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CLINICAL AND IMAGING FEATURES OF SURGICALLY TREATED LUMBAR SPONDYLOLISTHESIS

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ABSTRACT

Background: *Lumbar spondylolisthesis is a common cause of low back pain, reduced occupational capacity, impaired quality of life, and frequent recurrence. Without timely treatment, the disease may progress to spinal dysfunction, disability, and increased socioeconomic burden.* ***Objectives:*** *To describe the clinical and imaging characteristics and* ***to*** *evaluate the surgical treatment outcomes of lumbar spondylolisthesis treated with posterior lumbar interbody fusion (PLIF) using pedicle screws at Can Tho Central General Hospital.* ***Materials and methods:*** *A prospective descriptive study was conducted on 49 patients with lumbar spondylolisthesis treated with PLIF from July 2022 to April 2024. Clinical data, imaging findings, and treatment outcomes were collected and patients were followed up for 6 months.* ***Results:*** *The mean age of patients was 58.4 ± 10.4 years; females accounted for 67.3%. Mean BMI was 22.29 ± 2.79 and mean T-score was –2.42 ± 1.17; 73.5% of patients were diagnosed with osteoporosis. Imaging characteristics: X-ray imaging showed that 93.9% of cases were grade I spondylolisthesis, most commonly at L4-L5 (63.2%). MRI findings revealed disc herniation in 85.7%, foraminal stenosis in 38.8%. Clinical characteristics: 95.9% had low back pain and 93.9% had radicular pain. Positive Straight Leg Raise test was observed in 91.8%, sensory disturbances in 95.9%, motor deficits in 20.4%, and muscle atrophy in 8.2%. The mean preoperative VAS scores were 6.49 for back pain and 6.22 for leg pain. Outcomes: At 6 months post-surgery, the mean VAS scores significantly decreased to 1.80 for back pain and 1.20 for leg pain ($p < 0.001$). PLIF surgery significantly improved clinical symptoms and functional outcomes.* ***Conclusions:*** *Lumbar spondylolisthesis predominantly affects middle-aged women, commonly presents as grade I at the L4-L5 level, and is associated with low back pain, radicular symptoms, and functional impairment. PLIF surgery significantly improves clinical symptoms, functional outcomes, and imaging findings after 6 months.*

Keywords: *Lumbar spondylolisthesis, posterior lumbar interbody fusion, pedicle screw, PLIF.*

I. INTRODUCTION

Lumbar spondylolisthesis (LS) is a condition in which a vertebra in the lumbar region abnormally shifts forward or backward, leading to spinal instability and nerve compression. The condition affects approximately 3–10% of the population[1]. The condition significantly impairs quality of life, reduces occupational capacity, and may result in disability if not treated in a timely manner [2].

Most cases of LS are managed conservatively, and surgery is typically indicated only in severe cases or when conservative treatment fails. Surgical options include decompression alone (which carries a progression risk of 30–60%) [3], posterolateral fusion (PLF) with a fusion rate of approximately 90–94% but a risk of screw breakage, and posterior lumbar interbody fusion (PLIF), which is currently preferred due to its high fusion rate of 95–100% [4].

II. MATERIALS AND METHODS

2.1. Participants

All patients with lumbar spondylolisthesis who underwent posterior lumbar interbody fusion (PLIF) surgery at Can Tho Central General Hospital from July 2022 to April 2024 were included in the study.

- Inclusion criteria:

+ Patients with Grade 1 or 2 spondylolisthesis who failed conservative treatment (i.e., symptoms did not improve or worsened despite medical management), or those with progression of slippage, muscle atrophy, or cauda equina syndrome.

+ Patients with Grade 3 or 4 spondylolisthesis.

- Exclusion criteria:

+ Patients with medical conditions that could affect data consistency, such as uncontrolled diabetes mellitus, coagulation disorders, or immunodeficiency.

+ Patients with a history of spinal surgery or congenital spinal deformities, such as scoliosis or kyphosis.

2.2. Methods

- Study design: A prospective descriptive study with no control group.

- Sample size: The sample size was calculated using a proportion (p) of 93.4% based on the study by Nguyen Vu (2015) [3], resulting in a minimum required sample size of $N \geq 48.32$. A total of 49 patients were included.

- Sampling method: Convenience sampling was used; all eligible cases from July 2022 to April 2024 were selected.

