Comparison of Effects of Nonoperative Treatment and Decompression Surgery on Risk of Patients with Lumbar Spinal Stenosis Falling

Evaluation with Functional Mobility Tests

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Background: Falls are a major factor contributing to fragility fractures. Patients with lumbar spinal stenosis have an increased risk of falling. We are aware of no prior report demonstrating the effect of medical treatment and decompression surgery on the risk of patients with lumbar spinal stenosis falling.

Methods: From June to November 2011, seventy-six patients were enrolled into the surgery group and fifty patients, into the nonoperative group. Four functional mobility tests, including the Alternate-Step test, Six-Meter Walk test, Sit-to-Stand test, and timed “Up & Go” test, were used to evaluate the risk of falling. The Oswestry Disability Index (ODI) and the EuroQol-5D (EQ-5D) visual analog scale (VAS) were utilized to assess clinical improvement.

Results: The mean age was 62.4 years in the surgery group and 64.6 years in the nonoperative group. The results of the Alternate-Step test significantly improved during the follow-up period in the surgery group (p = 0.001). However, the results of the Alternate-Step test significantly worsened during the follow-up period in the nonoperative group (p = 0.001). Comparison between the two groups showed more significant improvement in the surgery group, especially for the Six-Meter Walk test at one year postoperatively (p = 0.042) and for the timed “Up & Go” test at three months and one year (p = 0.046 and 0.000). However, the ODI and EQ-5D VAS scores improved in both groups. In a linear mixed model, age, surgery, and the presence of an osteoporotic compression fracture significantly affected the test results related to the risk of falling (p < 0.05).

Conclusions: The surgery group showed a greater decrease in the risk of falling than those in the nonoperative group. Improved physical performance, including walking and balancing, after decompression lumbar spinal surgery reduces the future risk of falling.

Level of Evidence: Therapeutic Level II. Retrospective analysis of prospectively collected data. See Instructions for Authors for a complete description of levels of evidence.

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Patients with symptomatic lumbar spinal stenosis experience intermittent neurogenic claudication with or without lower back pain, which substantially reduces walking distance and can lead to a largely sedentary indoor lifestyle. Physical inactivity leads to increased bone resorption, even in patients with high bone mass. Decompression surgery in patients with...
symptomatic lumbar spinal stenosis decreases bone resorption, possibly because of the ability to walk increased distances without pain. Since decompression surgery positively affects bone metabolism in patients with lumbar spinal stenosis, the risk of these patients falling becomes a new arena of investigation. It has been reported that patients with lumbar spinal stenosis have an increased risk of falling compared with those with knee osteoarthritis. However, we are not aware of any report that has demonstrated that the risk of patients with lumbar spinal stenosis falling differs according to treatment modality.

We hypothesized that both decompression surgery and nonoperative treatment of patients with symptomatic lumbar spinal stenosis improve pain perception and increase walking distance, consequently decreasing the risk of falling. The objectives of the current investigation were first to assess the decrease in the risk of falling after decompression surgery and nonoperative treatment in patients with lumbar spinal stenosis. The second aim was to correlate meaningful changes in the risk of falling, as represented by the outcomes of functional tests, one year after treatment in patients with symptomatic lumbar spinal stenosis depending on the treatment modality and other clinical factors.

Materials and Methods

This study was approved by the institutional review board of our hospital (IRB number 4-2011-0399). From June 2011 to November 2011, 107 patients underwent lumbar spine surgery consisting of decompression with or without fusion(s) for lumbar spinal stenosis and eighty-four (thirty-two men and fifty-two women) agreed to enroll in the present study. These patients were included prospectively, and the collected data were analyzed retrospectively. In addition, fifty-six patients (twenty men and thirty-six women) treated nonoperatively with a daily dose of oral medication including celecoxib and lamaiprost were enrolled when they were seen as new patients in our outpatient clinic. Surgery was recommended when patients experienced symptoms of lumbar spinal stenosis and neurogenic claudication within ten minutes after the initiation of walking. Patients with these clinical symptoms who refused surgical treatment were allocated to the nonoperative group (see Appendix). Patients with other conditions that impacted their functional performance tests were excluded 16,17. In order to exclude previous medication as a confounding factor, only patients who had never taken lumbar spinal stenosis-related medications, or who agreed to stop taking such medications for at least two weeks, were enrolled in the nonoperative group.

Eight of the eighty-four patients in the surgery group could not be followed at three months or one year postoperatively, and six of the fifty-six patients in the nonoperative group could not continue to be treated nonoperatively because of increased symptoms. These six patients who were initially in the nonoperative group underwent decompression surgery and were excluded from the per-protocol analysis.

