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Paraspinal Muscle Cross-Sectional Area, Sacral Slope and Canal Diameter as Predictor for Clinical Improvement Following Decompression and Fixation of Degenerative Lumbar Canal Stenosis

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ABSTRACT

Lumbar degenerative disease was associated with paraspinal muscle atrophy, alterations in spinal alignment and sagittal balance, and narrowing of the spinal canal. This study aimed to evaluate the paraspinal muscle cross-sectional area (CSA), sacral slope (SS), and canal diameter (CD) as predictors of functional outcome improvement measured by the Oswestry Disability Index (ODI) following decompression and fixation for degenerative lumbar stenosis. A retrospective case–control study was conducted involving 40 patients with degenerative lumbar canal stenosis who underwent decompression and fusion surgery. Preoperative radiographic evaluations included sacral slope, multifidus muscle CSA (MFCSA), erector spinae muscle CSA (ESCSA) at the L4–L5 level, and canal diameter at the stenotic level. The ODI was assessed preoperatively and postoperatively on the first, second, fourth, and sixth days, as well as at the eighth postoperative week. Patients with an ESCSA of at least 900 mm² demonstrated a significant improvement in ODI scores at postoperative weeks 2, 4, 6, and 8 ($p < 0.005$). No significant differences in postoperative ODI improvement were observed between patients with MFCSA below or above 600 mm² or between those with sacral slope below or above 30 degrees ($p > 0.05$). Preoperative canal diameter showed a significant correlation with postoperative ODI improvement at weeks 2, 4, 6, and 8 ($p < 0.05$). In conclusion, a larger erector spinae muscle CSA and a narrower preoperative canal diameter were significant predictors of postoperative functional improvement in patients with degenerative lumbar stenosis undergoing decompression and fixation. Multifidus muscle CSA and sacral slope were not significant predictors of ODI improvement in this study.

Keywords: Canal Diameter, Degenerative Lumbar Stenosis, Oswestry Disability Index, Paraspinal Muscle Cross-Sectional Area, Sacral Slope

INTRODUCTION

Degenerative lumbar canal stenosis (CSL) is one of the spinal disorders that is often found in elderly patients. This abnormality is defined as compression of the spinal canal due to mechanical compression of the spinal nerve roots. CSL causes low back pain that can interfere with the patient's quality of life. Degenerative CSL, which is often found in the elderly population, is triggered by the process of degeneration of the nucleus pulposus of the intervertebral disc due to the aging process. Degenerative CSL disorders can be diagnosed through clinical and radiological approaches. Degenerative CSL is one of the most common causes of spinal surgery in Indonesia. A comprehensive and *reliable* approach is needed to predict postoperative outcomes of CSL, one of which can be assessed radiologically through *X-ray* examination and *magnetic resonance imaging* (MRI) which are standard in degenerative CSL evaluation.

The process of degenerative CSL includes intervertebral disc degeneration, hypertrophy of the facet joint, calcification or thickening of ligaments, spinal stenosis, and compression of nerve structures (Kwon et al., 2022). The symptoms of degenerative CSL vary, including lost low back pain, which can persist over time, claudication, and neurological deficits in severe cases (Hennemann and de Abreu, 2021; Kwon et al., 2022). CSL degeneratif merupakan diagnosis klinis dan radiologis. Radiologically, the examination A simple *X-ray* cannot show spinal canal stenosis, but it can describe degenerative processes that occur in the spine, such as ligament calcification, facet joint hypertorphy, and foramen stenosis. Not only that, degenerative processes can cause atrophy in the paraspinal muscles such as the iliopsoas, quadratus lumborum, erector spinae, and multfidus muscles have an important role in maintaining spinal stability and maintaining *sagittal and coronal* lines (alignment)(Ding et al., 2022). Proses degeneratif pada CSL dapat menyebabkan perubahan atau *malalignment* tulang belakang terhadap axis tubuh, seperti adanya perubahan parameter *pelvic incidence*, *pelvic tilt, sacral slope, sagittal vertical axis*, dan *lumbar lordosis* yang merupakan *spinopelvic parameter* (Costa et al., 2021; Farrokhi et al., 2016; Wang and Sun, 2019). The MRI examination can detect CSL and measure the diameter of the canal and the degree of degenerative changes of the spine. It should be underlined that it is not uncommon for severe morphological abnormalities to appear on MRI not to correlate with the severity of clinical symptoms. MRI can be used to confirm the diagnosis in patients with claudication or persistent radiating pain. (Kwon et al., 2022)