- Study content: General information (age, sex, address), clinical characteristics, subjective and objective symptoms, etiology of spondylolisthesis, degree of functional impairment based on the Oswestry Disability Index (ODI), and postoperative clinical and imaging improvement were collected.

- Data processing and analysis: Data were entered and analyzed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA). Preoperative and postoperative variables were compared using appropriate statistical tests.

III. RESULTS

3.1. General Characteristics of the Study Population

Table 1. Distribution of Patients by Age Group

Characteristic		Frequency (n)	Percentage (%)
Age	<50	7	14.3
	50 – 59	18	36.7
	60 – 69	17	34.7
	≥70	7	14.3
	Mean ± SD	58.4 ± 10.4	
Characteristic		Frequency (n)	Percentage (%)
Sex	Male	16	32.7
	Female	33	67.3
BMI	< 18.5	3	6.1
	18.5 - 23	26	53.1
	23 - 25	10	20.4

Characteristic		Frequency (n)	Percentage (%)
	≥ 25	10	20.4
	$\underline{X}$ ± SD	22.29 ± 2.69	
T-score	> –1 (Normal)	3	6.1
	–1 - –2.5 (Osteopenia)	10	20.4
	≤ –2.5 (Osteoporosis)	36	73.5
Total		49	100

The mean age of patients was 58.4 ± 10.4 years (range: 24–74), with the majority (71.4%) aged between 50 and 69 years. Patients under 50 and those aged 70 or older each accounted for 14.3%. Female patients predominated, representing 67.3%, nearly twice the proportion of males (32.7%). The average BMI was 22.29 ± 2.69 kg/m², with most patients (53.1%) falling within the 18.5–23 kg/m² range; only 6.1% had a BMI below 18.5 kg/m². Bone mineral density assessment revealed generally poor bone quality: 73.5% of patients had a T-score ≤ –2.5 (osteoporosis), 20.4% had osteopenia, and only 6.1% had normal bone density.

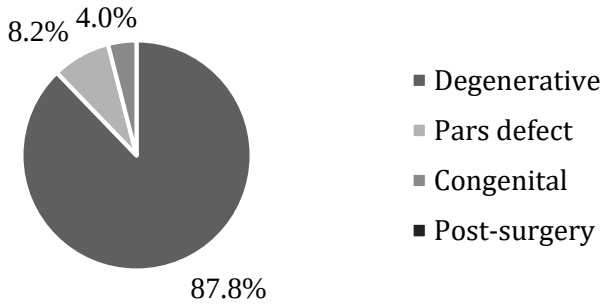

Figure 1. Causes of lumbar spondylolisthesis

Degeneration was the leading cause of lumbar spondylolisthesis, accounting for 87.8% of cases. No cases of postoperative spondylolisthesis were recorded, whereas isthmic and congenital causes were relatively uncommon, at 8.2% and 4.1%, respectively.

3.2. Imaging Characteristics of the Study Population

Table 2. Radiographic characteristics of spondylolisthesis on conventional X-ray

	Frequency (n)	Percentage (%)
Degree of Spondylolisthesis		
Grade I	46	93.9
Grade II	2	4.1
Grade III	1	2.0
Slipped Level		
L3-L4	8	16.3
L4-L5	31	63.2
L5-S1	10	20.5
Isthmic Defect	3	6.1
Loss of Physiological Lordosis	8	16.3

Most patients had mild spondylolisthesis, with grade I accounting for 93.9%, grade II accounting for 4.1%, and grade III being rare (2.0%); no cases of grade IV were observed. Slippage was predominantly located in the lower lumbar segments, with L4 being the most common (63.2%), followed by L5 and L3. X-ray imaging also revealed

pars defects (isthmic spondylolysis) in 6.1% and loss of lumbar lordosis in 16.3%, indicating associated structural changes.

Table 3. MRI Imaging Characteristics

Characteristic	Frequency (n)	Percentage (%)
Isthmic Defect	4	8.2
Disc Herniation	42	85.7
Foraminal Stenosis	19	38.8
Intervertebral Space Narrowing	14	28.6
Facet Joint Hypertrophy	5	10.2

On MRI, disc herniation was observed in 85.7% of patients, pars defects in 8.2%, foraminal stenosis in 38.8%, intervertebral space narrowing in 28.6%, and facet joint hypertrophy in 10.2%.

