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Case study

Narrow width of muscle-preserving selective laminectomy demonstrated sufficient surgical outcomes and reduced surgical invasiveness

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ABSTRACT

Sufficient width of laminectomy or laminoplasty is considered a criterion for successful surgical outcomes following posterior cervical decompression. No previous study has focused on surgical outcomes achieved by wide versus narrow decompression. This study examined whether narrow laminectomy width (LW) affected surgical outcomes in cervical compressive myelopathy (CCM). Between 2005 and 2010, we performed muscle-preserving selective laminectomy (SL) with decompression between the bilateral medial margin of the facet joints (wide SL). After 2010, we began to perform narrow SL, in which the LW was no more than 2–3 mm wider than the spinal cord width (SW). Clinical features and radiological findings from 97 CCM patients in whom SL was performed at two consecutive levels, including the C4/5 level, were examined in this study. The relationship between LW and patients' functional outcomes was analyzed. Mean blood loss was lower in the narrow SL group than in the wide SL group. The length of hospital stay was also shorter in the narrow SL group. The wide SL group showed greater posterior spinal cord shift. The incidence of C5 palsy correlated with LW and LW minus SW (LW-SW). The recovery rate (RR) of Japanese Orthopaedic Association score was comparable between the two groups. The RR was not correlated with LW and LW-SW. Sufficient functional recovery can be achieved by narrow SL, and it offers advantages over wide posterior decompression, including reduced surgical invasiveness and complications. Wide decompression width is not always necessary for CCM patients.

1. Introduction

Posterior decompression techniques, including laminoplasty and laminectomy, are commonly applied for patients with cervical compressive myelopathy (CCM), as they can remove posterior compressive factors, such as hypertrophied ligamentum flavum and compressive bones. Moreover, they allow spinal cord mobility, keeping it away from anterior compressive factors.

Sufficient decompression width is considered a successful functional outcome indicator following posterior cervical decompression surgery. The decompression width should be wider than the width of the spinal cord. Previous studies reported that 43% of conventional wide laminectomies resulted in postoperative cervical malalignment [1,2]. To address this issue, conventional laminectomy has been combined with posterior fixation techniques. However, the use of the latter in combination with conventional laminectomy increases surgical costs [3]. Moreover, wide posterior decompression increases surgical invasiveness and associated complications, such as facet and muscle damage, blood loss, and the incidence of C5 palsy [4–8]. Previously, we reported that a wide decompression width increased the risk of C5 palsy, whereas muscle-preserving selective laminectomy (SL) of limited width prevented the incidence of C5 palsy [4]. Although narrow posterior decompression without posterior fixation has the potential to reduce surgical invasiveness, postoperative complications, and surgical costs, its effects on functional outcomes have not been

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determined. To date, no study has focused on differences in surgical outcomes between wide and narrow posterior decompression.

For over 12 years, our institute has used SL to decompress CCM. In SL, laminae are decompressed without disturbing deep extensor muscles or facet joints, thereby minimizing the damage of the cervical posterior structure and maintaining cervical alignment [9–13]. Before 2010, we used wide SL, performing decompression between the bilateral medial margin of the facet joints. Since 2010, we have performed narrow SL, in which the laminectomy width (LW) is no more than 2–3 mm wider than the spinal cord width (SW) [4]. Two-level consecutive SL cases that included the C4/5 level were analyzed in this study. The present study directly compared surgical outcomes between wide and narrow SL.

2. Material and methods

2.1. Subjects

Between 2005 and 2013, 341 consecutive CCM patients underwent SL at a single academic institution. The inclusion criteria for SL patients were as follows: 1) local kyphosis was <20° [13], 2) spondylolisthesis was <3.5 mm [14], and 3) the amount of ossification of the posterior longitudinal ligament (OPLL) was <60% [15]. All patients underwent preoperative cervical myelogram-computed tomography (CT), and the presence and type of OPLL were identified for each patient. We excluded patients who required instrumented fixation or combined anterior and posterior surgery or foraminotomy, as well as those who presented with radiculopathy alone, trauma, tumors, infections, rheumatoid arthritis, ankylosing spondylitis, or previous cervical spinal surgeries. In total, 97 consecutive CCM patients who underwent decompression at two consecutive levels, including the C4/5 level (C3–C4 SL, C4–C5 SL, or C5–C6 SL), were enrolled in this study. The C4/5 level was chosen as the focus because this is the most common site of two consecutive levels of decompression. Between April 2005 and March 2010, 35 patients underwent wide SL. The remaining 62 patients underwent narrow SL between April 2010 and March 2013.

