Limitation of activities of daily living accompanying reduced neck mobility after laminoplasty preserving or reattaching the semispinalis cervicis into axis

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Abstract Although difficulties with neck mobility often interfere with patients' activities of daily living (ADL) after cervical laminoplasty, there was no detailed study on the relation between the limitations of ADL accompanying postoperative reduced neck mobility and the cervical posterior approach. The aim of this study was to compare retrospectively the frequency of limitations of ADL accompanying neck mobility after laminoplasty preserving the semispinalis cervicis inserted into the C2 spinous process with that after laminoplasty reattaching the muscle to C2. Forty-nine patients after C4–C7 laminoplasty with C3 laminectomy preserving the semispinalis cervicis inserted into C2 (Group A) and 24 patients after C3–C7 laminoplasty reattaching the muscle (Group B) were evaluated. The frequency of postoperative limitations of ADL accompanying each of three neck movements of extension, flexion and rotation were investigated. The postoperative O–C7 angles at extension and flexion was measured on lateral extension and flexion radiographs of the cervical spine, respectively. The postoperative cervical range of motion in rotation was measured in the cranial view using a digital camera. Frequency of limitations of ADL accompanying extension was lower ($P = 0.037$) in Group A (2%) than in Group B (17%). Frequency of limitations of ADL accompanying flexion was similar in Group A (8%) and Group B (4%). Frequency of limitations of ADL accompanying rotation was lower ($P = 0.031$) in Group A (12%) than in Group B (33%). Average O–C7 angle at extension was

significantly larger ($P = 0.002$) in Group A (147°) than in Group B (136°). Average O–C7 angle at flexion was similar in Group A (93°) and Group B (91°). Average range of motion in rotation was significantly larger ($P = 0.004$) in Group A (110°) than in Group B (91°). This retrospective study suggested that the frequency of limitations of ADL accompanying neck extension or rotation was lower after laminoplasty preserving the semispinalis cervicis inserted into C2 than after laminoplasty reattaching the muscle.

Keywords Cervical laminoplasty · Activities of daily living (ADL) · Cervical myelopathy · Semispinalis cervicis muscle · Surgical outcome

Introduction

Cervical laminoplasty is an established treatment for cervical spondylotic myelopathy. Many clinical investigations have shown that the neurological improvement following cervical laminoplasty has been satisfactory [12, 23, 28]. On the other hand, the difficulties of neck mobility, including extension, flexion and rotation often interfere in patients' ADL after laminoplasty [10, 29], despite their good postoperative neurological improvements. However, the relation between the limitations of ADL accompanying postoperative reduced neck mobility and the cervical posterior approach remains unclear.

In our institutions, C3–C7 double-door laminoplasty has been adapted to cervical myelopathy since 1987 when we have introduced laminoplasty as a treatment for cervical myelopathy [18]. To expose the C3 lamina completely during C3–C7 laminoplasty, it generally is necessary to detach the semispinalis cervicis (SSC) from the C2 spinous process and then reattach it at the time of closure. The SSC,

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most of which inserts into the C2 spinous process [19], act as an extensor of the cervical spine [4, 5, 27]. For complete preservation of the SSC inserted in C2, therefore, the authors changed the laminoplastic procedure from C3–C7 laminoplasty to C4–C7 laminoplasty with C3 laminectomy in 2001 [25].

This retrospective study compared the frequency of limitations of ADL accompanying reduced neck mobility after the modified laminoplasty preserving the SSC inserted into C2 with that after conventional C3–C7 laminoplasty reattaching the muscle to C2. This knowledge might be useful to improve the clinical outcomes following cervical laminoplasty.

Materials and methods

Subjects

Forty-nine patients who underwent C4–C7 laminoplasty with C3 laminectomy were the subject group in this study, designated Group A. All patients who were followed more than 1 year had an average age of 66 years (range 26–90 years) at the time of surgery. There were 31 men and 18 women. Cervical spondylotic myelopathy (CSM) was clinically evident in all cases and ossification of the posterior longitudinal ligament (OPLL) was excluded from this study. Average Japanese Orthopedic Association (JOA) score was 10.5 before surgery and 12.8 at the latest follow-up visit. The average follow-up period was 1 year and 8 months (range 1–3 years).

Twenty-four patients who underwent C3–C7 laminoplasty were the control group in this study, designated Group B. All patients who were followed more than one year had an average age of 63 years (range 45–75 years) at the time of surgery. There were 13 men and 11 women. Cervical spondylotic myelopathy was clinically evident in all cases and OPLL was excluded from this study. Average JOA score was 9.5 before surgery and 12.9 at the latest follow-up visit; these were similar to those of Group A. The average follow-up period was 3 years and 2 months (range 12–81 months); it was significantly longer ($P < 0.0001$) than that of Group A.