3.3. Clinical Characteristics Before and After Surgery

Table 4. Preoperative pain symptoms

Clinical Symptoms	Number (n=49)	Percentage (%)
Lower Back Pain	47	95.9
Radicular Pain along the Sciatic Nerve	46	93.9
Clinical Symptoms	Number (n=49)	Percentage (%)
Neurogenic Claudication		
< 100 m → *Less than 100 meters*	12	24.5
100 – 500 m → *100 to 500 meters*	6	12.5
> 500 m → *More than 500 meters*	31	63.3

Most patients with spondylolisthesis (95.9%) experienced lower back pain, accompanied by radicular pain along the sciatic nerve in 93.9% of cases, with bilateral pain being more common. All patients reported neurogenic claudication, primarily occurring after walking more than 500 meters (63.3%), whereas only 12.5% experienced symptoms after walking 100–500 meters.

Table 5. Comparison of Neurological Compression Symptoms Before and After Surgery

Symptom	*Preoperative n (%)*	*At Discharge n (%)*	*1 Month n (%)*	6 Months *n (%)*
Positive Straight Leg Raise Test	45 (91.8)	42 (85.7)	40 (81.6)	13 (26.5)
Sensory Disturbance				
Paresthesia	39 (79.6)	35 (71.4)	19 (38.8)	8 (16.3)
Paresthesia with Hypoesthesia	8 (16.3)	11 (22.4)	6 (12.2)	0
No Sensory Disturbance	2 (4.1)	3 (6.1)	24 (49.0)	41 (83.7)
Motor Deficit				
Muscle Strength 3/5	3 (6.1)	3 (6.1)	0	0
Muscle Strength 4/5	7 (14.3)	9 (18.4)	6 (12.2)	6 (12.2)
Muscle Strength 5/5	39 (79.6)	37 (75.5)	43 (87.8)	43 (87.8)
Muscle Atrophy	4 (8.2)	4 (8.2)	2 (4.1)	1 (2.0)

After surgery, the rate of positive Lasègue sign decreased from 91.8% preoperatively to 85.7% at discharge, 81.6% at 1 month, and 26.5% at 6 months. The proportion of patients without sensory disturbances increased from 4.1% to 83.7%, whereas paresthesia dropped to 16.3%, and no cases of numbness with hypoesthesia remained.

Muscle strength of 5/5 was achieved in 87.8% of patients by 1 month was maintained at 6 months, with no cases of 3/5 strength; muscle atrophy decreased to 2.0%.

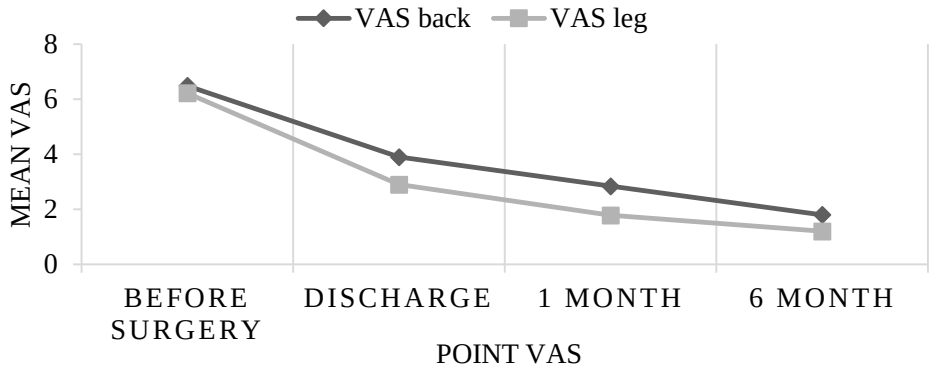

Figure 2. Trend of Mean VAS Score

After surgery, the mean VAS score for back pain decreased from 6.49 preoperatively to 3.90 at discharge, 2.84 at 1 month, and 1.80 at 6 months ($p < 0.001$). The mean VAS score for leg pain decreased from 6.22 to 2.90, 1.78, and stabilized at 1.20 after 6 months ($p < 0.001$).