The management of degenerative CSL includes both nonoperative and operative approaches. Operative therapy is chosen in patients who are not successfully treated conservatively. There are also the type of surgery chosen that correlates with the findings of the imaging examination. The purpose of surgery in CSL is to increase the patient's functional capacity, reduce pain and reduce or prevent neurological deficits (Kwon et al., 2022). Which factors are related to the clinical outcomes of postoperative CSL have not been all studied, especially the relationship between paraspinal muscles, spinopelvic parameters and canal diameter to degenerative CSL output.

Based on the description above, the author is interested in researching the relationship between paraspinal muscle cross-sectional area, spinopelvic *sacral slope* parameters and canal diameter to postoperative output of degenerative CSL, so the purpose of this study is to find out whether the cross-sectional area of paraspinal muscle, *sacral slope* and canal diameter is a predictor of improvement in clinical output of ODI after decompression and CSL fixation on the first day. Second, fourth, sixth, and eighth weeks

MATERIALS & METHODS

This retrospective case–control study was conducted to evaluate the association between paraspinal muscle cross-sectional area, sacral slope, and spinal canal diameter with postoperative functional outcomes measured using the Oswestry Disability Index (ODI) in patients with degenerative lumbar spinal stenosis undergoing decompression, stabilization, and fusion surgery. Consecutive sampling was applied to patients treated at RSUP Prof. Dr. IGNG Ngoerah, Denpasar, Indonesia, between September 2024 and February 2025. Patients aged 35–75 years with degenerative lumbar spinal stenosis confirmed by plain radiographs and magnetic resonance imaging, who experienced persistent low back pain unresponsive to at least three months of conservative treatment and consented to surgical intervention, were included. Patients with obesity (BMI >27), a history of routine heavy physical activity, infection, autoimmune disease, malignancy, immunosuppressive or steroid use, congenital spinal abnormalities, prior spinal trauma or surgery, or who declined participation were excluded. A total of 40 patients were enrolled based on case–control sample size calculation with an additional 20% allowance for potential dropout.

Preoperative radiographic evaluation included measurement of the cross-sectional area of the erector spinae and multifidus muscles on axial T2-weighted magnetic resonance imaging at the inferior endplate level of L4 using SIMETRIS software. Erector spinae muscle cross-sectional area was categorized as <900 mm² or ≥900 mm², while multifidus muscle cross-sectional area was categorized as <600 mm² or ≥600 mm². Sacral slope was measured on standing lateral lumbosacral radiographs as the angle between the sacral plate and a horizontal reference line perpendicular to gravity and was categorized as <30° or ≥30°. Spinal canal diameter was measured on axial T2-weighted magnetic resonance imaging as the anteroposterior diameter of the dural sac at the level of maximal stenosis.

All patients underwent standardized decompression stabilization fusion surgery performed by spine surgeons, including laminectomy and flavectomy followed by spinal instrumentation and synthetic bone graft fusion. Postoperative management consisted of routine wound care, empirical oral antibiotics, spinal orthosis immobilization, and oral analgesics. Functional outcomes were assessed using the Oswestry Disability Index preoperatively and postoperatively on day 1 and at weeks 2, 4, 6, and 8. Improvement in ODI was defined as the difference between preoperative and postoperative scores at each follow-up interval.

