

Post-operative neurological improvement is associated with significant neck pain attenuation after surgery for cervical ossification of the posterior longitudinal ligament: a prospective multicenter registry study

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Abstract

Although favourable surgical outcomes for myelopathy caused by cervical ossification of the posterior longitudinal ligament (OPLL) have been reported, factors significantly associated with post-operative neck pain attenuation still remain unclear. The primary aim of the present study was to determine factors significantly associated with post-operative neck pain attenuation in patients with cervical OPLL using a prospective multi-centre registry of surgically treated cervical OPLL. Significant postoperative neck pain reduction (50% reduction of neck pain) was achieved in 84 patients (30.9%). There was no significant difference in neck pain attenuation between surgical procedures. Statistical analyses revealed neurological recovery as a factor having a significant positive association with post-operative neck pain attenuation ($p = 0.04$).

Neurological recovery was an independent factor having a significant positive association with post-operative neck pain attenuation in patients with cervical myelopathy caused by OPLL who underwent cervical spine surgery.

Introduction

Ossification of the posterior longitudinal ligament (OPLL) is a disease with heterotopic ossification in the spinal posterior longitudinal ligament [1]. Computed tomography screening has revealed an unexpectedly high prevalence of OPLL in the cervical spine, which affects about 7%-10% of the general population in Japan [2][3]. Increase of thickness of ossification foci can cause compression of nerve roots and the spinal cord, possibly resulting in neurological deficits [4]. Favourable surgical outcomes for cervical OPLL have been reported. Nerve root and spinal cord symptoms including numbness, palsy, and vesico-rectal disturbance can be attenuated after surgery for cervical OPLL [5].

In addition to neurological symptoms including radiculopathy and myelopathy, cervical OPLL can cause local symptoms such as neck pain and stiffness, which can be main complaints for patients [6]. Previous reports revealed neck pain attenuation by cervical spine decompression/fusion surgeries for cervical OPLL [7][8][9]. However, the precise aetiology of neck pain, postoperative change of neck pain, and factors significantly associated with post-operative neck pain attenuation in patients with cervical OPLL still remain unclear.

The primary aim of the present study was to elucidate the post-operative change of neck pain and to determine factors significantly associated with post-operative neck pain attenuation in patients with cervical OPLL using a prospective multi-centre registry of surgically treated cervical OPLL.

Results

Patient demographics are shown in Table 1. Pre-operative visual analogue scale (VAS 1-100 mm) neck pain score was 62.0 ± 21.4 mm on average. On average (\pm SD), VAS neck pain score was reduced to 48.1 ± 29.0 mm at 2 years after surgery; therefore, post-operative VAS neck pain score reduction was $14.0 \pm$

28.3 mm and VAS neck pain score reduction was by $18.8 \pm 53.5\%$. Sixty-one patients (22.4%) showed post-operative neck pain deterioration, whereas the remaining 211 (77.6%) showed no deterioration. Significant attenuation of neck pain, which was set to 50 % reduction of VAS neck pain, was achieved in 84 patients (30.9%), whereas the proportion of pain reduction of the remaining 188 (69.1%) did not reach 50% (Table 2).

There was no significant difference in pre-operative VAS neck pain score between surgical procedures. Post-operative VAS neck pain scores, neck pain reduction score, and proportion of neck pain reduction showed no significant difference between surgical procedures (Table 3).

Age, diabetes mellitus, disease duration and Japanese Orthopedic Association score for evaluating cervical myelopathy (JOA score) recovery rate were identified by initial uni-variate analyses (Table 4). Logistic regression analysis revealed the JOA score recovery rate as a factor having a significant positive association with post-operative neck pain attenuation ($p = 0.04$, Table 4). Receiver-operator characteristic (ROC) analysis revealed a JOA score recovery rate of 52.6% as a cut-off value to achieve at least a 50% reduction of post-operative neck pain score (area under curve (AUC) = 0.6).

Discussion

The present results demonstrated that neurological recovery was an independent factor having a significant positive association with post-operative neck pain attenuation.

There are many previous reports showing the possible aetiologies of neck pain.

Axial pain, as first reported by Hosono, which is defined as post-operative neck pain related to posterior approach-induced muscle damage, is regarded as a major cause of post-operative neck pain [10]. Various kinds of muscle preserving posterior approaches have been reported to attenuate post-operative axial neck pain [11][12][13]. The anterior approach does not invade the posterior musculo-ligamentous complex; therefore, post-operative muscle-related neck pain can be decreased compared with that in the posterior approach [14]. However, the present results showed that there is no significant difference in post-operative neck pain attenuation between surgical approaches (anterior, posterior and A-P combined) or surgical procedures (laminoplasty, PDF, ADF, and A-P), suggesting that surgical damage of the cervical musculature has no significant association with post-operative neck pain in the present patient series. Possible explanations for this discrepancy in muscle damage-related neck pain between previous reports and the present data might be as follows: the posterior approach-related muscle damage decreased according to the recent popularization of muscle-preserving posterior approaches and the impact of posterior approach-related muscle damage might be limited to the early post-operative phase and not the chronic phase.

