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Time-course of physical and mental well-being improvements after cervical surgery

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Abstract (295/300)

Study Design

Retrospective cohort study

Objective

To elucidate the postoperative time-course of improvements in physical and mental well-being in patients with cervical spondylotic myelopathy (CSM).

Summary of Background Data

Spinal surgeons should understand the postoperative course in detail. However, data are still needed regarding the time-course of improvements in well-being, a fundamental aspect of human life, after cervical surgery for CSM.

Methods

One hundred consecutive patients who underwent laminoplasty for CSM, with complete clinical data preoperatively and 3 months and 2 years postoperatively, were enrolled. The Short Form-36 physical component summary (PCS) and mental component summary (MCS) scores were used as parameters of physical and mental well-being, respectively, and 4.0 was defined as the minimal clinically important difference (MCID) for both parameters.

Results

On average, PCS and MCS scores were significantly improved after surgery ($p<0.001$, $p=0.004$, respectively). Moreover, 64 and 48 patients achieved meaningful improvement (>MCID) in PCS and MCS scores at 3 months

postoperatively, with maintained improvement (to 2 years) in 46/64 (71.9%) and 34/48 patients (70.8%), respectively (PCS vs. MCS: p=0.912). Additionally, 15/36 patients (41.7%) and 8/52 patients (15.4%) achieved late improvement (meaningful improvement at 2 years but not at 3 months) in PCS and MCS scores, respectively (PCS vs. MCS: p=0.007). In multivariate regression analysis, improvement in cJOA score was significantly associated with PCS improvement, but not MCS improvement, at both 3 months and 2 years (p=0.001, p>0.001, respectively).

Conclusion

The overall outcome of physical well-being improvement is decided within 3 months postoperatively, in proportion to the recovery in myelopathy, with a relatively high chance of meaningful improvement over the next 21 months. The outcome of improvement in mental well-being is decided within 3 months postoperatively, independently from the recovery in myelopathy, with a low chance of meaningful improvement over the next 21 months.

Level of evidence: III (Prognosis: Cohort study**)**

Keywords: well-being, physical well-being, mental well-being, quality of life, laminoplasty, cervical spondylotic myelopathy, spinal surgery, time-course, improvement, recovery, minimal clinically important difference

Key points:

・Data are still needed regarding the time-course of improvements in well-being after cervical surgery for cervical spondylotic myelopathy.

・On average, both physical and mental well-being were significantly improved after surgery.

・Individually, improvements in physical and mental well-being are largely decided within the first 3 months.

・The physical well-being was more likely to improve over the next 21-month period than mental well-being.

・Physical well-being, but not the mental well-being, was associated with improvement in myelopathy.

Mini abstract: (48/50 words)

Individual change analysis of postoperative improvements in physical and mental well-being in patients with CSM showed that improvements in physical and mental well-being are largely decided within 3 months. Physical well-being was associated with improvement in myelopathy and was more likely to improve over the next 21-month period than mental well-being.

Introduction

Well-being or quality of life (QOL) is an essential and fundamental concept of human life.[1] In 1995, the World Health Organization defined the concept as "An individual's perceptions of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns."[1] Spine-related disabilities, including neurological symptoms, pain, and numbness, significantly impair the activities of daily life, resulting in significant impairment in well-being.[2,3]

Cervical spondylotic myelopathy (CSM) is the most frequent abnormality of the cervical spine, with an incidence of at least 605 per million in the North American region.[4] Surprisingly, 1.4% of Japanese volunteers aged over 50 years show cervical canal stenosis, with some neurological symptoms.[5] Cervical surgery is currently widely accepted as a standard treatment for patients with moderate to severe CSM and is associated with significant improvements in physical function postoperatively.[6-9] A previous study on the detailed time-course of the postoperative functional improvement showed that the physician-assessed functional status significantly recovered within 1 year postoperatively, with further recovery up to 2 years postoperatively and that this improvement could be sustained for at least 5 years postoperatively.[8] However, there is still a need for data regarding the time-course of patient-reported improvement in well-being after cervical surgery for CSM, as it is critical for spinal surgeons and physicians to understand the overall postoperative course in detail.