Statistical analysis was performed using descriptive statistics to summarize patient characteristics. Data normality was assessed using the Shapiro–Wilk test. Independent t-tests were applied for normally distributed continuous variables, while the Mann–Whitney U test was used for non-normally distributed data. Correlations between numerical variables were analyzed using Pearson's correlation test. All statistical tests were two-tailed, with a significance level set at $p < 0.05$ and a 95% confidence interval.

Statistical Analysis

Descriptive statistics were used to summarize patient characteristics. Continuous variables were presented as mean ± standard deviation or median with interquartile range, while categorical variables were expressed as frequencies and percentages.

Data normality was assessed using the Shapiro–Wilk test due to a sample size of fewer than 50 subjects. For comparisons between categorical independent variables and numerical outcomes, independent t-tests were applied for normally distributed data, while the Mann Whitney U test was used for non-normally distributed data. Correlations between numerical variables were analyzed using Pearson's correlation test.

All statistical analyses were conducted using a two-tailed approach with a 95% confidence interval. A p-value of less than 0.05 was considered statistically significant.

RESULT

General Characteristics of Research Subjects

Table 1 Distribution of research subject characteristics

Variable	Quantity (%)	Mean ± Standard Deviation
Age (years)		57.20 ± 13.67
Sex		
Male	21 (52.5)	
Female	19 (47.5)	
Sacral slope		
< 30°	16 (40.0)	
≥ 30°	24 (60.0)	
Erector spinae cross-sectional area		
< 900 mm²	10 (25.0)	
≥ 900 mm²	30 (75.0)	
Multifidus cross-sectional area		
< 600 mm²	22 (55.0)	
≥ 600 mm²	18 (45.0)	
Spinal canal diameter (mm)		7.56 ± 1.98
Preoperative ODI score		38.15 ± 13.70
ODI improvement on postoperative day 1		2.75 ± 1.79
ODI improvement at postoperative week 2		7.70 ± 3.72
ODI improvement at postoperative week 4		12.00 ± 4.98
ODI improvement at postoperative week 6		18.30 ± 8.02
ODI improvement at postoperative week 8		23.50 ± 9.79

From the descriptive analysis, a total of 40 subjects were obtained with an average age of 57.20 ±13.67 years and there were 21 male subjects (52.5%) and 16 female subjects (47.5%). Of the 24 subjects, 16 subjects had a *sacral slope value* of less than 300 (40%). A total of 30 subjects (75%) had a cross-sectional area *of the erector spinae* ≥ 900mm2. There are also 18 subjects (45%) for multifidus muscles, with a muscle cross-sectional area of ≥ 600mm2. The average canal diameter in this study population was 7.56 ± 1.98.

Postoperative ODI scores were measured on the first, second, fourth, sixth and eighth days postoperatively. The average preoperative ODI score was 38.15 ± 13.70 which was included in the moderate disability. The improvement in ODI value is the difference between ODI measured pre-operatively and ODI evaluated at each predetermined time point. On the first day post-surgery, the average ODI score improvement was 2.75 ± 1.79, while for the second week it was 7.70 ± 3.72, in the fourth week it was 12.0 ± 4.98, the sixth week was 18.30 ± 8.02 and the eighth week it was 23.5 ± 9.79.

Data Normality Test

The normality test using the Saphiro-Wilk test was carried out because the number of samples was less than 50. Based on normality tests, canal diameter, preoperative ODI, ODI improvement in the second, fourth, sixth and eighth weeks had normal data distribution, while *sacral slope* variables, cross-sectional area of erector spinae muscle, multifidus, and ODI improvement on the first day had abnormal data distribution.