Operative technique and postoperative collar period

During the surgical procedure in Group A, laminectomy was performed at C3 and the SSC insertion in C2 was preserved completely. Laminoplastic procedure was performed at C4–C7. In Group B, the SSC insertion into C2 was transiently detached from the C2 spinous process and then reattached to the C2 spinous process at the time of

closure. Laminoplastic procedure was performed at C3–C7. In both groups, the laminoplastic procedure was adapted from the spinous process-splitting laminoplasty using hydroxyapatite spinous process spacers (double-door type) reported by Nakano et al. [18]. Bone graft was not performed in either of the groups. The postoperative collar period was within 2 weeks in both groups.

Evaluation of ADL accompanying neck mobility

In both groups, the frequencies of postoperative limitations of ADL accompanying each of the following neck movements were investigated: (1) extension, (2) flexion, and (3) rotation (Table 1). The severity of limitations of each ADL was assessed using a questionnaire that was completed by the patient (Table 2). The postoperative limitations of ADL were compared between the two groups.

Measurements of O–C7 angle and rotation ROM

The postoperative O–C7 angles at flexion and extension were measured using McGregor line and the posterior tangents of the C7 vertebral body on lateral extension and flexion radiographs of the cervical spine, respectively (Fig. 1). The postoperative rotation range of motion (ROM) of the patients with spectacles on as measure lines was photographed in the cranial view using a digital camera (Fine Pix 4900 Zoom, Fuji Photo Film Co., Ltd., Tokyo, Japan) (Fig. 2).

All the radiographs and digital photographs were scanned on a computer (Windows; VAIO computer, Sony Corp., Tokyo, Japan), and were measured using CANVAS 8 accurate to 0.1° (Deneba System, Inc. Arlington, USA).

Table 1 ADL index accompanying neck mobility

Movement	ADL
Extension	Gargling
Flexion	Watching one's step when climbing down the stairs or going down a slope
Rotation	Looking right and left when driving a car or crossing the street

ADL activities of daily living

Table 2 Questionnaire about the severity of the limitations of ADL

1.	Easy (no limitation)
2.	Difficult (mild limitation)
3.	Impossible (severe limitation)

ADL activities of daily living

Fig. 1 Measurements of O–C7 angle at flexion (a) or extension (b). The lines for measurements were obtained using McGregor line and the posterior tangents of the C7 vertebral body on lateral extension or flexion radiographs of the cervical spine

The measurements of the O–C7 angle and the rotation ROM were done by two observers and interobserver reliability was calculated. The second observer was blinded as to the findings of the first observer. Reliabilities for the O–C7 angles and the rotation ROM were studied in terms of the intraclass correlation coefficient [2].

Statistical analysis

The Fisher's exact, χ^2 test and Student's t test were used in the statistical analysis. The relations between follow-up period and O–C7 angle, and rotation ROM measurement

were statistically analyzed using the Spearman's rank correlation test. All P values less than 0.05 were considered statistically significant.

Results

Frequency and severity of limitations of ADL accompanying each movement

The frequency and severity of limitations of ADL in both groups are shown in Fig. 3. In all directions of movements, no patients had severe limitation. During gargling, which is

Fig. 2 Measurements of rotation ROM. The lines for measurements were obtained using the glasses and the pattern of clothes. **a** Left rotation angle (α°). **b** Right rotation angle (β°). The total of the left and right rotation angles was calculated as rotation ROM ($\alpha^\circ + \beta^\circ$)

Fig. 3 Frequencies and severity of limitations of ADL accompanying each movement after cervical laminoplasty in both groups

the ADL requiring extension, frequency of mild limitations of ADL accompanying extension was lower ($P = 0.037$) in Group A (2%) than in Group B (17%). In watching one's step when climbing down the stairs or going down a slope, which is the ADL requiring flexion, frequency of mild limitations was similar in Group A (8%) and Group B (4%). In looking right and left when driving a car or crossing the street, which is the ADL requiring rotation, frequency of mild limitations of ADL accompanying rotation was lower ($P = 0.031$) in Group A (12%) than in Group B (33%).

Postoperative O–C7 angle and rotation ROM

Results of measurements of postoperative O–C7 angle and rotation ROM are shown in Table 3. Average O–C7 angle at extension was significantly larger ($P = 0.002$) in Group A (147°) than in Group B (136°) (Fig. 4). Average O–C7 angle at flexion was similar in Group A (93°) and Group B (91°). Average rotation ROM was significantly larger ($P = 0.004$) in Group A (110°) than in Group B (91°) (Fig. 5). There was no correlation between follow-up period and O–C7 angles, and rotation ROM.

