A novel surgical approach to the lumbar spine involving hemilateral split-off of the spinous process to preserve the multifidus muscle: technical note

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In the conventional posterior approach to the lumbar spine, the lamina is exposed by stripping the paravertebral muscles from the spinous process, and the resulting paravertebral muscle damage can produce muscle atrophy and decreased muscle strength. The author developed a novel surgical approach to the lumbar spine in which the attachment of the paravertebral muscles to the spinous process is preserved. In the novel approach, the spinous process is split on the midline without stripping the attached muscles, and a hemilateral half of the spinous process is then resected at the base, exposing only the ipsilateral lamina. Before closing, the resected half is sutured and reattached to the remaining half of the spinous process. Thirty-eight patients with lumbar spinal canal stenosis (LSCS) undergoing unilateral partial laminectomy and bilateral decompression using this novel approach were analyzed. Postoperative changes in the multifidus muscle were evaluated by T2 signal intensity on MR images. MRI performed 1 year after the operation revealed no significant difference in the T2 signal intensity of the multifidus muscle between the approach and nonapproach sides. This result indicated that postoperative changes of the multifidus muscle on the approach side were slight. The clinical outcomes of unilateral partial laminectomy and bilateral decompression using this approach for LSCS were satisfactory. The novel approach can be a useful alternative to the conventional posterior lumbar approach.

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The paravertebral muscles play an important role in the elastic stability and functional movement of the spine. In the conventional posterior surgical approach to the lumbar spine, the lamina is exposed by stripping the paravertebral muscles from the spinous process. Whether the spinous process is resected or preserved, the junction between the detached muscle and bone cannot be restored to its original tight connection. The loss of the normal junction of the paravertebral muscles with the spinous process may be presumed to result in abnormal muscle contractions and a decline in muscle support of the spinal column. Moreover, the paravertebral muscles would have already suffered injuries due to direct retraction during surgery. The paravertebral muscle damage originating from conventional posterior lumbar spine surgery can produce muscle atrophy and decreased muscle strength. Attempting to reduce invasiveness to the paravertebral muscles related to posterior lumbar spine surgery, procedures such as spinous process osteotomies, unilateral laminotomy and bilateral decompression, a tubular retractor system, spinous process-splitting laminectomy and muscle-preserving interlaminar decompression have been conceived. The unilateral laminotomy and bilateral decompression for lumbar spinal canal stenosis (LSCS) reported by Poletti is an excellent procedure, allowing preservation of the paravertebral muscles on the nonapproach side. However, on the approach side, the paravertebral muscles are inevitably damaged because of their detachment from the spinous process. In 2002, Shiraishi reported an innovative procedure for posterior exposure of the cervical spine in which the spinous process is longitudinally split on the midline, and the lamina is exposed without stripping the semispinalis cervicis and multifidus muscles from the spinous process.
Watanabe et al. developed a lumbar spinous process-splitting laminectomy in which the lamina is exposed by longitudinally splitting the spinous process while the muscular and ligamentous attachments to the spinous process remain intact. They reported that the paravertebral muscle atrophy rate was significantly lower in their procedure than in conventional laminectomy. However, a disadvantage of the procedure is that the force of the multifidus muscle cannot be transmitted to the spinal column because of the separation of the spinous process and the lamina.

In the novel approach reported here, hemilateral split-off of the spinous process (HSS), the spinous process is split on the midline without stripping the attached muscles, and then a hemilateral half of the spinous process is resected at the base, exposing only the ipsilateral lamina. Before closing, the resected half is sutured and reattached to the remaining half of the spinous process. The author has used the HSS approach to perform various posterior lumbar spine surgeries. For LSCS, unilateral partial laminectomy and bilateral decompression has been performed using the HSS approach.

In the study presented here, the author describes a surgical technique using the HSS approach for LSCS and reports postoperative changes in the multifidus muscle evaluated by T2 signal intensity on MR images as well as clinical outcomes.

Methods

Surgical Technique (HSS Approach)

The patient is placed prone on a 4-point frame under general anesthesia. A midline skin incision is made over the cranial spinous process of the intervertebral level to be decompressed (Fig. 1A). Without detachment of the paravertebral muscles, the tip of the spinous process is palpated, and the spinous process is longitudinally split on the midline (to a depth of approximately 1.5 cm) using a micro bone saw (Fig. 1B). A hemilateral half of the spinous process is resected at the base and the resected half with the attached paravertebral muscles is laterally retracted. The rotator muscles terminating in the lamina are resected, and the ipsilateral lamina is exposed (Fig. 1C). Unilateral partial laminectomy and bilateral decompression are performed with a surgical microscope (Fig. 1D). Finally, the resected half is reattached to the remaining half of the spinous process by ligation with a couple of suture threads (Fig. 1E and F). After surgery, a soft corset is applied to fuse the split spinous process by bone union, and walking is permitted beginning the next day. The corset is used continuously for the first 3 weeks after surgery, and thereafter only during the daytime for the next 3 weeks.

