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Functional outcome analysis of lumbar canal stenosis patients post decompression and posterior stabilization with stenosis grading using magnetic resonance imaging

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Abstract. Lumbar canal stenosis (LCS) is a condition that can potentially cause disability. It often occurs in aging populations. The aim of this study was to analyze the correlation between the clinical outcomes of postoperative patients and classifications that were based on MRI assessments. This prospective cohort study was carried out at Cipto Mangunkusumo General Hospital from January to July 2016 using consecutive sampling. Thirty-eight patient samples were obtained, all of whom were managed with the same surgical technique of decompression and posterior stabilization. The patients were categorized in four types based on MRI examination using the Schizas classification. Pre- and post-treatment (three months and six months) assessments of the patients were conducted according to Visual Analogue Scale (VAS), the Oswestry Disability Index (ODI), the Japanese Orthopedic Association Score (JOA), and the Roland-Morris Disability Questionnaire (RMDQ). The statistical analysis was performed using the statistical program for social science (SPSS) v.19. The average age of the patients in this sample was 58.92 years (range 50–70 years). There were 16 males and 22 females. Most patients were classified as type C (21 subjects) based on MRI examination. The improvement in the clinical scores of male subjects was better than in the female subjects. Significant differences were found in the six-month postoperative VAS ($p = 0.003$) and three-month postoperative JOA scores ($p = 0.029$). The results at follow-up showed that the VAS, ODI, JOA and RMDQ scores were improved. There were no statistical differences between the MRI-based classification and the clinical outcomes at preoperative, three and six months postoperative according to VAS ($p = 0.451$, $p = 0.738$, $p = 0.448$), ODI ($p = 0.143$, $p = 0.929$, $p = 0.796$), JOA ($p = 0.157$, $p = 0.876$, $p = 0.961$), and RMDQ ($p = 0.065$, $p = 0.057$, $p = 0.094$). There was clinical improvement after decompression and posterior stabilization in lumbar canal stenosis, which was manifested at three and six month post-operation follow-up in the VAS ODI, JOA and RMDQ scores. There was no association between the degree of LCS and VAS, ODI, JOA and RMDQ scores.

1. Introduction

Lumbar canal stenosis (LCS) is defined as the constriction of the spinal canal, the lateral radix nerve canal, or the neural intervertebral foramina due to the progressive hypertrophy of the anatomical structure of osteocartilage or ligament. LCS may involve the neurogenic or vascular compression of the spinal canal structure at least at one level, which causes disability [1]. LCS is a common condition especially in the elderly, and it increases with age. Acadaveric study found that 90–100% of the

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examined anatomical specimens had experienced at least one type of vertebral degenerative process. Another study found that 20% of patients who did not have any symptoms exhibited stenosis in their spine [2].There are four syndromes of symptomatic LCS: neurogenic claudication, nerve compression, central low back pain, and non-radicular lower extremity pain. The classical clinical feature of LCS is neurogenic claudication. Decreasing tolerance while walking due to neurogenic claudication is one of the reasons that people consult a doctor [3].

Diagnosis is often delayed because of the slow progression of LCS and its emergence in the elderly, which causes it to be confused with other differential diagnoses. Surgical management by decompression and stabilization is the primary treatment of LCS. In America, surgeries on the lumbar area are mostly conducted to treat LCS. Despite the various conservative managements, the aim of the surgical approach is to diminish the pressure on the neurovascular structures around the stenotic area. Thus, an accurate diagnosis is important in determining the management. Because the degree of spinal cord constriction that is considered symptomatic in LCS is unclear, the relation between clinical appearance and the degree of constriction based on radiological examination are also poorly understood. The correlation between the patient's disability level and constriction according to radiological examination of the lumbar spinal canal has been a subject of research [1-3].The sensitivity and specificity of magnetic resonance imaging (MRI) in determining individual suffering from LCS is superior to other methods, such as computed tomography and myelography. Measuring the area of the dural sac is considered more effective in diagnosing central stenosis than measuring the osseus spinal canal is [4].