The intraclass correlation coefficient for the O–C7 angle at extension and flexion, and the rotation ROM were 0.95, 0.96 and 0.95, respectively. Good interobserver reliability was observed for the parameters.

Table 3 Postoperative O–C7 angle and rotation ROM

Parameter	Group A	Group B	<i>P</i>
O–C7 angle at extension (°)	147.2 ± 10.8	136.3 ± 11.9	0.002
O–C7 angle at flexion (°)	92.9 ± 13.6	90.5 ± 10.9	0.555
Rotation ROM (°)	109.5 ± 19.3	91.2 ± 20.2	0.004

ROM, range of motion

Fig. 4 Postoperative O–C7 angle at extension in both groups. * $P < 0.05$

Fig. 5 Postoperative rotation ROM in both groups. * $P < 0.05$

Discussion

Although there were many reports of good postoperative neurological improvements after laminoplasty for cervical myelopathy [12, 23, 28], several postoperative problems have also been reported, including late deterioration of myelopathy symptoms [9, 15, 20, 23], C5 root palsies [3, 16, 17, 21, 28], axial symptoms [7, 11, 14, 24, 25, 31], cervical malalignment [8, 15, 26, 28, 30] and loss of flexion-extension ROM [1, 5, 6, 13, 15, 22, 26, 28, 30]. Especially in recent years, a great deal of attention has been paid to axial symptoms as postoperative complications which adversely affect patients' quality of life. As is the case with postoperative axial symptoms, difficulties with neck mobility also often interfere with patients' ADL accompanying neck mobility after cervical laminoplasty [10, 29]. To our knowledge, however, there are no detailed

clinical studies on the relation between the limitations of ADL accompanying postoperative reduced neck mobility and the cervical posterior approach.

This study has several limitations. The frequency of limitation of ADL accompanying neck mobility after this modified laminoplasty preserving the SSC for patients with OPLL was not examined in the present study. Yokoyama et al. [29] examining retrospectively postoperative difference between 30 OPLL and 32 CSM after laminoplasty reattaching the SSC to C2, reported that there were significantly more patients with limitations of ADL accompanying flexion in OPLL than in CSM, and that there was no significant correlation between the disease and the limitations of ADL accompanying extension or rotation. To avoid false results due to differences between CSM and OPLL, this study was carried out for patients with CSM alone. On the other hand, the average follow-up period of Group B was significantly longer than that of Group A. Kawaguchi et al. evaluating the long-term results over 10 years of 126 patients after laminoplasty, also reported that the ROM decreased rapidly 1 year after surgery and the subsequent ROM was almost unchangeably maintained [21]. Therefore, there might be no correlation between follow-up period and O–C7 ROM angles, because the minimum follow-up period was one year in the current study.

After cervical laminoplasty, more than a few patients had limitations of ADL accompanying reduced neck mobility in the present study. Clinical data demonstrated that the frequency of limitations of ADL accompanying extension or rotation in Group A was lower than those in Group B. Moreover, objective data showed that the postoperative O–C7 angles at extension or the rotation ROM in Group A were significantly larger than those in Group B, as if to corroborate the clinical data. Because most of the SSC inserts into the C2 spinous process [19] and acts as an important extensor of the cervical spine [4, 5, 27], the posterior approach preserving the SSC inserted into the C2 spinous process might cause the larger angle at extension and the reduction of limitations of ADL accompanying extension. On the other hand, Takeuchi et al. [25] evaluating prospectively the cross-sectional areas of the cervical posterior muscles after laminoplasty preserving or reattaching the SSC inserted into C2, reported that preservation of only the SSC inserted into C2 maintained the whole cervical posterior muscular volume well. In Group A in the present study, therefore, there is a possibility that the well-maintained cervical posterior rotators, including splenius capitis, levator scapulae, scalenus medius and anterior, and semispinalis capitis which were reported by Conley et al. [4], maintained postoperative rotation ROM and reduced the postoperative limitations of ADL accompanying rotation. Regarding

flexion, both the frequency of limitations of ADL and the O–C7 angle in Group A were similar to those in Group B. Though, posterior approach preserving the SSC inserted into C2 had no influence on neck flexion after laminoplasty in the present study.

Conclusions

This retrospective study suggested that the frequencies of limitations of ADL accompanying neck extension or rotation were lower after laminoplasty preserving the SSC inserted into C2 than after laminoplasty reattaching the muscle to C2.

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