3 [Slight disturbance] The patient makes awkward use of chopsticks, writes in a clumsy manner, but can fasten buttons on his/her shirt.	(1.5 [Slight disturbance] Slight numbness (normal sensation))
4 [Normal] Normal	2 [Normal] Normal
Shoulder/elbow function	Trunk
–2 [Severe disturbance] The muscle strength of the deltoid muscle or the brachial muscle evaluated by manual muscle testing (MMT) was graded as ≤2.	0 [Severe disturbance] Complete sensory loss (touch sensation, pain sensation)
–1 [Moderate disturbance] The muscle strength of the deltoid muscle or the brachial muscle evaluated by MMT was graded as 3.	(0.5 Partial sensory loss ≤5/10 (touch sensation, pain sensation); intolerable pain and numbness)
–0.5 [Slight disturbance] The muscle strength of the deltoid muscle or the brachial muscle evaluated by MMT was graded as 4.	1 [Moderate disturbance] Partial sensory loss ≥6/10 (touch sensation, pain sensation); numbness and hypersensitivity.
0 [Normal] The muscle strength of the deltoid muscle or the brachial muscle evaluated by MMT was graded as 5.	(1.5 [Slight disturbance] Slight numbness (normal sensation))
	2 [Normal] Normal
Lower extremity	Lower extremity
0 [complete disturbance] The patient cannot stand or walk alone.	0 [Severe disturbance] Complete sensory loss (touch sensation, pain sensation)
(0.5 The patient can stand up.)	(0.5 Partial sensory loss ≤5/10 (touch sensation, pain sensation); intolerable pain and numbness)
1 [Severe disturbance] The patient needs support to walk on a flat surface.	1 [Moderate disturbance] Partial sensory loss ≥6/10 (touch sensation, pain sensation); numbness and hypersensitivity.
(1.5 The patient can walk on a flat surface without any support but the walking is not stable.)	(1.5 [Slight disturbance] Slight numbness (normal sensation))
2 [Moderate disturbance] The patient can walk on a flat surface without any support, but needs a handrail to walk up and down stairs.	2 [Normal] Normal
(2.5 The patient can walk on a flat surface without any support, but needs a handrail only to walk down stairs.)	Urinary bladder function
3 [Slight disturbance] The patient can walk fast, although awkwardly.	0 [Severe disturbance] Urinary retention, incontinence
4 [Normal] Normal	1 [Moderate disturbance] Feeling of residual urine, straining of oneself, dull urination, elongation of urination (retarded urination), urinary incontinence
	2 [Slight disturbance] Retarded urination, pollakisuria
	3 [Normal] normal
	Total 17

1. A question for which 80% of answers were concentrated on one choice.
2. A question whose answer was highly correlated with that of other questions. For this analysis, the Spearman's correlation coefficients for the distribution of answers to each question were used. $P \geq 0.45$ indicates a significant correlation.
3. A question that could be explained by other questions.
4. A question for which the distribution of the answers obtained from the patients was not different from that obtained from the normal volunteers.
5. Discriminant analysis was used to examine the ratio of discrimination when one of the residual items ob-

tained from these analyses above was selected as an objective parameter and the others as explanatory variables. Using this analysis, the minimal ratio of discrimination for each choices and the ratio of discrimination through all choices were calculated. To evaluate the agreement of these discriminations, a κ value was used. Each item was evaluated if it was excluded statistically. If the minimal ratio of discrimination reached more than 70% in the choice of the answers for any question items, the selected question items could be deleted.

Statistical analysis

Data were analyzed using STATISTICA for Windows (1988) (StatSoft, Tulsa, OK, USA) and SPSS software (version 12; Chicago, IL, USA). Spearman's correlation coefficient, discriminant analysis, and χ^2 analysis were used to make a short list of questions as an outcome measure for patients with cervical myelopathy. $P < 0.05$ was considered significant.

Results

Two hundred and fifty patients with cervical myelopathy and 216 healthy volunteers were enrolled in the study. The patients comprised 164 men and 86 women, and the healthy volunteers 96 men and 120 women. Cervical myelopathy was secondary to a herniated disc in 33 patients, spondylosis in 146 patients, ossification of the posterior longitudinal ligament in 59 patients, calcification of the ligament flavum in 2 patients, spinal cord tumor in 7 patients, and combined disorders in 3. Table 4 shows the age and sex distribution of patients and healthy volunteers. Although enrollment of more than 15 healthy volunteers within each age decade and from each sex was planned, more than 20 healthy individuals were distributed into each age decade except for those over 80 years. The authors then excluded individuals with any complications from another orthopedic disorder, giving 233 patients and 213 volunteers whose data were analyzed.