Discogenic and/or facet genic neck pain, which is caused by degenerated intervertebral disks and facet joints accompanied with segmental instability, can be another possible source of neck pain [15][16][17]. Fusion surgery can be indicated for discogenic/facet genic neck pain because this category of pain can

theoretically be attenuated by fusion of the pain-generating segment [16]. However, the present results unexpectedly showed that there was no significant difference in post-operative neck pain attenuation between segmental motion-preserving laminoplasty and fusion surgeries (anterior, posterior and A-P). Therefore, discogenic/facet genic neck pain was not likely to be a major aetiology of neck pain in the present series.

The present results revealed post-operative neurological recovery as an independent factor having a significant association with post-operative neck pain attenuation. These lines of evidence suggest that neurogenic pain is one of the major causes of neck pain in patients with cervical OPLL. There might be several possible origins of myelopathy-related neck pain. Spinal cord compression can stimulate the posterior ramus of the spinal nerve, possibly resulting in neck pain [18]. Segmental spinal cord sign caused by compressive myelopathy may, like girdle pain, be another origin of neck pain [19]. Segmental spinal cord compression can cause local impairment of the spinothalamic tract at its chiasma at the central grey matter of the spinal cord [20]. Irrespective of the precise cause, a large-scale cohort study revealed that cervical myelopathy can cause neck pain [21].

The present study includes several major limitations. The present registry lacks data regarding cervical sagittal alignment. Recently, the concept of sagittal alignment has been introduced to the cervical spine, similar to the thoracolumbar spine. Cervical sagittal alignment is important to evaluate neck pain because it has been reported to correlate with neck pain [22]. Therefore, the outcome might be changed significantly if cervical sagittal alignment data were added. To solve this problem, future collection of data regarding cervical sagittal alignment is needed. Another major limitation of the present study is that the present registry lacks information about the precise location and characteristics of neck pain and evaluation of neuropathic pain. Those data are important to elucidate the origin of neck pain. As a result, we can only speculate on the origin of neck pain using indirect evidence including post-operative change of neck pain, pre-operative patient factors, surgical factors, radiological changes, and neurological status. Future data collection of the precise characteristics of neck pain and neuropathic pain evaluation are warranted.

In conclusion, neurological recovery was an independent factor having a significant positive association with post-operative neck pain attenuation in a prospective study of a cohort of patients with cervical myelopathy caused by OPLL who underwent cervical spine surgery.

Methods

We used a prospective cohort design for the present study.

The present study protocol was approved by the review board for clinical trials of Tokyo Medical and Dental University as a central review board of all the participating institutes and performed in accordance with the relevant guidelines and regulations. On participation to the registry, informed consent was obtained from all the participants. The registry included data from 478 patients who underwent cervical spine surgery for myelopathy caused by cervical OPLL. Amongst these patients, we excluded data from

those who lacked pre-operative neck pain evaluation (40 cases) and who showed a pre-operative neck pain score < 30 mm on a visual analogue scale (VAS, 0-100 mm, 166 cases). Therefore, we included data from 272 patients with cervical OPLL and a pre-operative neck pain severity score ≥ 30 mm on a VAS. Patient demographics are shown in Table 1.

Neck pain was evaluated using the VAS score pre- and post-operatively. The proportion of VAS score reduction was calculated as (pre-operative VAS neck pain – post-operative VAS neck pain) / pre-operative VAS neck pain $\times 100$ (%). Post-operative neck pain deterioration was expressed as the negative proportion of VAS score reduction.

Data for patient factors including age at surgery, sex, body mass index, disease duration, and diabetes mellitus were collected. Pre- and post-operative neurological status were analysed using the Japanese Orthopedic Association score for evaluating cervical myelopathy (JOA score; 0–17 points [23]). The recovery rate of JOA score was calculated using the following method: (post-operative JOA score – pre-operative JOA score) / (17 (full mark) – pre-operative JOA score) $\times 100$ (%) [24]. Post-operative neurological deterioration was expressed as the negative value JOA score recovery rate. Imaging factors including types of OPLL (continuous, segmental, mixed and localized types [25]), canal narrowing rate (thickness of OPLL at its peak level / antero-posterior diameter of corresponding spinal level (%)), post-operative change of C2-7 angle (angle between inferior endplates of C2 and C7 vertebral bodies), change of C2-7 range of motion (ROM; subtraction of C2-7 angle from extension position to flexion position) and spinal cord signal intensity change in magnetic resonance imaging (MRI) T2 weighted image were assessed. Surgical factors including surgical procedures (laminoplasty, posterior decompression with instrumented fusion (PDF), anterior decompression and fusion (ADF), and antero-posterior decompression and fusion (A-P)) and surgical approach (anterior, posterior and antero-posterior) were evaluated.

Missing data were supplemented by the last observation carried forward method.