Several ways are used to access the outcomes of postoperative patients. One way is to have the patient fill out a questionnaire. The Oswestry Disease Index (ODI) is a questionnaire that includes 10 subjective questions. It is distributed to individuals affected by LCS in order to determine the level of disability that they experience in their daily activities. It is a simple and easily understood method of assessment, and it can assess the function, pain, and limitations in the patient's health status.[5] Other questionnaires that are used to evaluate disability and pain are the Visual Analogue Scale (VAS), the JOA score, and the Roland-Morris Disability Questionnaire (RMDQ). These also provide commonly used benchmarks to assess the outcomes of LCS management. In this study, the main objective is to determine the relationship between the degree of anatomic stenosis indicated in the radiological examination and the patient's disability level.

2. Materials and Methods

This observational research, which conducted a descriptive analytic study using a prospective cohort design, was carried out at Cipto Mangunkusumo General Hospital in Jakarta from January to July 2016. The inclusion criteria were as follows: patients aged 50–70 years with a diagnosis of lumbar canal stenosis due to degeneration; having undergone operative treatment by an orthopedic surgeon at Cipto Mangunkusumo Hospital; having signed the informed consent form. The subjects were selected consecutively from patients who came to Cipto Mangunkusumo General Hospital from January to December 2015. The ODI, Roland-Morris, JOA, and VAS assessments were performed at preoperative or conservative and six months postoperatively treatments. The data analysis was conducted using Microsoft Excel and SPSS 17. Clinical profiles, radiology (MRI), and outcome functions were analyzed using ODI, Roland-Morris Score, JOA Score, and VAS, which were compared with the preoperative condition and the postoperative conditions at three months and six months using the paired categorical comparative hypothesis test with two repetitions using the marginal homogeneity test and the Wilcoxon test.

3. Results and Discussion

3.1 Results

Of the 38 subjects, 57.9% were female, and the mean age was 58.92 years (50–70 years) (Table 1). Two subjects (5.26%) did not undergo postoperative fusion.

Table 1. Subject's characteristics and the outcome measurement results

Variables		Description	Normality* (p value)
Gender = n (%)	Males	16 (42.1)	
	Females	22 (57.9)	
Age	Mean (SD)	58.92 (5.86)	0.053
	Median (Min-Max)	59.5 (50 - 70)	
Fusion = n (%)	Yes	36 (94.74)	
	No	2 (5.26)	
Stenosis = n (%)	Central	35 (92.1)	
	Lateral	3 (7.9)	
Degree of stenosis = n (%)	A	0 (0)	
	B	8 (21.1)	
	C	21 (55.3)	
	D	9 (23.7)	
VAS	Preoperative:		
	Mean (SD)	6.95 (1.39)	0.018
	Median (Min-Max)	7 (4-9)	
	3 months postoperative:		
	Mean (SD)	3.29 (1.39)	0.001
	Median (Min-Max)	3 (1-6)	
	6 months postoperative:		
	Mean (SD)	1.45 (1.11)	0.001
	Median (Min-Max)	2 (0-4)	
ODI	Preoperative:		
	Mean (SD)	54.79 (15.86)	0.027
	Median (Min-Max)	59 (24-86)	
	3 months postoperative:		
	Mean (SD)	14.68 (10.16)	<0.001
	Median (Min-Max)	12 (4-56)	
	6 months postoperative:		
	Mean (SD)	9.63 (8.68)	<0.001
	Median (Min-Max)	8 (0-56)	
JOA	Preoperative:		
	Mean (SD)	9.76 (2.73)	0.171
	Median (Min-Max)	10 (5-16)	
	3 months postoperative:		
	Mean (SD)	22.32 (2.34)	0.002
	Median (Min-Max)	23 (16-26)	
	6 months postoperative:		
	Mean (SD)	25.08 (1.86)	0.006
	Median (Min-Max)	25.5 (19-28)	
RMDQ	Preoperative:		
	Mean (SD)	19.97 (2.29)	0.024
	Median (Min-Max)	20 (16-24)	
	3 months postoperative:		
	Mean (SD)	11.16 (2.68)	0.001
	Median (Min-Max)	10 (8-19)	
	6 months postoperative:		
	Mean (SD)	5.37 (1.92)	0.126
	Median (Min-Max)	6 (2-10)	