The distribution of the revised JOA score is shown in Table 5 and revealed that patients with mild to severe myelopathy were involved in the present study. The distribution of this patients' group was not anomalous as a group of patients with cervical myelopathy. Most of volunteers had a normal score.

The distribution of the answers to the questions that were designed to evaluate the physical functions of the cervical spine and the spinal cord was evaluated. The questions that elicited no answer or "I am not sure" from more than 5% of the participants were C-8, C-23, C-24, C-25, C-26, and C-41 in the patients, and C-23, C-24, and C-41 in the healthy volunteers. The volunteers answered more than 80% of questions with the choice "I can do it without difficulty," except questions C-8, C-30, and C-33. Taking question C-8 ("Can you eat a meal using a spoon or a fork with your left hand?") together with question C-7 (the same question but with

Table 4. Demographic data in the primary survey

	Patients with cervical myelopathy			Healthy volunteers		
	Male	Female	Total	Male	Female	Total
n	164	86	250	96	120	216
Age (years)						
20–29		1	1	15	33	48
30–39	7	2	9	18	22	40
40–49	20	9	29	20	16	36
50–59	40	18	58	15	21	36
60–69	55	20	75	12	15	27
70–79	32	27	59	12	12	24
80–89	9	9	18	4	1	5
90 or more	1		1			
Disorders of the cervical spine						
Disc herniation			33			
Spondylosis			146			
Ossification of the posterior longitudinal ligament			59			
Calcification of the ligament flavum			2			
Spinal cord tumor			7			
Combined			3			
Other orthopedic disorders						
Yes			17			3
No			233			213

Table 5. The distribution of revised Japanese Orthopaedic Association (JOA) score

Motor function (upper extremity, finger)								
Score	0	1	2	3	4			
Patients with cervical myelopathy (*n*)	3	20	65	92	53			
Healthy volunteers (*n*)	0	0	0	1	212			
Motor function (upper extremity, shoulder/elbow)								
Score	–2	–1	–0.5	0				
Patients with cervical myelopathy (*n*)	6	4	38	185				
Healthy volunteers (*n*)	0	0	0	213				
Motor function (lower extremity)								
Score	0	0.5	1	1.5	2	2.5	3	4
Patients with cervical myelopathy (*n*)	2	1	27	32	53	18	41	59
Healthy volunteers (*n*)	0	0	0	0	0	0	4	209
Sensory (upper extremity)								
Score	0	0.5	1	1.5	2			
Patients with cervical myelopathy (*n*)	7	42	118	47	19			
Healthy volunteers (*n*)	0	0	1	0	212			
Sensory (trunk)								
Score	0	0.5	1	1.5	2			
Patients with cervical myelopathy (*n*)	5	9	42	18	159			
Healthy volunteers (*n*)	0	0	0	1	212			
Sensory (lower extremity)								
Score	0	0.5	1	1.5	2			
Patients with cervical myelopathy (*n*)	4	24	73	45	87			
Healthy volunteers (*n*)	0	0	0	1	212			
Bladder function								
Score	0	1	2	3				
Patients with cervical myelopathy (*n*)	1	29	58	145				
Healthy volunteers (*n*)	0	3	6	204				

the other hand), as an indicator of hand dominance, increased the normal response rate to more than 90%. The question C-30 ("How often do you go to the bathroom [to void urine] at night?") had a concentrated response of more than 75% in the normal volunteer group. Responses to the question C-33 (about the number of evacuations or constipation) did not differ significantly between the patients and healthy volunteers. (χ^2 analysis, $P = 0.20$) In the patients, more than 80% of the answers to the questions C-11, C-12, C-15, C-17, C-27, C-29, and C-34 were concentrated on one option, "I can do it without difficulty." About 80% of the answers to the questions C-38, C-39 and C-40 were concentrated on one option, "I can do it without difficulty." Based on these findings, the authors excluded items C-11, C-12, C-15, C-17, C-27, C-29, and C-34 from the questionnaire.