IV. DISCUSSION

4.1. General characteristics of the study population

The mean age of patients was 58.4 ± 10.4 years, with the 50–59 age group being the most common (36.7%), similar to findings by Hoang Gia Du [5]. Females accounted for 67.3%, consistent with other domestic studies such as those by Nguyen Khac Linh [9], but in contrast to Vo Ba Tuong [6]. The average BMI was 22.29 ± 2.69 kg/m², with overweight and obese patients making up 40.8%—lower than in the study by MacLean, though still predominantly in the overweight range [7]. Elevated BMI contributes to increased spinal load and accelerates degeneration through inflammatory and cartilage metabolic pathways [8]. Degeneration was the leading cause of spondylolisthesis (87.8%), followed by isthmic (pars interarticularis defect) at 8.2%, and congenital factors at 4.1%. In our study, the mean T-score at the lumbar spine was –2.42 ± 1.17, with 73.5% of patients diagnosed with osteoporosis. In this study, osteoporosis was observed in 73.5% of patients, predominantly among females (67.3%), indicating a correlation between gender and bone quality. Analysis revealed a significant association between T-score and age, particularly in older female patients ($p < 0.05$). Additionally, BMI showed a notable correlation, as patients with lower BMI tended to have reduced bone mineral density ($p < 0.05$).

4.2. Imaging characteristics of the study population

All patients underwent conventional X-ray imaging to assess bony lesions, determine the degree of slippage, and identify the affected vertebral level. Results showed that grade I spondylolisthesis was predominant, accounting for 93.9% of cases, consistent with findings by Nguyen Khac Linh (97.1%) [9] and similar to Nguyen Vu (72.3%) [3]. The most commonly affected level was L4-L5 (63.2%), which aligns with domestic studies, as the L4–L5 segment bears significant axial load and is prone to early degeneration [5] [9]. On MRI, disc herniation was observed in 85.7% of patients, and foraminal stenosis in 38.8%. Disc degeneration at the slipped level was predominantly grade 4 (71.4%), which was lower than in Nguyen Vu's study.

4.3. Clinical characteristics before and after surgery, and postoperative recovery outcomes

Before surgery, most patients presented with significant pain and marked functional impairment. The average VAS scores were 6.49 for back pain and 6.22 for leg pain, similar to findings reported by Hoang Gia Du and Nguyen Khac Linh [5], [9]. Radicular pain was present in 93.9% of patients, predominantly bilateral (77.6%), higher than in studies by [3] Notably, 100% of patients experienced neurogenic claudication, with symptoms triggered after walking more than 500 meters in 63.3% of cases, indicating prolonged disease progression with serious impact on daily activities. The mean preoperative ODI score was 51.7%, with most patients (51.3%) in grade III, consistent with Nguyen Vu and Hoang Gia Du [5], [3], reflecting substantial disability and limited work capacity.

Physical examination revealed severe symptoms, including a positive Lasègue sign in 91.8%, paraspinal muscle spasm in 83.7%, sensory disturbances in 95.9% (mostly paresthesia at 79.6%), motor deficits in 20.4%, and muscle atrophy in 8.2%, all indicating prolonged nerve compression and spinal instability [5], [9], [6], [3]. Postoperative outcomes showed marked improvement at each follow-up. At discharge, back and leg VAS scores decreased to 4.55 and 3.38, respectively, and positive Lasègue sign reduced to 85.7%, though still present due to postoperative pain and muscle stiffness. After one month, improvement continued: VAS scores fell to 3.73 (back) and 2.55 (leg); Lasègue sign to 81.6%; no cases remained with muscle strength of 3/5, and muscle atrophy halved to 4.1%.

By six months, outcomes were highly favorable: VAS scores decreased further to 2.84 (back) and 1.78 (leg). The rate of positive Lasègue sign dropped to 26.5%, no patients showed muscle atrophy, and 5/5 muscle strength was restored in nearly 88% of cases, demonstrating not only pain relief but also functional and neurological recovery. Bridwell fusion grade I–II was achieved in 89.8%, consistent with findings by Nguyen Vu and Do Manh Hung [10], [3].

These results suggest that patients with lumbar spondylolisthesis often present late with severe symptoms and disability, but experience progressive and substantial improvement after PLIF surgery—most notably at 6 months—supporting its long-term effectiveness in pain relief, neurological recovery, solid fusion, and functional restoration.

V. CONCLUSION

Lumbar spondylolisthesis commonly occurs in middle-aged individuals, with a higher prevalence in females, and is primarily caused by degenerative changes. Preoperatively, most patients experienced significant pain and functional impairment affecting daily activities. PLIF surgery demonstrated marked improvement over time, effectively reducing pain, restoring neuromuscular function, and achieving a high rate of spinal fusion. After 6 months, the majority of patients achieved good to excellent outcomes, reinforcing the role of surgical intervention in cases where conservative treatment fails.

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