First, we analysed the association of surgical procedures with post-operative neck pain. Pre- and post-operative VAS neck pain scores and the proportion of post-operative pain reduction were compared between surgical procedures including laminoplasty, PDF, ADF and A-P surgeries with Steel-Dwass analyses. Next, we performed uni-variate analyses followed by multi-variate analysis using stepwise logistic regression to elucidate the independent factors having a significant positive association with post-operative neck pain attenuation. Achievement of 50% or more post-operative neck pain reduction ratio was set as a response variable. The background factors for the patients as mentioned above, surgical factors, neurological factors, and imaging factors were set as explanatory variables. Factors showing a p -value < 0.1 with initial uni-variate analyses were then analysed by logistic regression. Factors showing a p -value < 0.05 were determined as independent factors having a significant positive association with post-operative neck pain attenuation. Screened factors were then analysed using receiver-operator characteristic (ROC) curves to determine their cut-off values. All the statistical analyses were conducted with statistical analytics software JMP (version 12.0; SAS Institute, Cary, NC, USA).

Declarations

Author contributions

MK, TY, KK, KA and YK contributed to planning and conduct of the present study and to reporting the present manuscript. SE, KS, KK, TF, SM, HT, MM, SI, KT, MN, MM, AO and MY contributed to conception and design of the present study and to reporting the present study. YN, TH, KW, NN, KW, TK, YN, YO, KA, MT, KM, HN, KM, SM, TK, KY, SK, SK, TO, SI, SF, HK, HK, GI, MT, contributed to conducting the present study and to edit the present manuscript. All authors reviewed the manuscript.

Additional Information

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This study was approved by each institutional review board.

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Tables

Table 1 Demographics (n = 272)

Male: Female (cases)	199: 73
age at surgery (years old)	63.2 ± 11.7
disease duration (months)	43.5 (0 - 434)
body mass index	25.7 ± 4.2
diabetes (No. of cases)	90/272
JOA score (pts.)	
Pre-op.	10.4 ± 3.1
Post-op. 2y	13.4 ± 2.9
acquired points	3.0 ± 2.7
recovery rate (%)	44.9 ± 35.5
pre-op. neck pain (VAS, mm)	62.0 ± 21.4
Surgical procedures (cases)	
Laminoplasty	145 (C7 involvement: 91/145)
Posterior decompression & fusion	64
Anterior decompression & fusion	56
A-P	7
Imaging findings	
Type of OPLL (cases)	
Continuous	31
Segmental	100
Mixed	120
Localized	21
Canal narrowing rate (%)	43.5 ± 15.6
C2-7 angle (°)	9.3 ± 11.9 (Δ C2-7 angle: -1.7 ± 9.9)
range of motion (°)	26.7 ± 13.9 (Δ ROM: -9.6 ± 15.1)
T2 high signal change (cases)	231/272

Table 2: neck pain

Neck pain (VAS, 0-100mm)

pre-op.	62.0 ± 21.4 mm
post-op. 2y	48.1 ± 29.0 mm
VAS reduction	14.0 ± 28.3 mm
VAS reduction rate	18.8 ± 53.5 %
50% pain reduction (cases)	84/272 (30.9%)

Table 3: Surgical procedures and neck pain

	LMP (n = 145)	PDF (n = 64)	ADF (n = 56)	A-P (n = 7)
Neck pain				
Pre-Op. (mm)	60.0 ± 22.4	64.0 ± 20.5	65.1 ± 20.0	63.6 ± 21.1
Post-Op. (mm)	48.0 ± 28.3	47.6 ± 30.0	49.4 ± 29.7	41.9 ± 37.2
Change (mm)	11.9 ± 27.5	16.3 ± 30.1	15.9 ± 28.8	21.7 ± 25.3
Reduction rate (%)	16.0 ± 55.4	21.9 ± 51.3	21.7 ± 51.0	40.9 ± 43.4
50% pain red. (cases)	41/145 (28.3%)	22/64 (34.4%)	20/56 (35.7%)	3/7 (42.9%)
JOA score				
Pre-Op. (pts.)	11.0 ± 2.7	8.8 ± 3.5	11.0 ± 2.7	9.7 ± 2.7
Post-Op. (pts.)	13.7 ± 2.5	12.2 ± 3.6	14.1 ± 2.6	12.7 ± 3.4
Change (pts.)	2.6 ± 2.4	3.4 ± 3.3	3.3 ± 2.6	3.0 ± 2.7
Recovery rate (%)	42.6 ± 36.6	42.3 ± 34.3	54.3 ± 33.0	36.4 ± 40.7

Table 4: Statistical analyses

Univariate analysis	<i>p</i> -value (#: $p < 0.1$)
Patients factors	
age	0.04#
sex	0.36
body mass index	0.20
disease duration	0.07#
diabetes mellitus	0.07#
Neurological status	
pre-op. JOA score	0.56
post-op. JOA score	0.05
JOA score change	0.11
JOA score recovery rate	0.02#
Neck pain	
Pre-op. neck pain	0.52
Imaging factors	
OPLL types	0.19
Canal narrowing rate	0.67
C2-7 angle change	0.68
C2-7 range of motion change	0.38
MRI T2WI signal change	0.30
Stepwise Logistic Regression	
	<i>p</i> -value (*: $p < 0.05$)
age	0.05
disease duration	0.08
diabetes mellitus	0.07
JOA score recovery rate	0.04*