In general, health-related well-being can be classified into two types: physical- and mental-related well-

being.[10,11] We hypothesized that physical well-being would relatively improve quickly after surgery, in proportion with improvements in physical function, and that mental well-being would improve with some delay, subsequent to improvements in physical function and physical well-being. To test this hypothesis, the primary aim of current study was to delineate the improvement process after surgery for CSM, in terms of physical and mental well-being, with a focus on not only the average change but also individual change, using the minimal clinically important difference (MCID) framework.[12] The secondary aim was to identify the variables associated with improvement for each type of well-being.

Methods

Study design and ethics

We performed a retrospective cohort study of patients who underwent cervical surgery for CSM. All study participants provided informed consent, and the study protocol was approved by the Institutional Review Board at our institution (No. 3170).

Patient population

To eliminate inconsistency in the surgical method and the effect of missing data, we selected 100 consecutive current patients who underwent laminoplasty for CSM at our institution between 2007 and 2016 who had more than 2 years of follow-up, with complete preoperative, 3-month, and 2-year follow-up clinical data. Patients with previous cervical surgery or aged less than 30 years were excluded.

Surgical procedure

All patients underwent open-door laminoplasty.[13] The surgical indication and approach were decided on a case-by-case basis by the treating physicians. Hydroxyapatite spacers or anchor screws were used at each level to fix the opened lamina.[14] The day after surgery, all patients were allowed to sit up with a soft neck collar and stand and walk. Removal of the soft brace was allowed 1 week after surgery. Subsequently, all patients were encouraged to start range-of-motion and isometric muscle strengthening exercises of the neck as early as possible. All patients were treated with the same postoperative rehabilitation protocol, which included in-

hospital physical therapy for two weeks after surgery.

Clinical evaluations

The cervical Japanese Orthopaedic Association (cJOA) score, which is a physician-assessed scoring system of the severity of myelopathy, was evaluated preoperatively and at 3 months, 1 year, and 2 years postoperatively.[15] Patient-oriented questionnaire scores, including the 36-item Short Form Health Survey (SF-36), were performed preoperatively and at 3 months, 6 months, 1 year, and 2 years postoperatively. The SF-36 is a 36-item scale measuring eight domains of health-related QOL as follows: physical functioning (PF), physical role limitations (RP), bodily pain (BP), general health perceptions (GH), energy/vitality (VT), social functioning (SF), emotional role limitations (RE), and mental health (MH)[16]. The domain scores were summarized as the physical component summary (PCS) score and mental component summary (MCS) score, using a previously proposed algorithm.[17]

Well-being parameters

The PCS score and MCS score of the SF-36 were used as parameters of physical and mental well-being, respectively.[18] Based on previous reports, the MCID was defined as 4.0 for both the PCS and MCS scores.[19]

Study design & statistical analysis

Patients demographics analysis

The tendency of improvement in cJOA score from preoperatively to three months and two years postoperatively was evaluated using the Jonckheere-Terpstra trend test.

Overall improvement analysis

The average change in SF-36 PCS and MCS scores from preoperatively to 3 months, 6 months, 1 year, and 2 years postoperatively was evaluated using repeated measurement 1-way analysis of variance, with a calculation of the overall p-value. In subsequent post-hoc analyses, t-tests with Bonferroni correction were performed to evaluate differences between the preoperative scores and the scores at each time-point.

Individual change analysis

We determined the number of patients who achieved an improvement in the PCS and MCS greater than the MCID at 3 months and 2 years postoperatively. For both PCS and MCS, patients who achieved an improvement greater than the MCID at both 3 months and 2 years postoperatively were considered to have “maintained improvement”. Additionally, patients who failed to achieve an improvement greater than the MCID at 3 months, but achieved an improvement greater than MCID at 2 years postoperatively were considered to have “late improvement”. The chi-squared test was used to evaluate differences between the PCS and MCS in the numbers of patients with an improvement greater than the MCID at 3 months and 2 years postoperatively, and the number of the patient with maintained improvement, and late improvement.

