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Correlation between grading of fat infiltration in multifidus muscle and degree of facet joint arthropathy in degenerative spondylolisthesis patients based on lumbosacral MRI: a cross-sectional study

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ABSTRACT

Background: Degenerative spondylolisthesis is a disorder caused by displacement of one vertebral body by one above or below it due to degenerative changes. Possible contributing causes of degenerative spondylolisthesis are facet joint osteoarthritis and inadequate muscle stabilization. The facet joint and multifidus muscle are innervated by the medial branch of the dorsal ramus of the segmental nerve. This study aims to investigate the relationship between grading of multifidus muscle fat infiltration and degree of facet joint arthropathy in patients with degenerative spondylolisthesis based on lumbosacral MRI.

Methods: This research employs a cross-sectional observational design, utilizing secondary data from the Picture Archiving and Communication System (PACS) and medical records. The aim is to investigate the relationship between the grading of multifidus muscle fat infiltration and the severity of facet joint arthropathy in patients with degenerative spondylolisthesis, based on non- weight-bearing lumbosacral MRI. The study includes all data stored in the PACS at our center from January 2022 until the required sample size was reached.

Results: This study analyzed 100 non-weight-bearing lumbosacral MRI samples of patients with degenerative spondylolisthesis. The distribution of samples based on lumbar multifidus muscle fat infiltration revealed that grade 2 had the highest prevalence at 33%. Similarly, the distribution based on facet joint arthropathy showed the highest occurrence at grade 2, or moderate, at 45%. Significant relationships were found between gender and age with lumbar multifidus muscle fat infiltration ($p<0.05$), and between gender and spinal level with facet joint arthropathy ($p<0.05$). Additionally, there is a strong positive correlation ($r=0.64$; $p<0.05$) between the grading of the multifidus muscle and the degree of facet joint arthropathy in these patients.

Conclusion: There is a strong positive and significant correlation between grading multifidus muscle and degree of facet joint arthropathy in patients with degenerative spondylolisthesis.

Keywords: Degenerative Spondylolisthesis, Multifidus Muscle Fat Infiltration, Facet Joint Arthropathy, Lumbosacral MRI.
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INTRODUCTION

Degenerative spondylolisthesis is a disorder caused by the displacement of one corpus vertebrae with one above or below it due to degenerative changes. On plain radiographs, spondylolisthesis is often found at CV L4 to CV L5 and there are also some at CV L5 to CV S1 and CV L3 to CV L4.[1] Degenerative changes in the intervertebral discs are a very important factor in assessing spinal function in old age.[2] The male to female ratio for degenerative spondylolisthesis is 1:5-6. Degenerative spondylolisthesis is rarely found in ages below 50 years. The displacement of the corpus vertebrae is limited to 30% of the width of the involved corpus vertebrae. The occurrence of degenerative spondylolisthesis is strongly associated with increasing age in both women and men. Pregnancy, generalized joint weakness and increased BMI also predispose to degenerative spondylolisthesis.[3]

In many cases, degenerative spondylolisthesis is associated with facet joint arthrosis and motion segment failure. Listhesis occurs as a result of facet joint subluxation, associated with significant and progressive loss of cartilage and articular remodeling.[4] Facet arthrosis or degenerative facet disease is the most frequent form of facet pathology. The disease mainly affects the elderly population, occurring in almost everyone after the age of 60 and in varying degrees

affecting most adults, suggesting that facet arthrosis has a large role in neck pain and back pain in the elderly population.[5]