Patients were directed to continue taking the provided oral medications with strict adherence for the first month and freely thereafter on the basis of their need. Additional treatment including physiotherapy and local injection therapy was allowed if it was deemed that it would be helpful.

In total, seventy-six patients (thirty men and forty-six women) in the surgery group and fifty patients (eighteen men and thirty-two women) in the nonoperative group were spinal stenosis (twenty-eight patients). Thirty-one patients (41%) had one-level surgery and forty-five (59%) underwent multiple-level surgery. The major diagnoses for the nonoperative group were spinal stenosis (thirty-seven patients) and spinal stenosis with spondylolisthesis (thirteen patients).

Walking distance during a single-trial walk, the Oswestry Disability Index (ODI), and the score on the EuroQol-5D (EQ-5D) visual analog scale (VAS) (range, 0 to 100, with higher scores indicating better health) were recorded during the initial evaluation, at the preoperative evaluation in the surgery group, and before medical treatment in the nonoperative group. The clinical data were remeasured during follow-up outpatient clinic visits at three months and one year in both the surgery group and the nonoperative group. Other basic demographic data were also gathered, including the grade of knee osteoarthritis according to the Kellgren-Lawrence scale and whether the patient had undergone a total knee replacement. Twenty-two patients in the surgery group and eighteen patients in the nonoperative group had knee osteoarthritis with a Kellgren-Lawrence grade of 3 or 4, and thirteen patients in the surgery group and six patients in the nonoperative group had previously undergone total knee replacement. Area bone mineral density of the lumbar spine was measured in all enrolled patients with dual x-ray absorptiometry using a GE Lunar Prodigy densitometer (GE Healthcare Lunar, Madison, Wisconsin).

The presence of an osteoporotic vertebral compression fracture was determined with conventional thoracolumbar lateral radiographs with use of an established visual semiquantitative system.18

The patients were evaluated prospectively with four functional mobility tests by a clinical research coordinator. The clinical research coordinator was trained to evaluate patients in a standardized manner. When an enrolled patient visited the outpatient clinic, the clinical research coordinator met the patient on the day before the surgery or the day before the medication was started. The clinical research coordinator explained how the four tests were performed. The clinical research coordinator repeated four functional tests at the three-month and one-year follow-up visits to collect the results and record them in a database. The clinical research coordinator was trained to not ask the patients which treatment modality they had received, but was permitted to provide explanations to patients who had difficulty completing the tests. The clinical research coordinator was also blinded to the initial data to avoid biasing the postoperative and post-treatment results.

Assessment of the Risk of Falling with Four Functional Mobility Tests

The risk of falling was evaluated with four functional mobility tests: the Alternate-Step test, Six-Meter Walk test, Sit-to-Stand test, and timed “Up & Go” test. These four tests have been validated in previous studies.6,11-15. The Alternate-Step test is used to evaluate a person’s ability to maintain standing balance while performing potentially destabilizing activities such as standing on one leg during stepping.11. The Six-Meter Walk test has been used as a measure of walking ability or speed, and has previously been reported to be an independent risk factor for recurrent falls.3,10,17. The Sit-to-Stand test has been related to postural control, lower-extremity strength, proprioception, and the risk of falling.6,11,12. The timed “Up & Go” test is a screening test for mobility dysfunction and reflects executive functional change and impairment in older adults with mild cognitive impairment, including early memory loss and physical decline.14,20.

Statistical Analysis

The intraclass correlation coefficients (ICCs) of the four tests were measured in a random sampling of twenty-five patients from each group. Repeated measurements with the four tests showed high ICCs in both groups, with a range of 0.838 to 0.990. Also, a linear mixed model was used to evaluate the significance of the difference between the adjusted least square means of the values in the surgery and nonoperative groups with adjustment for time (between the measures, performed preoperatively, at three months, and at one year), age, sex, bone densitometry findings, presence of a preexisting osteoporotic vertebral compression fracture, comorbidities, ODI score, and EQ-5D VAS score. For factors that showed significance, the Bonferroni method was used for multiple comparison. P values of <0.05 were considered significant.

Source of Funding

There was no outside source of funding for this study.
The mean age was 62.4 years (range, fifty-five to eighty-four years) in the surgery group and 64.6 years (range, fifty-three to eighty-four years) in the nonoperative group. The mean ODI score was 25.8 (range, 9 to 39) preoperatively, 19.2 (range, 8 to 39) at three months postoperatively, and 18.0 (range, 8 to 32) at one year postoperatively ($p = 0.000$) in the surgery group and 22.3 (range, 10 to 31) before medical treatment, 18.2 (range, 5 to 29) at the three-month follow-up visit, and 18.2 (range, 7 to 31) at the one-year follow-up visit ($p = 0.004$) in the nonoperative group (Table I).