Analysis of the factors associated with improvement in PCS and MCS scores

The Pearson correlation coefficient was used to evaluate associations between improvement in PCS and MCS scores, age, and improvement in the cJOA score. Subsequently, multivariate linear regression analyses were performed, with the change in PCS or MCS scores (from the preoperative value to the value at 3 months or 2 years postoperatively) set as the objective variable, and age, sex, and change in cJOA score (from the preoperative value to the value at 3 months or 2 years postoperatively) were included as explanatory variables, adjusting for these variables. Unstandardized partial regression coefficients (B), standardized partial regression coefficients (β), and p-values were calculated.

All analyses were performed using SPSS software (version 23; SPSS, Chicago, IL). A p-value <0.05 was considered statistically significant.

Results

Patient demographics are shown in Table 1. The average age was 64.5 ± 11.6 years; 42 females and 58 males were included; the major surgical level was C3-C6, and the total cJOA score significantly tended to improve after surgery ($p<0.001$).

Average improvement

The SF-36 PCS score significantly improved from 24.7 ± 13.4 preoperatively to 34.4 ± 14.1 at 2 years postoperatively (overall $p<0.001$), with significant differences between the preoperative and postoperative scores at all time points ($p<0.001$, Figure 1). Likewise, the SF-36 MCS score significantly improved from 43.0 ± 13.1 preoperatively to 47.4 ± 12.1 at 2 years postoperatively (overall $p=0.004$), with significant differences between the preoperative score and the scores at 6 months and 1 year postoperatively ($p=0.020$ and 0.010, respectively, Figure 1).

Individual improvement

There were 64 and 48 patients who achieved an improvement greater than the MCID at 3 months postoperatively for the PCS and MCS, respectively (Table 2). Additionally, 61 and 42 patients achieved an improvement greater than the MCID at 2 years for the PCS and MCS, respectively. The number of patients with an improvement greater than the MCID at 3 months and 2 years postoperatively was significantly higher in PCS than MCS ($p=0.032$ at 3 months, and $p=0.011$ at 2 years).

Furthermore, 46/64 patients (71.9%) and 34/48 patients (70.8%) showed maintained improvement in the PCS and MCS scores, respectively, and 15/36 patients (41.7%) and 8/52 patients (15.4%) showed late improvement in the PCS and MCS scores, respectively (Table 3). Although the number of patients with maintained improvement showed no significant differences between the PCS and MCS scores (p=0.912), the number of patients with late improvement was significantly higher in the PCS scores than MCS scores (p=0.007, Table 3).

Factors associated with improvement in PCS and MCS scores

On univariate analysis, significant correlations were observed between the 3-month changes in PCS and cJOA scores (r=0.293, p=0.006, Table 4), between age and the 2-year change in the PCS score (r=-0.274, p=0.006), and between the 2-year changes in PCS and cJOA scores (r=0.437, p<0.001). However, the 3-month and 2-year changes in the MCS score did not show significant correlations with the tested variables (Table 4). On multivariate linear regression, the change in cJOA score was significantly associated with the change in PCS score at both 3 months and 2 years postoperatively (p=0.001, p>0.001, respectively, Table 5); when the cJOA score improved, the PCS score similarly tended to improve. In contrast, the 3-month and 2-year changes in the MCS score did not correlate with any tested variable (Table 5).

Discussion

This study is the first to report both individual change and average time-course data for postoperative improvements in the well-being of patients with CSM. Previous reports exclusively focused on average improvements in the well-being of patients with CSM. For example, Zhang *et al* reported that the preoperative QOL score was severely reduced in patients with CSM compared to that in the normal population; however, the QOL score significantly improved after surgery.[20] Fehlings *et al* reported that physical- and mental-related QOL scores were significantly improved in patients with CSM 1-year postoperatively, regardless of whether anterior or posterior surgery was performed.[21] Consistent with these previous reports, physical and mental well-being scores significantly improved after cervical surgery, on average, in the current study. The individual change analysis showed that up to 60% and 45% of patients experienced meaningful improvements in their physical and mental-related well-being, respectively.