The distribution of answers to the questions relating to QOL was also statistically evaluated. No option elicited a response of less than 5%. There were no similarities in the distribution of the answers to the questions about QOL between the patients and volunteers. (χ^2 analysis, $P < 0.50$). In patients, no questions had an answer that concentrated on one option.

When the items, which were correlated with one another, were picked up on the table obtained from the analysis using the Spearman's correlation coefficients, the questions related to the physical functions of the cervical spine and the spinal cord were divided into four groups: C-1 to C-10 (10 items), C-11 to C-14 (4 items), C-16 to C-26 (11 items), and C-35 to C-40 (6 items). Some questions within each group correlated significantly with one another. The questions in different groups also correlated significantly, such as C-1 to C-5 with C-18 to C-22, C-10 with C-18 to C-22, and C-29 with C-32. The questions related to QOL were also divided into four groups: QOL-3-1 to QOL-4-4 (14 items, which were related to daily activities); QOL-4-1 to QOL–8 (10 items); QOL-8 to QOL-9-9 (10 items); and QOL-11-1, QOL-11-2, and QOL-11-4 (3 items). Some questions within each group correlated significantly. The questions in different groups also correlated significantly, such as QOL-1 with QOL-2; QOL-4-4 with QOL-9-8; QOL-10 with QOL-4-1 to QOL-6; and QOL-11-4 with QOL-1, QOL-9-1, QOL-9-8, and QOL-10. For the questions related to the physical functions of the cervical spine and the spinal cord, significant correlations were observed between C-1 and QOL-3-7, QOL-3-9 and QOL-3-10; between C-4 and QOL-3-4 and QOL-3-7, between C-5 and QOL-3-7, between C-16 and QOL-3-2 to QOL-4-4; and between C-18 to C-22, C-25, C-26 and QOL-3-1 to QOL-4-4. Utilizing the

analysis of the Spearman's correlation coefficients, 1 item of questions that were correlated with each other was selected.

Table 6 summarizes all reasons for excluding or including a certain question in the final questionnaire. Fifty-three items were excluded. Thirteen items from the questions about the physical functions of the cervical spine and the spinal cord and 11 items from SF-36 were selected for the final outcome measure questionnaire for cervical myelopathy.

Table 7 shows the ratios of discrimination obtained from discriminant analysis and κ value. The question items, which can be excluded for multivariate using discriminant analysis, were reviewed, but all items of questions were retained. Because the minimal ratio of discrimination did not reach more than 70% in the choice of the answers for any question items, any selected question items could not substitute for other items.

Discussion

Previous outcome measures to evaluate recovery of the neurological function in patients with cervical myelopathy included a one-dimensional scale, which was used only by medical professionals and which rated a certain neurological function using descriptors such as excellent, good, fair, and poor.[9–11] This type of one-dimensional scale of neural function cannot be used to evaluate more complex dimensions such as activities of daily living and work capacity, and may be inadequate as an outcome measure for patients with cervical myelopathy. Nurick's grading system has been used to evaluate surgical outcomes throughout the world.[12] However, Nurick's system cannot be used to evaluate physical function of the upper extremities and cannot be used with older, retired patients because it involves questions about job-related activities.

The JOA score may be a better method to evaluate the neurological function of patients with cervical myelopathy because it considers the pathophysiology of cervical myelopathy and provides a quantitative measure of outcomes (i.e., a score). Only one multicenter study, by Yonenobu et al.,[13] has demonstrated the high inter- and intraobserver reliability of the JOA score. However, there are few reports about the sensitivity, feasibility, validity, and responsibility of the JOA score. In addition, the JOA score attaches importance to the

Table 6. Fifty-three items were excluded and 24 items were selected for the questionnaire