The preoperative values (least square means and standard error) of the four functional tests in the surgery group were $16.9 \pm 1.5$ seconds for the Alternate-Step test, $9.3 \pm 1.3$ seconds for the Six-Meter Walk test, $20.8 \pm 2.5$ seconds for the Sit-to-Stand test, and $15.4 \pm 2.3$ seconds for the timed “Up & Go” test. The mean values in this group at three months postoperatively were $12.0 \pm 1.0$ seconds for the Alternate-Step test, $6.5 \pm 0.6$ seconds for the Six-Meter Walk test, $11.8 \pm 1.2$ seconds for the Sit-to-Stand test, and $10.5 \pm 1.8$ seconds for the timed “Up & Go” test. The mean values measured at one year postoperatively were $11.8 \pm 1.1$ seconds for the Alternate-Step test, $6.7 \pm 0.6$ seconds for the Six-Meter Walk test, $10.5 \pm 1.2$ seconds for the Sit-to-Stand test, and $10.5 \pm 1.8$ seconds for the timed “Up & Go” test.

The pretreatment values of the four functional tests in the nonoperative group were $15.0 \pm 1.4$ seconds for the Alternate-Step test, $10.4 \pm 1.3$ seconds for the Six-Meter Walk test, $9.9 \pm 2.4$ seconds for the Sit-to-Stand test, and $16.9 \pm 2.3$ seconds for the timed “Up & Go” test. The mean values at three months in the nonoperative group were $13.7 \pm 0.9$ seconds for the Alternate-Step test, $7.5 \pm 0.5$ seconds for the Six-Meter Walk test, $9.0 \pm 1.1$ seconds for the Sit-to-Stand test, and $17.6 \pm 1.5$ seconds for the timed “Up & Go” test. The mean values measured at the one-year follow-up visit were $14.1 \pm 0.9$ seconds for the Alternate-Step test, $7.8 \pm 0.5$ seconds for the Six-Meter Walk test, $9.3 \pm 1.0$ seconds for the Sit-to-Stand test, and $18.5 \pm 1.5$ seconds for the timed “Up & Go” test. Comparison between the two groups showed more significant improvement in the surgery group for the Six-Meter Walk test at one year postoperatively ($p = 0.042$) and for the timed “Up & Go” test at three months and one year ($p = 0.046$ and 0.000).

The mean EQ-5D VAS score for general health status was 34.9 (range, 0 to 70) preoperatively, 60.0 (range, 30 to 100) at three months postoperatively, and 64.3 (range, 30 to 100) at one year postoperatively in the surgery group ($p = 0.000$). The mean EQ-5D VAS for general health status was 36.4 (range, 0 to 70) before treatment, 55.7 (range, 30 to 100) at the three-month
There was no significant difference in the results of the four functional mobility test according to the surgery type (decompression only or additional fusion) or the fusion level (one level or multiple levels).

The linear mixed model demonstrated a significant correlation of time (between the measures, performed preoperatively, at three months, and at one year), surgery*time (interaction between surgery and time), age, and the presence of osteoporotic vertebral compression fracture with the results of the Alternate-Step test; surgery*time with the results of the Six-Meter Walk test; surgery and time with the results of the Sit-to-Stand test; and surgery, surgery*time, and age with the results of the timed “Up & Go” test (p < 0.05, see Appendix).

**Discussion**

The association between the risk of falling and lumbar spinal stenosis has been previously reported, and the current study is an analysis of the risk of falling based on the results of widely accepted functional mobility tests of patients treated surgically or medically for lumbar spinal stenosis.

Falling is the most common cause of accidental death of people older than seventy-five years and is responsible for considerable morbidity among survivors. Numerous studies on the risk factors for falling have focused on adults eighty-five years of age or older.