The innervation of the lumbar facet joint originates from the medial branch of the lumbar dorsal ramus, or, as it is also known the posterior branch of the lumbar vertebral nerve. The vertebral nerve is divided into four different branches, after exiting the intervertebral foramen respectively; communicating branches, meningeal branches, ventral ramus, and to a lesser extent the dorsal ramus. At the L1-L4 level, the dorsal ramus separates at the spinal nerve which is usually at the right facet angle. The dorsal ramus then crosses the vertebral foramen, which then forms the dorsal and caudal pathways.[5,6] The dorsal ramus is the point encountered on the foramen formed by the superior border of the adjacent transverse processes and the inferior border of the lumbar facet joint at each level. The last aspect of the dorsal ramus is located at the medial intertransverse muscle. In addition, the middle branch also displays numerous anastomoses with other branches, thus forming a complex nerve plexus. The medial branch is there branched into three different branches; muscular, articular and cutaneous branches, innervating the lumbar facet joints, multifidus muscle and superior and intervertebral ligaments. Therefore, it becomes the basic theory that there is a relationship between the facet joint and the multifidus muscle.[6]

Based on those mentioned above, this study aims to investigate the relationship between the grading of multifidus muscle fat infiltration and the degree of facet joint arthropathy in patients with degenerative spondylolisthesis based on lumbosacral MRI.

METHODS

Study design and Patients Selection

This study employed a cross-sectional observational research design using consecutive sampling at our center from January 2022 until the required sample size was achieved. Secondary data was collected through the Picture Archiving and Communication System (PACS) and medical records to determine the correlation between the grading of multifidus muscle fat infiltration and the degree of facet joint arthropathy in patients with degenerative spondylolisthesis, based on non-weight-bearing lumbosacral MRI.

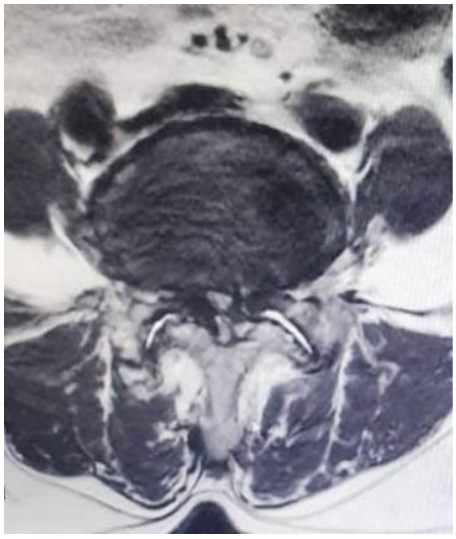

Figure 1. Evaluation of fat infiltration of multifidus muscle based on Goutallier classification and facet joint arthropathy based on Weishaupt classification.

Figure 2. Measurement of spinal canal ratio to determine degenerative spondylolisthesis.

Inclusion criteria are degenerative spondylolisthesis patients over 50 years old and with findings of degenerative spondylolisthesis from lumbosacral MRI. Exclusion criteria are patient with history of spinal trauma, spinal fracture, thoracolumbar/lumbar vertebral column scoliosis, pars interarticularis fracture, spinal tumor, congenital spinal defects, history of previous vertebral surgery, isthmic spondylolisthesis, and inadequate image quality on MRI.

Image assessment obtained from non-weight bearing MRI 3 Tesla T2WI lumbosacral vertebrae at the midline sagittal view and axial level of spondylolisthesis.

Grading of multifidus muscle fat infiltration

Grading of multifidus muscle fat infiltration are compositional changes from the degenerative process of the lumbar multifidus muscle from muscle composition to fat infiltration. Criteria of grading based on Goutallier classification are: (1) grade 0: no fat infiltration; (2) grade 1: fatty infiltration in the form of fine lines in the muscle; (3) grade 2: muscle composition is more than fat composition (fat infiltration less than 50%); (4) grade 3: muscle composition is equal to fat composition (fat infiltration +/- 50%); (5) grade 4: more fat composition than muscle composition (fat infiltration more than 50%) (Figure 1).