Excluded item	Reason	Accepted candidate
C-2	Correlated to C-1, C-7, and C-18	C-1
C-3	Correlated to C-1	C-7
C-4	Correlated to C-1, C-7, C-18, C-21, and QOL-3-7	C-13
C-5	Correlated to C-1, C-21, and QOL-3-7	C-18
C-6	Correlated to C-1 and C-7	C-21
C-8	Correlated to C-1 and C-7	C-28
C-9	Correlated to C-1 and C-7	C-30
C-10	Correlated to C-1, C-7, C-18, and C-21	C-31
C-11	The answer was concentrated on "I can do it without difficulty."	C-32
C-12	The answer was concentrated on "I can do it without difficulty."	C-35
C-14	Correlated to C-13	C-37
C-15	The answer was concentrated on "I can do it without difficulty."	C-38
C-16	Correlated to C-18, C-21, QOL-3-5, QOL 3-6, and QOL 3-7	C-41
C-17	The answer was concentrated on "I can do it without difficulty."	QOL-1
C-19	Correlated to C-18, C-21, QOL-3-5, QOL-3-6, QOL-3-7, and QOL-4-2	QOL-3-5
C-20	Correlated to C-18, C-21, QOL-3-5, QOL-3-6, QOL-3-7, and QOL-4-2	QOL-3-6
C-22	Correlated to C-1, C-18, C-21, QOL-3-5, QOL-3-6, and QOL-3-7	QOL-3-7
C-23	Correlated to C-18 and C-21	QOL-4-2
C-24	Correlated to C-18 and C-21	QOL-8
C-25	Correlated to C-1, C-18, C-21, QOL-3-5, QOL-3-7, and QOL-4-2	QOL-9-6
C-26	Correlated to C-18, C-21, QOL-3-5, QOL-3-7, and QOL-4-2	QOL-9-7
C-27	The answer was concentrated on "I can do it without difficulty."	QOL-9-8
C-29	Correlated to C-32. The answer was concentrated on "I can do it without difficulty."	QOL-11-2
C-33	Same distribution of answers as healthy	QOL-11-3
C-34	The answer was concentrated on "I can do it without difficulty."	
C-36	Correlated to C-35	
C-39	Correlated to C-35. There was a trend toward the answer being concentrated on I can do it without difficulty."	
C-40	Correlated to C-35. There was a trend toward the answer being concentrated on "I can do it without difficulty."	

Table 6. *Continued*

Excluded item	Reason	Accepted candidate
QOL-2	Correlated to QOL-1	
QOL-3-1	Correlated to QOL-3-7 and C-18	
QOL-3-2	Correlated to QOL-3-5, QOL-3-6, QOL-3-7, QOL-4-2, C-18, and C-21	
QOL-3-3	Correlated to QOL-3-5, QOL-3-6, QOL-3-7, C-18, and C-21	
QOL-3-4	Correlated to QOL-3-5, QOL-3-6, QOL-3-7, QOL-4-2, C-18, and C-21	
QOL-3-8	Correlated to QOL-3-5, QOL-3-6, QOL-3-7, C-18, and C-21	
QOL-3-9	Correlated to QOL-3-5, QOL-3-6, QOL-3-7, C-1, C-18, and C-21	
QOL-3-10	Correlated to QOL-3-5, QOL-3-6, QOL-3-7, C-1, C-18, and C-21	
QOL-4-1	Correlated to QOL-3-7, QOL-4-2, and QOL-8	
QOL-4-3	Correlated to QOL-3-5, QOL-3-7, QOL-4-2, and C-18	
QOL-4-4	Correlated to QOL-3-5, QOL-3-7, QOL-4-2, QOL-8, QOL-9-8, and C-18	
QOL-5-1	Correlated to QOL-4-2 and QOL-8	
QOL-5-2	Correlated to QOL-4-2 and QOL-8	
QOL-5-3	Correlated to QOL-4-2 and QOL-8	
QOL-6	Correlated to QOL-4-2	
QOL-7	Correlated to QOL-8	
QOL-9-1	Correlated to QOL-9-6 and QOL-9-8	
QOL-9-2	Correlated to QOL-8 and QOL-9-6	
QOL-9-3	Correlated to QOL-8, QOL-9-6 and QOL-9-7	
QOL-9-4	Correlated to QOL-9-6 and QOL-9-8	
QOL-9-5	Correlated to QOL-9-8	
QOL-9-6	Correlated to QOL-9-6 and QOL-9-7	
QOL-10	Correlated to QOL-4-2	
QOL-11-1	Correlated to QOL-11-2	
QOL-11-4	Correlated to QOL-1, QOL-9-8, and QOL-11-2	

Table 7. The ratio of discrimination of answers in the selected items using discriminant analysis