We hypothesized that physical well-being would improve quickly, in proportion to the improvement in physical function, which was supported by the current results. On average, physical well-being improved by 3 months postoperatively, with improvements largely sustained for up to 2 years; and the improvement in myelopathy significantly correlated with the improvement in physical well-being. These results indicate that the overall outcome of physical well-being improvement was decided within 3 months, in proportion to the recovery in myelopathy. However, we similarly found that 42% of the patients who failed to achieve a meaningful improvement at 3 months postoperatively attained a meaningful improvement at 2 years postoperatively. These

results may indicate that, even if a patient fails to achieve a meaningful improvement at 3 months postoperatively, they still have a chance to achieve this improvement in the next 21 months.

Similarly, we hypothesized that mental well-being would improve subsequent to an improvement in physical well-being; however, the current study results do not support our hypothesis. On average, mental well-being quickly improved after cervical surgery, with improvements largely sustained for up to 2 years; and the improvement in mental well-being did not correlate with the improvements in myelopathy and physical well-being. Furthermore, only 15.4% of the patients who failed to achieve a meaningful improvement at 3 months postoperatively attained a meaningful improvement at 2 years postoperatively These results indicate that the overall outcome of improvement in mental well-being was decided within 3 months, and the chance of achieving a meaningful improvement in mental well-being after three months was significantly lower than that for physical well-being. Regarding variables related to MCS improvement, our previous study identified "social functioning," rather than myelopathy, as the key factor for the improvement in mental well-being after cervical surgery.[22] The study results provide new knowledge regarding the first 3 months postoperatively as the crucial period for achieving a meaningful improvement in mental well-being.

A better understanding of the detailed postoperative time-course of improvements in well-being in patients with CSM can help surgeons in several aspects. First, current results can aid surgeons in explaining the expected postoperative changes, which could result in greater patient satisfaction.[23] Second, as this study revealed the

first 3 months postoperatively as the crucial period for improving well-being (especially mental well-being) in patients with CSM, medical resources, such as physical and occupational therapy, should be concentrated in this period to achieve improvements effectively. Fourth, as 15% of overall patients showed late improvement in their physical well-being, the clinical course should be observed not only by 3 months but also after then. Finally, the current results indicate the necessity to establish new interventions for non-standard factors, such as social functioning, rather than for myelopathy, to achieve meaningful improvement in mental well-being.[22]

Several limitations to the present study need to be addressed. First, the study's retrospective nature makes it difficult to exclude bias, especially regarding the referral for a certain postoperative rehabilitation program and the particular surgical techniques utilized. In addition, although we used the SF-36 PCS and MCS as parameters of well-being, the status of well-being should be analyzed in a multifaceted manner, and the current result should be validated by further studies that would consider other aspects.[24] Finally, to evaluate a consistent population with regard to the surgical method, we only included patients who were treated with laminoplasty. Other surgical methods, including posterior decompression and fusion, and anterior cervical discectomy and fusion, should be validated. However, this is the first study to elucidate the time-course of individual improvements in physical and mental well-being after cervical surgery in detail, without any data omission.

Conclusion

The current study revealed that, on average, both physical and mental well-being significantly improve after cervical surgery. In the analysis of individual change, up to 60% and 45% of the patients experienced a meaningful improvement in their physical and mental well-being at 2 years preoperatively. The overall outcome of improvement in physical well-being was decided within 3 months postoperatively and was proportional to the recovery in myelopathy; however, there was still a high chance of improvement over the next 21 months. Additionally, the overall outcome of improvement in mental well-being was decided within 3 months postoperatively, independently from the recovery in myelopathy; furthermore, there was a low chance of improvement over the next 21 months. These results can potentially help spinal surgeons provide adequate explanations to patients with CSM and establish an effective postoperative treatment program.