Table 2 Test of the normality of variable data with Shapiro-Wilk test

Variable	p-value	Distribution
Sacral slope	0.000	Non-normal distribution
Erector spinae cross-sectional area	0.000	Non-normal distribution
Multifidus cross-sectional area	0.000	Non-normal distribution
Spinal canal diameter	0.945	Normal distribution
Preoperative ODI score	0.519	Normal distribution
ODI improvement on postoperative day 1	0.000	Non-normal distribution
ODI improvement at postoperative week 2	0.130	Normal distribution

ODI improvement at postoperative week 4	0.580	Normal distribution
ODI improvement at postoperative week 6	0.221	Normal distribution
ODI improvement at postoperative week 8	0.264	Normal distribution

Paraspinal Muscle Cross-Section Area as a Predictor of Clinical Output Improvement of ODI after Decompression and Fixation of Lumbar Stenosis Canal

Inferential Analysis

Inferential analysis was carried out using a 95% confidence interval with a p value at the meaning limit of 0.05. If the data has a normal distribution, a non-paired t-test is performed, while if the data distribution is abnormal, an inferential analysis is carried out using the Mann-Whitney test for a comparison test of categorical-numerical variables.

Table 3 Inferential test of the cross-sectional area of the erector spinae on the improvement of ODI scores

Variable	Cross-sectional area < 900 mm²	Cross-sectional area ≥ 900 mm²	p-value
Preoperative ODI score	36.20 ± 7.86	38.80 ± 15.22	0.610
ODI improvement on postoperative day 1	2.60 ± 2.20	2.80 ± 1.71	0.764
ODI improvement at postoperative week 2	5.80 ± 1.75	8.33 ± 4.00	0.009
ODI improvement at postoperative week 4	10.00 ± 2.31	12.67 ± 5.47	0.038
ODI improvement at postoperative week 6	14.20 ± 4.16	19.67 ± 8.57	0.012
ODI improvement at postoperative week 8	18.60 ± 5.82	25.13 ± 10.36	0.019

Table 4 Inferential test using multifidus cross-sectional wide unpaired t-test on ODI score improvement

Variable	Cross-sectional area < 600 mm²	Cross-sectional area ≥ 600 mm²	p-value
Preoperative ODI score	40.82 ± 14.33	34.89 ± 12.50	0.177
ODI improvement on postoperative day 1	2.73 ± 2.00	2.78 ± 1.56	0.931
ODI improvement at postoperative week 2	7.73 ± 3.72	7.67 ± 3.83	0.960
ODI improvement at postoperative week 4	11.91 ± 4.38	12.11 ± 5.76	0.900
ODI improvement at postoperative week 6	19.00 ± 8.28	17.44 ± 7.85	0.549
ODI improvement at postoperative week 8	24.55 ± 10.59	22.22 ± 8.83	0.462

From the inferential test for this categorical-numerical variable, it was obtained that the cross-sectional area of the erector spinae muscle was associated with the improvement of postoperative ODI scores in the second, fourth, sixth and eighth weeks ($p<0.05$), while preoperative ODI and improvement on the first day were not significant. Meanwhile, there was no association between multifidus muscle cross-sectional area and improvement in ODI scores on the first, second, fourth, sixth and eighth days ($p>0.05$).

Sacral Slope as a Predictor of Clinical Outcome Improvement of ODI after Decompression and Fixation of Lumbar Stenosis Canal

Inferential Analysis

Inferential analysis was carried out using a 95% confidence interval with a p value at the meaning limit of 0.05. If the data has a normal distribution, a non-paired t-test is performed, while if the data distribution is abnormal, inferential analysis is carried out using the Mann-Whitney test for a comparison test of categorical-numerical variables.

Table 5 Inferential test of sacral slope on ODI score improvement

Variable	Sacral slope < 30°	Sacral slope ≥ 30°	p-value
Preoperative ODI score	38.25 ± 9.77	38.08 ± 16.00	0.971
ODI improvement on postoperative day 1	2.63 ± 1.89	2.83 ± 1.76	0.724
ODI improvement at postoperative week 2	7.13 ± 2.91	8.08 ± 4.19	0.432
ODI improvement at postoperative week 4	10.63 ± 3.07	12.92 ± 5.80	0.113
ODI improvement at postoperative week 6	17.13 ± 6.45	19.08 ± 8.96	0.456
ODI improvement at postoperative week 8	21.88 ± 8.37	24.58 ± 10.66	0.398

In this analysis, there was no difference in preoperative ODI scores or in postoperative ODI score improvement on days one, second, fourth, sixth, and eighth days between the sacral slope <300 and ≥300 groups with a p>0.05 value.