Items	The minimal ratio of discrimination for each choice	The ratio of discrimination through all choices	κ value
C-1	56.0%	76.1%	0.59
C-7	56.5%	82.9%	0.52
C-13	25.0%	80.5%	0.43
C-18	50.0%	79.7%	0.65
C-21	43.1%	70.0%	0.53
C-28	13.8%	76.8%	0.35
C-30	43.4%	54.0%	0.23
C-31	44.0%	76.6%	0.48
C-32	40.4%	76.3%	0.44
C-35	54.2%	77.9%	0.54
C-37	16.7%	77.0%	0.44
C-38	20.0%	80.3%	0.39
C-41	39.1%	63.2%	0.44
QOL-1	25.0%	56.1%	0.31
QOL-3-5	58.1%	81.0%	0.68
QOL-3-6	61.5%	74.0%	0.55
QOL-3-7	35.1%	71.6%	0.56
QOL-4-2	0.0%	49.5%	0.34
QOL-8	25.0%	54.0%	0.40
QOL-9-6	31.6%	61.3%	0.45
QOL-9-7	25.9%	55.4%	0.40
QOL-9-8	16.7%	51.9%	0.36
QOL-11-2	18.2%	41.6%	0.22
QOL-11-3	0.0%	53.7%	0.17

physical function of the upper and lower extremities and bladder dysfunction but does not include the physical functions of the cervical spine, including the range of motion of the neck, pain, or stiff neck; patients' satisfaction; disability; social disability; or QOL.

Because of such problems associated with the JOA score, the authors believe that a better outcome measure is needed to evaluate patients with cervical myelopathy. The authors first devised a questionnaire that focused on the physical functions of the cervical spine and the spinal cord and combined it with the SF-36 to evaluate QOL. The authors administered this to patients with cervical myelopathy and healthy volunteers at the participating hospitals. The authors then used various statistical tools to make an appropriate questionnaire.[14,15] The authors excluded questions for which more than 80% of the answers were concentrated on one option, questions that correlated highly with other questions ($P \geq 0.45$), questions that could be explained by more than one question, or questions for which distributions of the answers were not different between the patients and healthy volunteers. The authors were able to develop a self-administered questionnaire of 24 items to provide a better outcome measure for patients with cervical myelopathy. Discriminant analysis demonstrated that none of the 24 items gave a minimal ratio of more than 70%, and therefore all 24 questions were retained. The questionnaire was then printed on two

pages of A4-size paper. Patients can complete the questionnaire in about 10 to 20 minutes.

Some questions asked about the identical function in the right and left hands, arms (e.g., C-2 and C-3, C-7 and C-8, C-11 and C-12, and C-13 and C-14), feet (e.g., C-21 and C-22, and C-23 and C-24), and sidedness (e.g., C-39 and C-40) separately. With these questions, the authors can identify the dominant hand and difference between the right and left sides of the body caused by asymmetry in the severity of symptoms. In the candidates of questions for an outcome measure, for item C-7, the authors changed the words from "right hand" to "dominant hand" and for item C-13, the authors changed the sentence from "Can you raise your right arm?" to "Can you raise your arm? (Answer about the weaker one.)". In question C-21, the authors also changed the options of answers to (1) "I can hardly do it with either leg," (2) "I cannot continue standing for more than 10 seconds on the weaker leg", and (3) "I can continue standing on either leg for more than 10 seconds." In question C-41 ("Can you turn your head when you back your car?") about 22% of patients and 10% of normal volunteers responded "I am not sure" or "I do not drive". Because some older patients no longer drive a car, the authors provided an alternative question to C-41, "While in the sitting position, can you turn your head toward the person who is seated behind you and speak to him/her while looking him/her in the face?"

Twenty-four items and one alternative remained as candidates for the final questionnaire (Table 8). Further studies are necessary to demonstrate that the alternative question can be used to replace the question C-41 by evaluating the reliability and responsiveness of the questionnaire with the alternative question. The authors will continue to elucidate the efficacy of this questionnaire through studies regarding the visual analogue scale for pain, neck stiffness, and numbness, and the patients' satisfaction in patients with cervical myelopathy. This new self-administered questionnaire may be effective and easy to use in clinical practice. However, because no objective parameter for each question has been standardized yet, the authors plan to combine and further assess this information using factor analysis.

This new self-administered questionnaire can be used to evaluate the outcomes in patients with cervical myelopathy more efficiently and will be helpful to identify the most appropriate treatment, medical services, and improved medical skills.