Table 1. Patient demographics

Variables	Values
Total number (cases)	100
Age (years)	64.5 ± 11.6
Sex (female/male)	42 / 58
Surgical level	
C3-C6	91
C3-C7	3
C4-C7	6
cJOA score	
Preoperative	
Total score	9.7 ± 3.2
Motor of UE	1.8 ± 1.2
Motor of LE	1.7 ± 1.2
Sensory of UE	0.9 ± 0.5
Sensory of trunk	1.6 ± 0.5
Sensory of LE	1.3 ± 0.6
BBD	2.2 ± 1.0
Three months postop	
Total score	13.1 ± 2.2
Motor of UE	3.1 ± 1.4
Motor of LE	2.4 ± 1.1
Sensory of UE	1.3 ± 0.7
Sensory of trunk	2.0 ± 0.3
Sensory of LE	1.6 ± 0.2
BBD	2.7 ± 0.8
Two years postop	
Total score	13.4 ± 2.3
Motor of UE	3.2 ± 1.0
Motor of LE	2.5 ± 1.0
Sensory of UE	1.4 ± 0.4
Sensory of trunk	2.0 ± 0.1
Sensory of LE	1.7 ± 0.3
BBD	2.7 ± 0.7

Motor of UE was defined as the sum of the finger motion score and the upper extremity motion score, cJOA: cervical Japanese Orthopaedic Association, postop: postoperatively, UE: upper extremity, LE: lower extremity, BBD: bowel bladder function

Table 2. Improvement greater than the MCID at 3 months and 2 years postoperatively

	Improved at 3m	Not improved at 3m	p-value
SF-36 PCS	64	36	0.032[#]
SF-36 MCS	48	52	
	Improved at 2ys	Not improved at 2ys	p-value
SF-36 PCS	61	39	0.011[#]
SF-36 MCS	42	58	

The definition of "Improved" is the patients who showed a positive change in the PCDS or MCS score more than MCID (=4.0 points). #: Chi-squared test, MCID: Minimal Clinically Important Difference, SF-36: Short form-36, PCS: physical component summary, MCS: Mental component summary, 3m: three months, 2ys: two years

Table 3. Cross-tabulated improvements in PCS and MCS scores

Patients who improved at 3 months			
	Improved at 2y	Not improved at 2y	p-value
SF-36 PCS (n=64)	46	18	0.912
SF-36 MCS (n=48)	34	14	
Patients who did not improved at 3 months			
	Improved at 2y	Not improved at 2y	0.007
SF-36 PCS (n=36)	15	21	
SF-36 MCS (n=52)	8	44	

The definition of "Improved" is the patients who showed a positive change in the PCS or MCS score more than MCID (=4.0 points). #: Chi-squared test, MCID: Minimal Clinically Important Difference, SF-36: Short form-36, PCS: physical component summary, MCS: Mental component summary, 3m: three months, 2y: two years

Table 4. Correlation between the change in cJOA score, PCS, and MCS

Change from preoperative to 3 months postoperatively				
	Age	cJOA score change	PCS change	MCS change
PCS change	-0.091 (p=0.371)	0.293 (p=0.006)		0.002 (p=0.987)
MCS change	-0.026 (p=0.796)	0.199 (p=0.063)	0.002 (p=0.987)	
Change from preoperative to 24 months postoperatively				
	Age	cJOA score change	PCS change	MCS change
PCS change	-0.274 (p=0.006)	0.437 (p<0.001)		0.042 (p=0.679)
MCS change	0.002 (p=0.983)	0.126 (p=230)	0.042 (p=0.679)	

cJOA: cervical Japanese Orthopaedic Association, PCS: physical component summary, MCS: Mental component summary

Table 5. Multivariate analysis of the factors associated with improvement in PCS and MCS scores at 3 months and 2 years postoperatively

