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Atrophy of the nuchal muscle and change in cervical curvature after expansive open-door laminoplasty

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Abstract We analyzed computed tomography (CT) images and plain X-ray films of 53 patients who had undergone expansive open-door laminoplasty, in a 3-year study. The relationship between the postoperative changes in the nuchal muscles and those in the cervical curvature was investigated. On postoperative CT images, the cross-sectional area of all nuchal muscles was reduced to approximately 80% of its preoperative size. This atrophic change was especially intense in the multifidus muscle and the semispinalis cervicis muscle. Postoperative cross-sectional area of the deep nuchal muscles was reduced approximately 30% from its preoperative size. No significant correlation was found between the all cross-sectional area of the nuchal muscles and the cervical curvature. However, a weak correlation was found between the deep nuchal muscles area and the curve index (correlation coefficient 0.29).

Introduction

A decrease in normal lordosis and straightening of the cervical spine after cervical expansive laminoplasty have been reported [5]. Especially in those cases with linear-type or kyphotic-type cervical curvature before the operation, kyphosis occurred or was exacerbated postoperatively. This kyphotic deformity is thought to be a factor leading to a poor prognosis. Nuchal muscle atrophy is usually considered to play a major role in kyphotic deformity. However, at present, the details of the postoperative changes in the nuchal muscles and their correlation with cervical curvature have not been reported. In this study, postoperative changes in the nuchal muscles after expansive open-door laminoplasty was evaluated with computed tomography (CT) and those in the cervical curvature with plain X-ray. The correlation between nuchal muscles and cervical curvature changes was investigated.

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Materials and methods

Fifty-three patients were evaluated in this study. They had undergone an expansive open-door laminoplasty [1, 2] for cervical myelopathy at Keio University Hospital. Patient were followed up for at least 3 years. All the patients had been examined by CT pre- and postoperatively. There were 44 men and 9 women. Their ages at the time of operation were 34–78 years (average 56 years), and the duration of follow-up was 36–116 months (average 53 months). Thirty-six cases had ossification of the posterior longitudinal ligament and 17 cases had cervical spondylotic myelopathy. The cross-sectional area of the nuchal muscles was measured from CT, and the curve index (by Ishihara's method) (Fig. 1) [3] was calculated from plain X-ray films before the operation and at 3–6 months, 1, 3 and 5 years after the operation. The correlation between the cross-sectional area of the nuchal muscles and the curve index was then analyzed.

Among the nuchal muscles, the cross-sectional area of the multifidus and semispinalis cervicis muscles, semispinalis capitis mus-

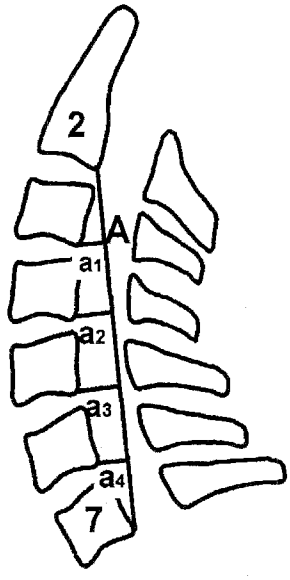

Fig. 1 Technique for measuring Ishihara's curve index. A line is drawn between the lower posterior edge of the body of C2 to the lower posterior edge of the body of C7, and the length of this line is defined as *A*. Perpendicular lines are drawn from the lower posterior edge of the bodies of C3–6 to this line, and the length of these lines as defined as *a1–a4*. The curve index is calculated by: Curve index = $(a1 + a2 + a3 + a4) / A \times 100$

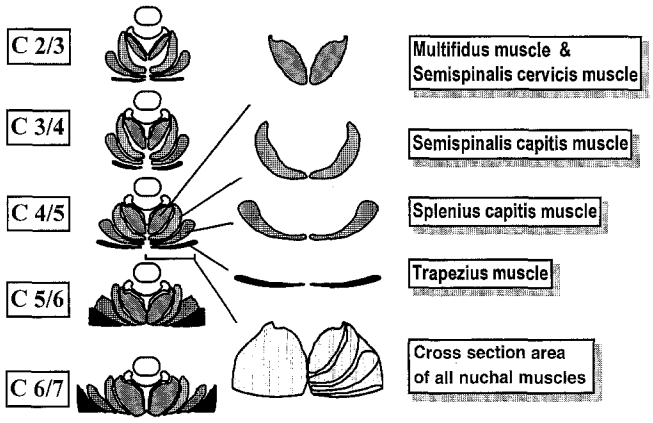

Fig. 2 Measuring method for cross-sectional area of nuchal muscles. The computed tomography (CT) cross-sectional images at each intervertebral level are presented. C2–3 and C3–4 levels are not appropriate for observation of changes in the multifidus and semispinalis cervicis muscles because they are too small here. At C5–6 and C6–7, the trapezius muscle is too large and extremely variable in size among the cases. At C4–5 level, these problems were not an issue, and the borders dividing the muscles were clearly distinguishable. The cross-sectional area of all muscles was defined as the area surrounding the four muscles studied