Canal Diameter as a Predictor of Clinical Output Improvement of ODI after Decompression and Fixation of Lumbar Stenosis Canal

Inferential Analysis

Inferential analysis for numerical variables was carried out using the Pearson correlation test with a significance limit of p value of 0.05.

Table 6 Inferential test of canal diameter against ODI score improvement

Dependent Variable	r	p-value
Preoperative ODI score	−0.452	0.003
ODI improvement on postoperative day 1	−0.186	0.250
ODI improvement at postoperative week 2	−0.416	0.008
ODI improvement at postoperative week 4	−0.398	0.011
ODI improvement at postoperative week 6	−0.452	0.003
ODI improvement at postoperative week 8	−0.507	0.001

From the analysis of canal diameter variables to the improvement of the postoperative ODI score, it can be observed there is a negative correlation between canal diameter and ODI score improvement, with larger channel diameter values associated with smaller ODI scores or in other words, greater ODI improvements. Canal diameter was associated with improvements in the second, fourth, sixth and eighth weeks of ODI which had significant correlation values (p<0.05).

DISCUSSION

General Characteristics of Research Subjects

In this study, the same distribution was obtained between the number of male and female patients. With an average age of 57.20 ±13.67. Degenerative lumbar canal stenosis is often found in patients over the fifth decade, and is the most common cause of spinal surgery in the population over 65 years of age. (Hennemann and de Abreu, 2021)

The average preoperative ODI score in this study was 38.15 ± 13.70. This value is included in the category of moderate disability. In another study by Hatakka, the average preoperative ODI score in lumbar canal stenosis patients in Finland was 41.7 (Hatakka, 2025). In another study by Koivunen *et al*, patients with lumbar canal stenosis who underwent surgery had a preoperative ODI value of 41.9 ± 16.9 (Koivunen 2025). Meanwhile, in another study, the preoperative ODI score of patients with degenerative lumbar canal stenosis who underwent surgery reached 50.19 ± 1.97. (Costa et al., 2021)

The cross-sectional parameters of the paraspinal muscle in this study evaluated two muscles: erector spinae and multifidus. The cross-sectional area of the erector spinae muscle is divided into a cross-sectional area of less than 900mm2 and more than 900mm2. In the study by Ding, the average cross-sectional area of the erector spinae muscle at *the L4-5 endplate level* was 903.5 ± 293.5. In this study, there were 10 patients (25%) who had a cross-sectional area of the erector spinae muscle of less than 900mm2. According to a study by Ding, patients with degenerative lumbar canal stenosis experienced degeneration of the erector spinae muscle compared to healthy subjects. (Ding et al., 2022)

In this study, as many as 45% of subjects had a multifidus muscle cross-sectional area of more than 600mm2. In the study by Wang, the average cross-sectional area of multifidus muscle in 69 patients with lumbar canal stenosis was 609.4 ±183.8, and when grouped by sex, the average area of multifidus cross-sectional in the study by Wang was 718.7 ±207.5 in men and 543.3 ± 131.1 in women. (Wang et al., 2020)

Of the 40 subjects, there were 16 subjects (40%) who had *a sacral slope* value of less than 30 degrees. Nakamae *et al* in their study obtained an average *sacral slope* of 29.2 ± 8.8 degrees in patients with lumbar canal stenosis. Meanwhile, a study by Wang that compared the spinopelvic parameters of healthy subjects with subjects with lumbar canal stenosis found an average *sacral slope* in the control group of 25.35 ± 11.59 and in the stenosis group of 30.19 ± 7.83. (Nakamae et al., 2019; Wang and Sun, 2019)