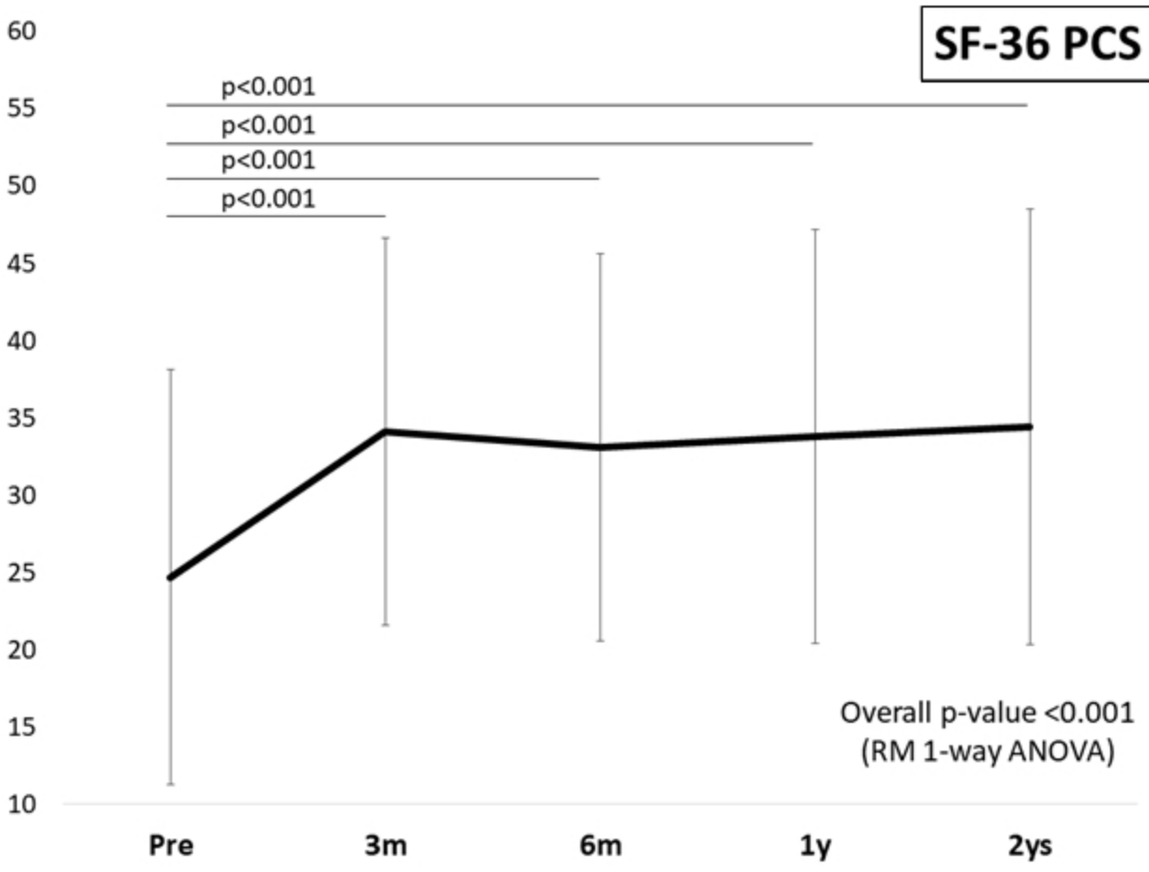
Objective variable	Explanatory variables	B	β	p-value
PCS change (base-3m)	Age	-1.15	-0.47	0.647
	Sex	-0.14	-0.14	0.182
	cJOA change (base-3m)	1.23	0.27	0.011
MCS change (base-3m)	Age	-0.26	-0.01	0.920
	Sex	-0.04	-0.04	0.730
	cJOA change (base-3m)	0.87	0.19	0.078
PCS change (base-2yrs)	Age	-6.06	-0.24	0.010
	Sex	-0.26	-0.24	0.011
	cJOA change (base-2yrs)	1.67	0.38	>0.001
MCS change (base-2yrs)	Age	1.04	0.04	0.712
	Sex	0.09	0.08	0.454
	cJOA change (base-2yrs)	0.65	0.14	0.142