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3.2 Discussion

In this study, the mean age of the subjects was 58.92 years. In a study conducted by O'Neill et al, changes in the discus and a significant osteofit were found, which caused clinical symptoms in the age range above 50 years. This study also found a prevalence of lumbar canal stenosis in the female population. Similarly, Kim *et al.* [6] found that more female patients were admitted to the hospital because of lower back pain. In 2007, 1,091,000 women, compared with 805,000 men, were admitted to hospital for complaints caused by lumbar canal stenosis. This study found that females tended to experience hospitalization periods longer than men did in terms of lower back disease [7]. Kim *et al.* [6], considered that this difference was due to the probability of different pain perceptions by Thesexes. This study also found that men generally had better pain and disability scores than women did although not all differences were statistically significant. Kim et al discussed several mechanisms that could make women more vulnerable than men, such as biological mechanisms, hormonal differences, psychological issues, depression, and perceptions of excessive pain.

In this study, the highest degrees of stenosis were B, C, and D based on the Schizas classification. No subject had the A degree of stenosis. The reason might be that patients with A degree of stenosis did not present at the hospital. In this study, patients with complaints and lumbar canal stenosis proven by examination were candidates for surgery, which also might have been the reason that degree A stenosis was absent in this study. The clinical outcome of the VAS comparison for back pain indicated a significant decrease in VAS level compared to the preoperative condition. VAS has been widely used as a benchmark of postoperative outcomes. The main advantage of this score is its ease of use. [8] There are two commonly used methods: listing the numbers 0–10 to indicate the degree of injury or choosing the available VAS diagram area. The results of the present study indicated that the VAS value was improved in the period of the follow-up. However, the findings showed that the greatest improvement in VAS values occurred in from the preoperative condition to three months postoperative condition. The improvement value was 3.66 points compared to the postoperative period of three months to six months, which showed an improvement value of 1.84 points. These results indicated that the surgical procedure positively affected the clinical improvement. Leslie [9] also found a significant relationship between the VAS values before and after surgery. Mussachio [10] also supported that result, finding a significant difference in VAS values before and after surgery.

ODI scores are considered useful for measuring the patient's outcome after the surgical management of lumbar canal stenosis. ODI scores are also considered valid and suitable for measuring the patient's subjective attitudes toward and perceptions of his or her abilities. In a study by the Medical Research Council, the ODI score was considered the best outcome marker [11]. In this study, the ODI scores showed significant improvement between the preoperative and postoperative conditions. The greatest increase was in the third month of follow-up. Cavusoglu *et al.* [12], conducted a study on 100 patients, calculating the ODI of preoperative, three months postoperative, and four years postoperative conditions. The results showed significant differences in the ODI scores before and after surgery. The results also indicated that the improvement in the ODI scores was greater in the preoperative to the three-month postoperative period compared to the three-month to four-year postoperative period. Leslie *et al.* [9], also found a significant relationship between ODI scores before and after surgery. The postoperative JOA scores were significantly increased compared to the preoperative JOA scores. The largest improvement in the JOA scores was in the preoperative to the three-month postoperative period by as many as 12.56 points. This result was in line with Nath *et al.*, which found a significant correlation between JOA scores before and after surgery [13]. That study showed that in 32 patients with surgery for canal stenosis, 62.5% had good outcomes, and 18.75% had satisfactory outcomes based on the three-month postoperative JOA scores.

The present study found a significant relationship between the preoperative and postoperative RMDQ scores at both three months and six months. These results were consistent with previous findings of significant differences in the preoperative and postoperative RMDQ scores of patients with canal stenosis [11]. Regardless of the degree of stenosis, there was a significant improvement in RMDQ score. These results showed that the surgical technique of Transforaminal Lumbar Interbody