Degree of facet joint arthropathy

The features of osteoarthritis of the facet joint are characterized by irregularity of the facet joint surface, narrowing of the facet joint and or sclerotic subchondral and or subchondral cyst. Criteria of grading are: (1) grade 1 or normal: no signs of degeneration (normal facet joint space (2-4 mm), no sclerosis and no osteophytes); (2) grade 2 or mild: joint space is narrowed and/or there are mild osteophytes; (3) grade 3 or moderate: subchondral sclerosis and/or moderate osteophytes; (4) grade 4 or severe: severe osteophytes and/or subchondral cyst (Figure 2).

Statistical analysis

Univariate analysis

Univariate analysis aims to explain or describe the characteristics of each variable studied. There are 7 variables in this study that have categorical data, namely variables of age, gender, body mass index, activity, spinal level, grading of multifidus muscle fat infiltration and degree of facet joint arthropathy. Univariate analysis will describe the number/value of the number and percentage of each group of variables

of gender, body mass index, activity, spinal level, degree of degenerative spondylolisthesis, degree of facet joint arthropathy and grading of fat infiltration of multifidus muscle.

Bivariate analysis

Bivariate analysis aims to determine the relationship between the two variables studied. Bivariate analysis in this study aims to analyze whether there is a relationship between age, gender, body mass index, history of physiotherapy activities, and spinal level with grading of multifidus muscle fat infiltration, and degree of facet joint arthropathy.

Categorical variables were analyzed using Chi-square test in normal distribution data, while Fisher exact test was used in non-normal data. To determine the relationship between grading of multifidus muscle fat infiltration and the degree of facet joint arthropathy in patients with degenerative spondylolisthesis, Spearman test was used. P values less than 0.05 were considered as statistically significant. This study using SPSS software version 26.0 for Windows.

RESULTS

A total of 100 patients were retrieved from medical records of our radiology department for non-weight bearing lumbosacral MRI examination in patients with degenerative spondylolisthesis from January 2022 to March 2024 who met the inclusion and exclusion criteria.

Table 1 presents the characteristics of the study patients. The data indicates that women comprised the majority with 63 samples (63%), while male accounted for 37 samples (37%). The age group with the highest representation was 56-65 years, with 49 samples (49%), and the least represented was those over 65 years, with 17 samples (17%). The most common BMI category was obesity, with 46 samples (46%), whereas the underweight category had the fewest, with 3 samples (3%). Regarding activity levels, patients with light activity were the most numerous at 54%, while those with heavy activity were the least at 9%. Concerning physiotherapy history, 69 patients (69%) had no history of physiotherapy, while 31 patients (31%) had such a history. For spinal levels, the L4-L5 level had the highest number of samples at 62 (62%), and the L3-L4 level had the fewest at 15 samples (15%).

Table 1. Patients' characteristics

Variables		N	%	Mean± SD
Gender	Male	37	37	
	Female	63	63	
Age (years)				59.4±6.8
	50-55 years	34	34	
	56-65 years	49	49	
	> 65 years	17	17	
BMI (kg/m^2)				24.2±2.8
	Underweight (< 18.5)	3	3	
	Normal (18.5 – 22.9)	24	24	
	Overweight (23 – 24.9)	27	27	
	Obese (> 25)	46	46	
	Light	54	54	
Activity	Moderate	37	37	
	Heavy	9	9	
Level of spinal	L3-L4	15	15	
spondylolisthesis	L4-L5	62	62	
	L5-S1	23	23	

Table 2. Distribution of study samples based on degenerative spondylolisthesis grading

Grading degenerative spondylolisthesis	N	%
Grade 1	98	98
Grade 2	2	2
Grade 3	0	0
Grade 4	0	0
Grade 5	0	0

Table 3. Distribution of study samples based on lumbar multifidus muscle fat infiltration

Grading lumbar multifidus muscle fat infiltration	Total (N=100)	Percentage (%)
Grade 1	25	25
Grade 2	33	33
Grade 3	25	25
Grade 4	17	17

Table 4. Distribution of study samples based on the degree of facet joint arthropathy

Grading facet joint osteoarthritis	Total (N=100)	Percentage (%)
Grade 1	6	6
Grade 2	45	45
Grade 3	30	30
Grade 4	19	19

Table 2 displays the frequency and percentage of samples according to the grading of degenerative spondylolisthesis. The data indicates that grade 1 is the most prevalent, with 98 samples (98%), while grade 2 is the least common, with only 2 samples (2%). This suggests that the majority of degenerative spondylolisthesis patients at our center had grade I. Notably, there were no patients with grade III-V degenerative spondylolisthesis.