### TABLE I: Comparison of Results Between the Surgery and Nonoperative Groups

<table>
<thead>
<tr>
<th></th>
<th>Surgery Group*</th>
<th>Nonoperative Group*</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (yr)</strong></td>
<td>62.4 ± 11.0</td>
<td>64.6 ± 6.2</td>
<td>Not signif.†</td>
</tr>
<tr>
<td><strong>Sex (men:women)</strong></td>
<td>30:46</td>
<td>18:32</td>
<td>Not signif.†</td>
</tr>
<tr>
<td><strong>Area bone mineral density on densitometry (T score)</strong></td>
<td>−1.6 ± 1.4</td>
<td>−1.9 ± 1.5</td>
<td>Not signif.†</td>
</tr>
<tr>
<td><strong>Osteoporotic vertebral compression fracture (no:yes)</strong></td>
<td>59:17</td>
<td>36:14</td>
<td>Not signif.†</td>
</tr>
<tr>
<td><strong>Neurogenic intermittent claudication</strong></td>
<td>81.1 ± 126.5</td>
<td>95.3 ± 87.2</td>
<td>Not signif.†</td>
</tr>
<tr>
<td><strong>No. of comorbidities</strong></td>
<td>1.0 ± 1.0</td>
<td>1.1 ± 0.9</td>
<td>Not signif.†</td>
</tr>
<tr>
<td><strong>Pretreatment scores</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ODI</strong></td>
<td>25.8 ± 9.7</td>
<td>22.3 ± 6.2</td>
<td>0.037†</td>
</tr>
<tr>
<td><strong>EQ-5D VAS</strong></td>
<td>34.9 ± 19.4</td>
<td>36.4 ± 18.9</td>
<td>Not signif.†</td>
</tr>
<tr>
<td><strong>3-mo scores</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ODI</strong></td>
<td>19.2 ± 8.2</td>
<td>18.2 ± 5.5</td>
<td>Not signif.†</td>
</tr>
<tr>
<td><strong>EQ-5D VAS</strong></td>
<td>60.0 ± 19.8</td>
<td>55.7 ± 16.5</td>
<td>Not signif.†</td>
</tr>
<tr>
<td><strong>1-yr scores</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ODI</strong></td>
<td>18.0 ± 6.8</td>
<td>18.2 ± 4.4</td>
<td>Not signif.†</td>
</tr>
<tr>
<td><strong>EQ-5D VAS</strong></td>
<td>64.3 ± 15.6</td>
<td>61.0 ± 14.9</td>
<td>Not signif.†</td>
</tr>
</tbody>
</table>

*The values are given as the mean and standard deviation. †According to the independent t test. ‡According to chi-square analysis.

### TABLE II: Results of Four Functional Mobility Tests in Surgery and Nonoperative Groups

<table>
<thead>
<tr>
<th></th>
<th>Pretreatment*</th>
<th>At 3 Mo*</th>
<th>At 1 Yr*</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surgery group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternate-Step test</td>
<td>16.9 ± 1.5</td>
<td>12.0 ± 1.0</td>
<td>11.8 ± 1.1</td>
<td>0.001</td>
</tr>
<tr>
<td>Six-Meter Walk test</td>
<td>9.3 ± 1.3</td>
<td>6.5 ± 0.6</td>
<td>6.7 ± 0.6</td>
<td>Not signif.</td>
</tr>
<tr>
<td>Sit-to-Stand test</td>
<td>20.8 ± 2.5</td>
<td>11.8 ± 1.2</td>
<td>10.5 ± 1.2</td>
<td>Not signif.</td>
</tr>
<tr>
<td>Timed “Up &amp; Go” test</td>
<td>15.4 ± 2.3</td>
<td>10.5 ± 1.8</td>
<td>10.5 ± 1.8</td>
<td>Not signif.</td>
</tr>
<tr>
<td><strong>Nonoperative group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternate-Step test</td>
<td>15.0 ± 1.4</td>
<td>13.7 ± 0.9</td>
<td>14.1 ± 0.9</td>
<td>0.001</td>
</tr>
<tr>
<td>Six-Meter Walk test</td>
<td>10.4 ± 1.3</td>
<td>7.5 ± 0.5</td>
<td>7.8 ± 0.5</td>
<td>Not signif.</td>
</tr>
<tr>
<td>Sit-to-Stand test</td>
<td>9.9 ± 2.4</td>
<td>9.0 ± 1.1</td>
<td>9.3 ± 1.0</td>
<td>Not signif.</td>
</tr>
<tr>
<td>Timed “Up &amp; Go” test</td>
<td>16.9 ± 2.3</td>
<td>17.6 ± 1.5</td>
<td>18.5 ± 1.5</td>
<td>Not signif.</td>
</tr>
</tbody>
</table>

*The values are given as the mean and standard error. †According to the Bonferroni method.

follow-up visit, and 61.0 (range, 30 to 100) at the one-year follow-up visit in the nonoperative group (p = 0.000).

There was no significant difference in the results of the four functional mobility test according to the surgery type (decompression only or additional fusion) or the fusion level (one level or multiple levels).
and older, the most rapidly growing segment of the adult population. Those with risk factors for falling and fall-related injuries may be appropriate targets for evidence-based fall-prevention programs.