Patient Population

The study population consisted of 38 patients (22 men and 16 women) with symptoms of cauda equina compression due to LSCS who underwent unilateral partial laminectomy and bilateral decompression using the HSS approach. All surgeries were performed by the same surgeon. The subjects were consecutive patients who were examined using MRI and CT about 1 year (11–13 months) after surgery. The mean age at the time of the surgery was 71 years (range 54–91 years). Decompression was performed at 1 intervertebral level in 27 patients, 2 levels in 9 patients, and 3 levels in 2 patients. Patients with severe

![Fig. 1. Illustrations of the HSS approach. A: Skin incision. B: Spinous process split. C: Hemilateral resection of the base of the spinous process. D: Bilateral decompression. E: Ligation of the resected half with the remaining half of the spinous process. F: Postoperative axial CT scan. Copyright Satoru Nakamura. Published with permission. Figure is available in color online only.](image-url)
low-back pain due to intervertebral instability were excluded from this study, because intervertebral fusion surgery was simultaneously performed. Patients with marked scoliosis were also excluded because of the bilateral discrepancy of the multifidus muscle.

**Evaluation of Clinical Outcome**

Clinical outcome measurements were made using the Japanese Orthopaedic Association Score for Assessment of Treatment for Low Back Pain (JOA score). The modified JOA scores (9 points of subjective symptoms and 6 points of clinical signs) were measured preoperatively and 1-year (11–13 months) postoperatively. Postoperative recovery rates were calculated using the following formula (the Hirabayashi method):

\[
\text{Recovery rate} = \frac{\text{postoperative score} - \text{preoperative score}}{15 - \text{preoperative score}} \times 100
\]

A recovery rate of 75% or greater was regarded as excellent, 50%–74% as good, 25%–49% as fair, and less than 25% as poor.

**Quantitative Analysis of the Multifidus Muscle**

The 1.5-T MRI system (Signa, GE) was used to obtain axial T2-weighted MR images (fast spin echo method) about 1 year (11–13 months) after the operation. An analysis of grayscale values (0–256) was performed with image-processing software (ImageJ, version 1.38; NIH), and the signal intensities of the multifidus muscle were quantified on the axial T2-weighted MR images. For patients who underwent multilevel decompression, the caudal decompression level was evaluated. The evaluated levels were L4–5 in 30 patients, L3–4 in 7, and L2–3 in 1. The signal intensities were measured in the most caudal scan of the decompression site. Measurement of signal intensity was performed bilaterally, and the multifidus muscle on the nonapproach side (which did not undergo surgical invasion) was used as a control. The regions of interest of the multifidus muscle were established in 3 layers (shallow, middle, deep) to be as large as possible while avoiding large fat masses between muscle layers (Fig. 2). Measurement of signal intensity was performed 3 times in each layer, and the mean value was reported as the signal intensity for each layer. The mean of the signal intensities of the 3 layers was calculated for each side. The difference in the signal intensity of the multifidus muscle between the approach and nonapproach sides was analyzed using the paired t-test. Statistical significance was accepted at \( p < 0.05 \).

**Results**

The mean operative duration was 111 minutes, and the mean intraoperative blood loss was 84 g per level. An intraoperative complication occurred in 1 patient, a dural tear. No neurological deterioration was observed in any patient. Thirty-seven of the 38 patients started to walk the day after surgery, and the remaining patient began 2 days after surgery. No patients required revision surgery for postoperative hematoma or surgical site infection.

The mean preoperative modified JOA score (maximum 15) was 8.9 (range 6–13) and the mean 1-year postoperative score was 13.8 (range 10–15). The mean recovery rate was 80% (range 38%–100%); the recovery rate was graded as excellent in 24 patients, good in 12, fair in 2, and poor in none. One-year postoperative CT revealed successful bone union of the split spinous processes in all patients. MRI performed 1 year after the operation showed no marked difference in the shape or size of the multifidus muscle between the approach and nonapproach sides in any patient (Fig. 3). Comparisons of the signal intensity of the multifidus muscle on the axial T2-weighted MR images between the approach and nonapproach sides showed no significant difference (Fig. 4).