Broad Relationship of Paraspinal Muscle Cross-Section with Improvement of ODI Clinical Outcomes After Decompression and Fixation of Lumbar Stenosis Canal on Days One, Second, Fourth, Sixth and Eighth Days

In this study, a comparative evaluation of postoperative ODI score improvement on the first, second, fourth, sixth and eighth days was conducted using the analysis of unpaired T-tests on normally distributed data and the Mann-Whitney test on data with abnormal distribution. From the analysis, it was found that there was a significant difference between the cross-sectional area groups of erector spinae muscles <900mm2 and ≥900m2 on the clinical outcomes of ODI score improvement in the second, fourth, sixth and eighth weeks ($p<0.05$), while preoperative ODI scores and ODI improvement on the first postoperative day were not significant between the two groups ($p>0.05$). Meanwhile, the analysis of the relationship between multifidus muscle cross-section area and postoperative ODI score improvement showed no significant difference at all ($p>0.05$).

In the case of degenerative lumbar stenosis, there is a process of degeneration and atrophy of the paraspinal muscles including the erector spinae muscles. Wang researched the effects of paraspinal muscles on the functional output of patients with lumbar canal stenosis undergoing decompression, stabilization and fusion procedures in China. According to Wang in his study, the preoperative ODI value correlated with *the functional cross-sectional area* of the multifidus muscle ($r = -0.304$, $p = 0.012$), in addition, the improvement of the 6-month postoperative ODI was related to a smaller cross-sectional area of the multifidus muscle ($p = 0.007$) (Wang et al., 2020). This is contrary to the findings of this study where the cross-sectional area of the multifidus muscle was not significantly related to the improvement of postoperative ODI scores on the first, second, fourth, sixth and eighth days. However, this difference could also be due to different postoperative ODI score measurement times, namely at the sixth month of the study by Wang, and at an earlier point in time in this study.

Still from the study by Wang, Wang found a negative correlation between the cross-sectional area of the erector spinae and multifidus muscles on changes in ODI scores, suggesting that patients with heavier muscle degeneration had poorer functional outputs. (Wang et al., 2020)

The area of the muscle cross-section represents the quantity of the paraspinal muscle and is an indicator of the muscle atrophy process that may occur in degenerative lumbar canal stenosis. Age is one of the factors related to paraspinal muscle degeneration. The paraspinal muscle acts as a stabilizer of the spine and according to previous studies has a protective effect against lumbar degenerative inhibitors. Muscle degeneration that occurs includes the process of atrophy and infiltration of fat into the muscle (*fatty infiltration*). Previous research has shown that multifidus muscle has an important role in maintaining the structure of the lordosis rather than the lumbar. (Ding et al., 2022)

This study evaluated the cross-sectional area of the paraspinal erector spinae muscle and preoperative multifidus. In patients who underwent spinal surgery consisting of stabilization with implant placement, there have been injuries to the muscles due to the process of dissection, retraction, and denervation during surgery. This can lead to muscle degeneration that occurs postoperatively, and lead to persistent low back pain (Klinger et al., 2019). This study could be developed to evaluate paraspinal muscles in patients undergoing more non-invasive procedures such as *mini-invasive transforaminal interbody fusion* with minimal muscle damage, compared to decompression and fixation procedures that expose a larger surgical area.