Fusion (TLIF) and posterior stabilization was still the gold standard in managing lumbar canal stenosis. The results of a meta-analysis by Jin Tao *et al.* [14] suggested that the TLIF method was still the preferred technique in treating lumbar canal stenosis. The current technique is minimally invasive, resulting in similar rates of fusion and complications rate. However, this technique has higher incidences of having revisions. In this study, all patients were treated with similarly principled techniques. In general, there were no significant differences in the VAS, JOA, ODI or RMDQ values at different levels of stenosis in either the preoperative condition or the follow-up condition. In the case of preoperative VAS, there were no significant differences among the groups categorized according to the degree of stenosis ($p = 0.451$). However, the mean of degree B was higher than that of degree D, which may have been because the patients with severe stenosis were chronic and had already undergone rehabilitation, physiotherapy, or pain medication. This result aligned with Spalzski [15] and Lee [16], which found that both central and lateral canal stenosis were correlated with the general symptoms of patients who had significant degenerative changes, and they were often found together. Thus, the clinical changes in preoperative and postoperative patients were not significantly different in both locations of stenosis.

Similar results were obtained in the clinical outcomes of ODI and JOA according to the degree of stenosis. These results were in line with Weber *et al.* [17], who found no significant differences in the ODI scores of preoperative and postoperative patients with radiological severity. Alicioglu *et al.* [18], conducted a similar study that evaluated the JOA values of 38 preoperative and postoperative patients with canal stenosis. The results showed no significant differences in the JOA scores according to the degree of stenosis and the severity of radiology. The radiological classification used by Alicigoglu *et al.* [18] was based on self-developed criteria. The radiological classification used in this study was the Schizas morphology classification. Following Weber *et al.* [17], this classification was used because it could better describe the degree of nerve compression.

The signs and symptoms of canal stenosis may vary, and they are not specific. Therefore, radiological imaging is important to exclude or confirm canal stenosis and to determine the surgical target and treatment plan for the patient. This study used the categories developed by Schizas *et al.* [19]. Shizas did not find a significant association between the symptoms and degree of canal stenosis, which suggested that the pathology in patients with lumbar canal stenosis indirectly causes symptoms. Epidemiologically, even in asymptomatic patients aged 60 years old, 1 in 5 patients had radiological features of canal stenosis. This result could have been caused by an improper measurement instrument. It was found that other measurement instruments, such as the Zurich Claudication Questionnaire, were more precise in diagnosing lumbar canal stenosis cases [20,21]. The reasons for the in consistent outcomes of the ODI, VAS, JOA and RMDQ scores in the classification of the degree of stenosis according to MRI were that the imaging technique only provides information in the static anatomical position, whereas there are variations in pedicle length and canal size as well as differences in nerve susceptibility. Furthermore, other pathological disorders might be a confounding factor in assessing symptoms of canal stenosis in elderly patients [16,17,22].

4. Conclusion

There was significant clinical improvement, which was marked by the significant decrease in ODI values in postoperative patients at three and six months in the follow-up period (decompression and stabilization) compared to the preoperative condition. The clinical improvement was also marked by a significantly reduced scale of VAS in all postoperative patients at three and six months after decompression and stabilization compared with the preoperative condition. The significant increase in the postoperative JOA scores at three and six months showed that patients had significant improvement in post decompression and stabilization. The significant decrease in the postoperative RMDQ scores at three and six months in the follow-up period showed that the patients had significant clinical improvement after the decompression and stabilization procedures. There was no significant relationship between the ODI score and degree of stenosis in either the preoperative or the postoperative conditions (decompression and stabilization). No relationship was found between the

degrees of patient disability and the degree of stenosis. Regarding the degree of VAS, there was no relationship between the degree of pain with the degree of stenosis. These results indicated that many other factors could affect the pain sensation in patients with spinal canal stenosis. Regarding the JOA scores, there was no significant relationship between them and the degree of stenosis. This result suggested that the clinical condition was indirectly proportional to the degree of stenosis. Similar to the other three outcomes, the RMDQ scores did not indicate a significant association with the degree of canal stenosis. Generally, the men showed better values than the women did in the VAS, ODI, JOA, and RMDQ scores although there was no significant relationship between postoperative outcomes and gender. Large amounts of data are required by longer follow-up periods to assess long-term clinical outcomes. The same number of samples was required with homogeneous characteristics. Prognostic and comparative studies involving different surgical techniques (e.g., minimally invasive spine surgery) could be conducted in future research. Treatment, complications, longer follow-up periods, and postoperative rehabilitation could be included in future studies.

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