2.2. Surgical procedure

SL was performed using an operating microscope [9–12]. Laminectomy levels were identified by complete obstruction of the subarachnoid space using preoperative cervical myelogram-CT, with the patient's neck in a neutral and extended position. Selective mono-laminectomy enabled decompression of the two adjacent intervertebral levels [9].

Two consecutive levels C4–C5 SL was performed as follows: After the nuchal fascia was divided in line with the midline skin incision, the C3/4, C4/5, and C5/6 interlaminar spaces were exposed using our previously described technique [9,10]. The C4 and C5 spinous processes were split longitudinally using a high-speed drill, and the spinous processes were divided at the base, without disturbing the bilateral deep extensor muscles. Adjacent decompression at three levels (C3/4, C4/5, and C5/6) was achieved by removing the C4 and C5 laminae, in addition to the upper half of the C6 lamina and yellow ligament of the ventral aspect of the C3 lamina [9]. The split fragments of the C4 and C5 spinous processes were tied together using a nonabsorbable suture.

For the narrow SL group, we measured the width of the spinal cord preoperatively at the upper edge of each lamina using myelogram-CT to determine the LW. We then performed narrow SL, in which the LW was no more than 2–3 mm wider than the SW [4,13]. The average LW was 15–19 mm, and bilateral facet joints were never affected or exposed during the procedure. For the wide SL group, decompression was performed between the bilateral medial margin of the facet joints, without measuring the width of the spinal cord preoperatively.

2.3. Characteristics and clinical outcomes of patients

The clinical characteristics of each patient, including age, sex, diagnosis, operative level, and length of hospital stay, were recorded. The scoring system of the Japanese Orthopaedic Association (JOA) for cervical myelopathy was used both preoperatively and during the final follow-up (at least 1 year after surgery) to evaluate clinical outcomes. Hirabayashi's method was applied to calculate the recovery rate (RR) of the JOA score [16].

2.4. Radiological evaluation

The LW was measured from the middle of each lamina via postoperative axial images obtained using magnetic resonance imaging (MRI) or CT (Fig. 1a); the average LW was used in further analyses [4]. The SW at the upper edge of each surgically treated lamina was measured using the preoperative axial myelogram-CT (Fig. 1b); the average SW was used in further analyses [4]. The difference between LW and SW was defined as LW minus SW (LW-SW). Preoperative and postoperative C2–C7 angles were obtained by measuring the angle between the tangential lines along the posterior borders of the C2 and C7 vertebral bodies in a standing lateral radiograph in a neutral position. Using T2-weighted mid-sagittal magnetic resonance images, the distances between the posterior margin of the compression factor (PMCF) at C4/5 and the nearest point of the anterior margin of the spinal cord (AMSC) or PMCF-AMSC (Fig. 1c) were measured pre- and postoperatively [4,17]. Postoperative posterior spinal cord shift (PSS) was calculated using the following formula: PSS = postoperative PMCF-AMSC-preoperative PMCF-AMSC. Postoperative radiographs, MRI, and CT were performed at least 1 month after surgery. The images were analyzed by two independent spinal surgeons using a DICOM viewer (RadiAnt, version 3.2.3, Meixant, Poznan, Poland, or Synapse, version 4.1.0, FUJIFILM Medical, Tokyo, Japan). The interclass correlation coefficient (ICC) (2, 1) was calculated to analyze the inter-rater reliabilities and showed strong correlations (ICC [2,1] >0.8) for each radiological measurement.

2.5. Statistical analysis

A chi-square test was conducted to determine the proportional difference of patients in the wide SL and narrow SL groups who underwent SL at the C3–C4, C4–C5 and C5–C6. Independent variables in the wide and narrow SL groups were compared using an unpaired *t*-test for continuous variables and a chi-square test or Mann-Whitney *U* test for discrete variables. The correlations of LW with clinical and radiological factors and LW-SW with clinical and radiological factors were analyzed using Pearson's correlation coefficient for continuous variables and Spearman's correlation coefficient for discrete variables. The inter-rater reliability of each radiograph measurement was analyzed using ICC. Statistical analyses were performed using SPSS, version 22.0 (IBM Corporation, Armonk, NY, USA). Post hoc power calculations were carried out using G*Power, version 3.1 [18]. Differences were considered significant at $P < 0.05$. Means ± standard deviations were used to describe continuous variables.

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