**Discussion**

Various procedures have been created to reduce the paravertebral muscle damage originating from posterior lumbar spine surgery. Kim et al. compared the effect of 3 different approaches to the lumbar spinal canal and demonstrated that preservation of the multifidus muscle attachment to the spinous process reduced muscle damage. Recently, Liu et al. reported an experimental study of the impact of 4 different surgical approaches on the lumbar multifidus muscle and concluded that the multifidus muscle could be effectively protected by reducing the extent of muscle detachment and reconstructing the posterior bone-tendon complex. Watanabe et al. reported that the postoperative multifidus muscle atrophy rate was significantly lower in spinous process–splitting laminectomy than in conventional laminectomy. However, a disadvantage of the spinous process–splitting laminectomy is that the force of the multifidus muscle cannot be transmitted to the spinal column due to separation of the spinous process and the lamina. In the novel HSS approach, only a hemilateral half of the spinous process is resected at the base, without stripping the attached muscles. Finally, the resected half is reattached to the remaining half of the spinous process. Consequently, the attachment of the multifidus muscle to the spinous process is preserved, and moreover, the spinous process is anatomically reconstructed by bone union. Although a careful subperiosteal dissection has been performed in the conventional approach, the periosteum is reattached to the spinous process by scar tissue and the normal attachment of the multifidus muscle to the spinous process cannot be reconstructed.
The multifidus muscle consists of several bundles that originate on the spinous process, spread downward and laterally for 2–4 segments, and then attach on the mamillary processes, iliac crest, and sacrum. Surgical invasion of the multifidus muscle involves not only the area exposed, but also the caudal area of its course. Therefore, in the present study, to evaluate surgical damage to the multifidus muscle, the signal intensity of the multifidus muscle on MR images was measured in the most caudal scan of the decompression site.

The high signal intensity on T2-weighted MR images of damaged muscle represents denervation and an increase in extracellular fluid, degeneration and fat infiltration, incomplete muscle fiber regeneration, and increased extracellular space. A less invasive approach results in less change in the T2 signal intensity of the multifidus muscle. In the present study, the signal intensity on T2-weighted MR images was measured in the most caudal scan of the decompression site.

The multifidus muscle on the approach side was evaluated by T2 signal intensity. One year after the operation, there was no significant difference in the T2 signal intensity of the multifidus muscle between the approach and nonapproach sides. This result indicated that postoperative changes of the multifidus muscle on the approach side were slight using the HSS approach.

There are several possible reasons that the HSS approach produces less invasiveness to the multifidus muscle. First, the HSS approach may reduce direct muscle damage during surgery because the multifidus muscle is not stripped from the spinous process and retracted through the bone fragment of the split spinous process. Second, the multifidus muscle may maintain its function and avoid disuse muscle atrophy because the attachment to the spinous process is preserved, and the spinous process is anatomically reconstructed by bone union. Third, when compared with the original unilateral laminotomy and bilateral decompression procedure, in which the spinous process is not resected, the visualization route is closer to the midline because of the hemilateral resection of the spinous process.
process in the HSS approach. This facilitates exposure of the spinal canal, not only on the approach side, but also on the contralateral side. Consequently, the paravertebral muscles need not be retracted beyond the inferior articular process, and the compression load to the muscles can be reduced. The multifidus muscle is innervated by the medial branch of the posterior ramus of the spinal nerve unisegmentally, and injury to this branch results in denervation changes in the multifidus muscle bundles. The medial branch of the posterior ramus of the spinal nerve may be injured by excessive lateral retraction of the paravertebral muscles during surgery. Boelderl et al. concluded that to prevent injury to the medial branches of the posterior rami of spinal nerves during a dorsomedian approach to the spine. Clin Anat 15:77–81, 2002.

Conclusions

The outcomes of unilateral partial laminectomy and bilateral decompression using the novel HSS approach for LSCS were satisfactory. MRI performed 1 year after the operation revealed no significant difference in the T2 signal intensity of the multifidus muscle between the approach and nonapproach sides. This result is indicative of the damage reduction of the multifidus muscle using the HSS approach, which does not require detachment of the multifidus muscle from the spine process and does not disturb the function of the multifidus muscle. The HSS approach is a useful method to preserve the multifidus muscle in posterior lumbar spine surgeries.

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References


FIG. 4. Scatterplot showing signal intensities on axial T2-weighted MR images of the multifidus muscle. Patients (n = 38) who underwent unilateral partial laminectomy and bilateral decompression using the HSS approach were assessed 1 year postoperatively. The horizontal axis shows the grayscale values of the T2 signal intensity of the multifidus muscle on the approach side and the longitudinal axis shows them on the nonapproach side. There was no significant difference of the T2 signal intensity between the approach and nonapproach sides.
A novel surgical approach to the lumbar spine


Disclosure
The author reports no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Supplemental Information
Previous Presentation
Portions of this work were presented in abstract form as proceedings at the 38th Annual Meeting of the Japanese Society for Spine Surgery and Related Research, in Kobe, Japan, April 25, 2009.

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