Relationship *of Sacral Slope* with Clinical Outcome Improvement of ODI Post-Decompression and Fixation of Lumbar Stenosis Canal on Days One, Second, Fourth, Sixth and Eighth Days

In this study, there was also no significant relationship between *sacral slope* values and postoperative ODI clinical outcomes on either the first, second, fourth, sixth and eighth days ($p > 0.05$). In the study by Costa, there was also no association between clinical outcomes 1 year after surgery and spinopelvic parameters, including *sacral slope.* (Costa et al., 2021)

Patients with lumbar canal stenosis had lower *sacral slope* values than healthy subjects in the study conducted by Farrokhi with a difference in *sacral slope* values of 31.390±11.2 versus 43.70±8.4 ($p=0.001$) (Farrokhi et al., 2016). In a study by Hsieh *et al*, a *sacral slope* value of 30 degrees did not indicate a relationship with clinical outcomes, but *sacral slopes* of more than 40 degrees had a higher risk of *adjacent-segment degeneration*, but not functional clinical outcomes (Hsieh et al., 2018). From another study by Kitagawa, it was found that *the sacral slope* variable was not associated with the clinical outcome of postoperative residual low back pain ($p>0.05$) (Kitagawa et al., 2021). In contrast to the population of lumbar canal stenosis patients who underwent surgery, in patients who received non-operative therapy in the form of facet joint injections and physiotherapy, *sacral slope was* actually found to be associated with improvement in ODI clinical output, in the form of *a higher sacral slope* providing higher ODI improvement. (Beyer et al., 2015)

The sagittal alignment of the spine, or also called *sagittal balance*, is related to mechanical stress on the lumbosacral area. Lumbar canal stenosis is associated with sagittal imbalance and decreased lumbar lordosis as well as *sacral slope*. *Sacral slope* is a parameter related to posture that is affected by pelvic position. (Farrokhi et al., 2016)

Relationship of Canal Diameter with Improvement of ODI Clinical Outcomes After Decompression and Fixation of Lumbar Stenosis Canal on Days One, Second, Fourth, Sixth and Eighth Days

In this variable, there was a relationship between canal diameter and postoperative ODI score improvement from the second, fourth, sixth and eighth weeks ($p<0.05$). The difference in preoperative ODI scores and improvement on the first day between the two groups was not significant ($p>0.05$). This is in line with research conducted by Aimar et al. which evaluated the predictors of postoperative clinical outcomes of lumbar stenosis canal decompression and obtained the degree of compression or canal diameter as one of the predictors of postoperative ODI clinical output improvement (Aimar et al., 2021). Another study by Hughes found a correlation between canal diameter and clinical outcomes, one of which was measured by ODI scores (Hughes et al., 2015). However, another study in India evaluating anteroposterior canal diameter with ODI clinical outcomes did not show a significant correlation between canal diameter and ODI score. (Goni et al., 2014)

Advantages and Limitations of the Study

This study is the first study in Indonesia to evaluate the relationship of radiological parameters of the cross-section of the paraspinal muscle and *sacral slope* to the improvement of functional output of ODI after surgical decompression and fixation of lumbar stenosis canal. The differences between the physical characteristics of the Asian population, particularly Indonesia compared to other previously studied populations, make this study a starting point to evaluate other radiological parameters that may be related to postoperative clinical outcomes in patients with lumbar canal stenosis. However, there are still limitations to this study, including short *follow-up* times and limited sample counts.

CONCLUSION

This study demonstrated that a larger preoperative erector spinae muscle cross-sectional area was a significant predictor of early postoperative functional improvement, as measured by the Oswestry Disability Index, from the second to the eighth postoperative week in patients with degenerative lumbar spinal stenosis undergoing decompression and fixation. In contrast, multifidus muscle cross-sectional area and sacral slope were not associated with postoperative ODI improvement during the evaluated follow-up period. Additionally, preoperative spinal canal diameter showed a significant association with postoperative functional improvement from the second postoperative week onward, indicating that patients with more severe canal narrowing experienced greater benefit from surgical decompression.

These conclusions should be interpreted in light of the study's limitations, including the relatively small sample size and short follow-up duration, which may limit the assessment of long-term functional outcomes. Nevertheless, the findings suggest that preoperative assessment of erector spinae muscle morphology and spinal canal diameter may provide clinically relevant information for predicting early postoperative recovery and counseling patients undergoing surgery for degenerative lumbar spinal stenosis.

Declaration by Authors

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