In 2005, the life expectancy of people residing in South Korea was an average of 78.5 years; this represented the greatest gain of any country in the Organization for Economic Cooperation and Development, with a rise of more than six months per year from 1960 to 2005. More than half of the people in South Korea are potential candidates for programs to prevent fall-related injuries. There have been many articles on the cost-effectiveness of preventing fall-related injuries.

Of the four functional mobility tests, only the Alternate-Step test showed significant improvement after decompression surgery in the surgery group (Table II). The surgery group had worse results than the nonoperative group on the Sit-to-Stand test prior to treatment, but the surgery group had greater improvement (despite a lack of a significant difference) in the three-month and one-year results of this test, thus reducing the gap in these scores between the groups. Although the pretreatment values for the Six-Meter Walk test and timed “Up & Go” test were better in the surgery group than in the nonoperative group, the gap between the two groups’ scores increased significantly at one year for the Six-Meter Walk test and at three months and one year for the timed “Up & Go” test (Fig. 1). However, the ODI and EQ-5D VAS scores improved equally in the two groups. This finding is supported by a previous study in which there was no significant correlation between the risk of falling and the ODI score. Although the ODI and EQ-5D VAS scores improved in both groups, actual walking ability and bodily balance during walking, which represent the risk of falling, improved more significantly in the surgery group than in the nonoperative group. Clinical improvement was similar between surgically and nonoperatively treated patients with lumbar spinal stenosis in previous intention-to-treat analysis.

In contrast to the improvements seen in our surgery group, there were no relevant improvements, or function even became worse, in the nonoperative group. In the nonoperative group, the results of the Alternate-Step test, Six-Meter Walk test, and Sit-to-Stand test were slightly improved at the three-months follow-up visit, but they worsened between three months and one year despite medical treatment.

The fact that the risk of falling decreased only in the surgery group can be explained by the characteristics of each test, which reflect the combined motor, sensory, proprioception, and coordination functions of the peripheral lumbar plexus. Impairment of both motor and sensory components in patients with lumbar spinal stenosis might be more resolved after surgical treatment, resulting in a better performance on those tests after operative treatment than after nonoperative treatment. Although ODI and EQ-5D VAS scores improved in the nonoperative group, the compressive neuropathic condition remained present, with limited recovery or deterioration of neurologic function expected.

There are several limitations to the current study. First, there are no standardized cutoff values of the four mobility tests with which to measure the risk of falling in either the general population or in patients with lumbar spinal stenosis. Cutoff values have been calculated statistically with use of the relative risk for subjects who had fallen multiple times based on the risk for those who had not or calculated in a way that reflects the characteristics of a specific group with high to intermediate-risk for multiple falls. Second, our finding that the type of intervention (decompression surgery alone versus decompression surgery plus an additional fusion procedure, or single versus multilevel surgery) had no effect on the outcome might have been due to the relatively short-term follow-up duration of one year.

In this study, we did not examine the relationship between the risk of falling and actual falls, which is consistent with our previous study. In keeping with the future directions suggested in our previous paper, we focused more on the functional mobility changes after each treatment modality in the present study. Whether improved results of mobility function tests can lead to prevention of actual falls was not shown in the current study.

Larger cross-sectional and longitudinal studies are needed to demonstrate the relative risk of patients with lumbar spinal stenosis falling compared with that in a normal, elderly population without lumbar spinal stenosis.

Finally, the baseline results of the four tests differed between the groups after adjustment with use of a linear mixed model. The surgically treated group showed worse baseline results on the Alternate-Step test and Sit-to-Stand test and better baseline results on the Six-Meter Walk test and timed “Up & Go” test as compared with the nonoperative group. In spite of the different baseline values, the surgery group showed more improvement and better final results on those four tests at the time of follow-up compared with the medically treated group. In addition, our hospital is a tertiary-care hospital; therefore, fewer symptomatic patients had already been screened at primary and/or secondary-care clinics. Although we tried to standardize which patients were included in the nonoperative group, we were not able to standardize which were included in the surgery group in terms of clinical symptoms and susceptibility of the condition to medical treatment.

This is the first study of which we are aware to compare the physical functional outcomes, based on four functional mobility tests, of surgical and nonoperative treatment of lumbar spinal stenosis. The surgery group showed a greater decrease in the risk of falling than the nonoperative group.

Appendix

Tables showing inclusion and exclusion criteria and the results of the linear mixed model for the correlation of the results of the four mobility tests with the treatment modality and other clinical factors are available with the online version of this article as a data supplement at jbjs.org. ■

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References