Table 8. Twenty-four items and one alternative remained as candidates for the questionnaire

C-1.Can you fasten the front buttons of your blouse or shirt using both hands?
1) I can do it without difficulty.
2) I can do it if I spend time.
3) I cannot do it.
0) I am not sure.

C-7. Can you eat a meal using a spoon or a fork with your right hand?
1) I can do it without difficulty.
2) I can do it if I spend time.
3) I cannot do it.
0) I am not sure.

C-13. Can you raise your right arm?
1) I can raise it straight upward.
2) I can raise it upward when flexed a little.
3) I can raise it halfway (up to shoulder level).
4) I cannot raise it.

C-18. Can you walk on a flat surface?
1) I can do it without difficulty.
2) I can do it slowly.
3) I can do it with support (of a handrail, a stick, or a walker).
4) I can do it only slowly even with support.
5) I cannot do it.
0) I am not sure.

C-21. Can you stand on your right leg without the support of your hand?
1) I can do it for more than 10 seconds.
2) I can do it for less than 10 seconds.
3) I can hardly do it.
0) I am not sure.

C-28. Do you have urinary incontinence?
1) No.
2) I have it when I sneeze or strain myself.
3) I have it when I do not release urine over a period of more than two hours.
4) Frequently.
5) Always.

C-30. How often do you go to the bathroom (to void urine) at night?
1) Hardly ever.
2) Once or twice.
3) Three times or more.

C-31. Do you have a feeling of residual urine even after voiding of urine (urination)?
1) I rarely have such a feeling.
2) I sometimes have such a feeling, and sometimes not.
3) I usually have such a feeling.
0) I am not sure.

C-32. Can you void urine immediately in the toilet?
1) I almost always can do it immediately.
2) I sometimes can do it immediately, and sometimes not.
3) I usually cannot do it immediately.
0) I am not sure.

C-35. While in the sitting position, can you look up at the ceiling by drawing your head directly backward?
1) I can do it without difficulty.
2) I can do it with some effort.
3) I cannot do it.

Table 8. *Continued*

C-37. Can you drink a glass of water in one gulp?
1) I can do it without difficulty.
2) I can do it with some effort.
3) I cannot do it.
0) I am not sure.

C-38. Can you see your feet when you walk down the stairs?
1) I can do it without difficulty.
2) I can do it with some effort.
3) I cannot do it.
0) I am not sure.

C-41. Can you turn your head when you back your car?
1) I can do it without difficulty.
2) I can do it with some effort.
3) I cannot do it.
0) I am not sure. I do not drive a car/I do not drive these days.

C-41-2. Alternative question
While in the sitting position, can you turn your head toward the person who is seated behind you and speak to him/her while looking him/her in the face?
1) I cannot do it.
2) I can do it with some effort.
3) I can do it without difficulty.

QOL-1. What is your present health condition?
1) Excellent
2) Very good
3) Good
4) Not very good
5) Poor

QOL-3. The following are ordinary daily activities. Please indicate if you have difficulty doing them because of your poor health condition and, if so, how difficult you think it is to do them. Circle the item number that most applies.
5. Climbing the stairs to one floor above
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

6. Bending forward, kneeling, and stooping
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

7. Walking a kilometer
1) I have great difficulty
2) I have some difficulty
3) I do not have any difficulty

QOL-4. When you engaged in your work or daily activities (including housework) during the last month, did you have any of the problems listed below because of your physical condition? (Circle the item number in each topic that best applies.)
2. I could not do my work or daily activities as well as I expected.
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) I was able to do my work or daily activities as well as I expected.

QOL-8. How severely was your work (including housework) hindered during the last month because of the pain?
1) Not at all
2) A little
3) Slightly
4) Fairly
5) Greatly

QOL-9. The following are questions about your feelings during the last month (circle the item number of each question that best applies).
6. Were you discouraged and depressed?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

7. Were you exhausted?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

8. Did you feel pleasant?
1) Always
2) Almost always
3) Sometimes
4) Rarely
5) Not at all

QOL-11. Circle the item number of each of the following topics that best applies to your condition.
2. I am in decent health.
1) Completely yes.
2) Almost yes.
3) I am not sure.
4) I hardly think so.
5) I do not think so.

3. I feel my health will get worse.
1) Completely yes.
2) Almost yes.
3) I am not sure.
4) I hardly think so.
5) I do not think so.

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