cle, splenius capitis muscle and trapezius muscles was measured separately. The multifidus and semispinalis cervicis muscles (deep nuchal muscles) were measured as one unit because it was difficult to differentiate them using CT. Measurement was done at the C4–5 intervertebral level because each nuchal muscle could be differentiated most clearly there. A digitizer was used for the measurement. In addition to the cross-sectional area of each individual nuchal muscle, that of all nuchal muscles together (whole area) was also measured (Fig. 2).

Results

The whole area was 2915 ± 193 mm^2 (mean ± SD) before the operation. It was 2638 ± 137 mm^2, 2332 ± 137 mm^2, 2340 ± 138 mm^2, 2259 ± 136 mm^2 at 3–6 months, 1, 3 and 5 years after operation, respectively. The whole area started to decrease within 3–6 months after the operation. It decreased to approximately 80% of its preoperative size by 1 year after the operation and did not change thereafter. Regarding the changes in the individual muscles over the course of time, the deep nuchal muscles area decreased to approximately 30% of its preoperative size by 1 year after the operation. However, changes in the area of the semispinalis capitis, splenius capitis and trapezius muscles were minimal (Table 1, Fig. 3).

The curve index decreased postoperatively in 49 of the 53 cases studied, and the average decrease in the index was 4.4. Similar to the cross-sectional area, the curve index decreased within 3–6 months after operation and did not change thereafter (Table 1).

Regarding the correlation between the cross-sectional area of the nuchal muscles and the curve index, no correlation was observed between the entire area and the curve index. On the other hand, there was a weak correlation between the deep nuchal muscles area and the curve index (correlation coefficient 0.29). A marked decrease in the curve index occurred in many cases in which the deep nuchal muscle area decreased to 60% or less of the preoperative size (Fig. 4).

Discussion

The nuchal muscles evaluated in this study were: multifidus, semispinalis cervicis, semispinalis capitis, splenius capitis, trapezius. The origin of the multifidus muscle is the inferior articular process of C4–7, and the insertion is the spinous process of C2–6. The origin of the semispinalis cervicis is the transverse process of T1–6, and the insertion is the spinous process of C2–5. These muscles are detached from the insertion of the spinous process of C2 when exposing the laminae during expansive open-door laminoplasty. The main cause of marked atrophy of the deep nuchal muscles might be retraction of these muscles after loss of insertion, since the atrophy was minimal in the other muscles which do not have their insertion at the C2 spinous process.

On the other hand, the existence of a chronometric relationship between the decrease in deep nuchal muscle area (atrophy of deep nuchal muscles) and that in the curve index (straightening or kyphotic change of curvature) suggested that the two factors are closely related. The exper-

Table 1 Mean cross-sectional area of the nuchal muscles and the curve index

	Preoperative (n = 53)	Postoperative			
		3–6 months (n = 53)	1 year (n = 53)	3 years (n = 53)	5 years (n = 40)
Mean percentage area (%)					
Multifidus muscle and semispinalis cervicis muscle	100	75.9 ± 10.7	31.1 ± 10.3	34.9 ± 8.7	30.2 ± 11.8
Semispinalis capitis muscle	100	95.7 ± 1.5	88.0 ± 4.2	82.8 ± 11.7	80.2 ± 10.7
Splenius capitis muscle	100	97.9 ± 0.7	96.9 ± 3.6	94.1 ± 7.5	95.8 ± 8.8
Trapezius muscle	100	93.2 ± 4.3	101.0 ± 9.4	102.6 ± 14.6	108.1 ± 13.7
Cross-sectional area of all nuchal muscles	100	90.6 ± 5.2	80.0 ± 4.6	80.4 ± 5.9	77.5 ± 6.0
Mean Curve Index	12.0 ± 10.7	8.4 ± 11.8	8.8 ± 11.0	7.9 ± 11.6	7.6 ± 12.0