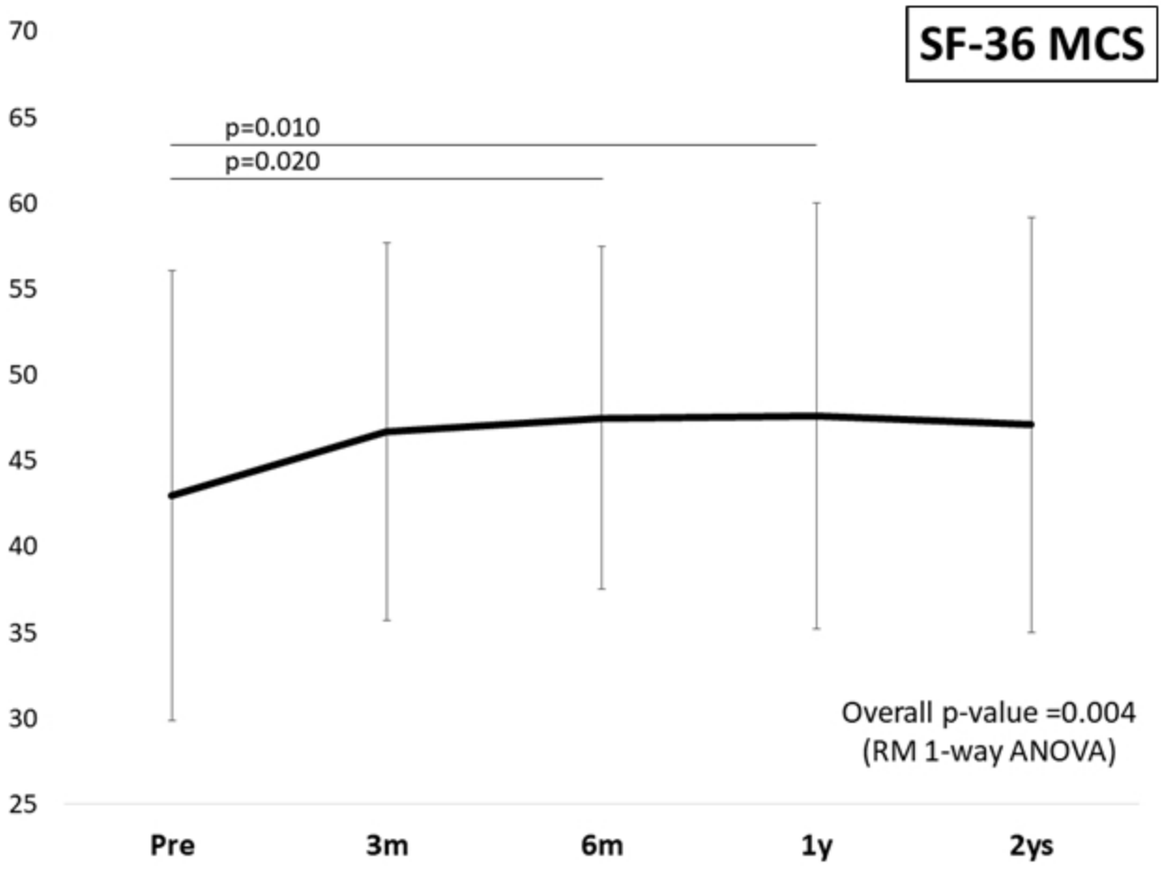
cJOA: cervical Japanese Orthopaedic Association, PCS: physical component summary, MCS: Mental component summary, 3m: three months, 2yrs: two years

Figure Legends

Figure 1. Improvement in the SF-36 PCS and MCS.

SF-36: Short form-36, PCS: physical component summary, MCS: Mental component summary, RM: Repeated measurement, ANOVA: analysis of variance


SF-36 PCS
60
55
50
45
40
35
30
25
20
15
10
p<0.001
p<0.001
p<0.001
p<0.001
Overall p-value <0.001
(RM 1-way ANOVA)
Pre
3m
6m
1y
2ys


SF-36 MCS
70
65
60
55
50
45
40
35
30
25
p=0.010
p=0.020
Overall p-value =0.004
(RM 1-way ANOVA)
Pre
3m
6m
1y
2ys

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