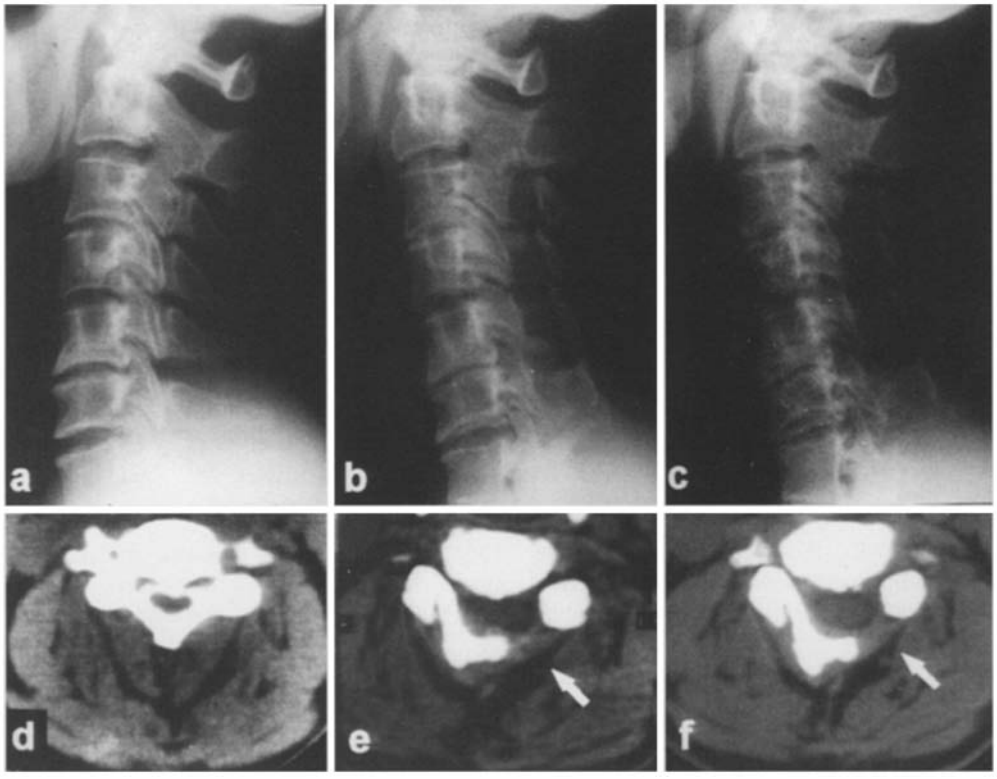

Fig. 3 a–f This 69-year-old man suffered from cervical spondylotic myelopathy and underwent expansive open-door laminoplasty between C3 and C7. **a–c** Plain X-ray films indicate straight neck after expansive open-door laminoplasty. **d–f** CT images indicate atrophy of deep nuchal muscles (**e, f** *arrows*). (**a, d** Before operation; **b, e** 1 year after operation; **c, f** 5 years after operation)

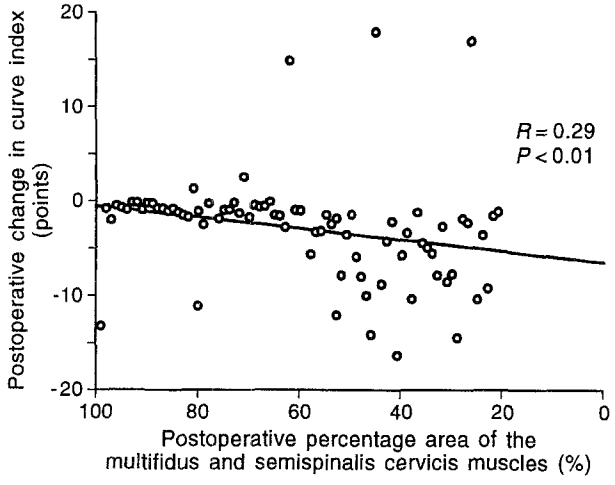

Fig. 4 Correlation between cross-sectional area of the deep nuchal muscles and the curve index. A decrease in the curve index was accompanied by a decrease in muscle cross-sectional area

imental data of Nolan and Sherk [4] reported that these muscles play a major role in the maintenance of normal lordosis of the cervical spine. Our results were in agreement with their findings. However, there are several cases in which lordosis was intensified despite remarkable atrophy or vise versa (Fig. 4). In other words, straightening or kyphotic change of the cervical curvature could not be explained by atrophy of the nuchal muscles alone. This suggested that changes in curvature after expansive open-door laminoplasty may be governed not only by muscular factors, but also by bony factors or ligamentous factors such as surgical invasion to facet joint or preservation of laminae or progression of ossification of the posterior longitudinal ligament.

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