Table 3 presents the frequency and percentage of samples based on the grading of lumbar multifidus muscle fat infiltration. The data reveals a relatively even distribution, with degree 2 having the highest occurrence at 33 samples (33%),

Table 5. Factors associated with grading of multifidus fat infiltration

Variables		Fat infiltration of the lumbar multifidus muscle				p
		Grade 1 (n=25)	Grade 2 (n=33)	Grade 3 (n=25)	Grade 4 (n=17)	
Gender	Male	20 (80.0)	9 (27.3)	6 (24.0)	2 (11.8)	<0.001*
	Female	5 (20.0)	24 (72,7)	19 (76.0)	15 (88.2)	
	50-55 years	10 (40.0)	16 (48,5)	4 (16.0)	4 (23.5)	
Age	56-65 years	11 (44.0)	14 (42,4)	14 (56.0)	10 (58.8)	0.035*
	> 65 years	4 (16.0)	3 (9.1)	7 (28.0)	3 (17.6)	
BMI	Underweight (< 18.5)	1 (4.0)	1 (3.0)	1 (4.0)	0 (0.0)	
	Normal (18.5 – 22.9)	7 (28.0)	10 (30.3)	4 (16.0)	3 (17.6)	0.994
	Overweight (23 – 24.9)	5 (20.0)	7 (21.2)	8 (32.0)	7 (41.2)	
	Obesity (> 25)	12 (48.0)	15 (45.5)	12 (48.0)	7 (41.2)	
	Light	19 (76.0)	17 (51.5)	13 (52.0)	5 (29.4)	0.074
Activity	Moderate	4 (16.0)	12 (36.4)	10 (40.0)	11 (64.7)	
	Heavy	2 (8.0)	4 (12.1)	2 (8.0)	1 (5.9)	
Level of spinal	L3-L4	3 (12.0)	7 (21.2)	4 (16.0)	1 (5.9)	0.098
	L4-L5	12 (48.0)	19 (57.6)	19 (76.0)	12 (70.6)	
	L5-S1	10 (40.0)	7 (21.2)	2 (8.0)	4 (23.5)	

*Statistically significant if p-value less than 0.05

Table 6. Factors associated with the degree of facet joint arthropathy

Variables		Facet joint arthropathy				P
		Grade 1 (n=25)	Grade 2 (n=33)	Grade 3 (n=25)	Grade 4 (n=17)	
Gender	Male	4 (66.7)	22 (48.2)	8 (26.7)	3 (15.8)	0.026*
	Female	2 (33.3)	23 (51.1)	22 (73.3)	16 (84.2)	
	50-55 years	3 (50.0)	13 (28.9)	11 (36.7)	7 (36.8)	0.568
Age	56-65 years	3 (50.0)	23 (51.1)	14 (46.7)	9 (47.4)	
	> 65 years	0 (0.0)	9 (20.0)	5 (16.7)	3 (15.8)	
BMI	Underweight (< 18.5)	0 (0.0)	2 (4.4)	1 (3.3)	0 (0.0)	0.751
	Normal (18.5 – 22.9)	3 (50.0)	13 (28.9)	6 (20.0)	2 (10.5)	
	Overweight (23 – 24.9)	0 (0.0)	10 (22.2)	9 (30.0)	8 (42.1)	
	Obesity (> 25)	3 (50.0)	20 (44.4)	14 (46.7)	9 (47.4)	
	Light	6 (100.0)	23 (51.1)	18 (60.0)	7 (36.8)	0.060
Activity	Moderate	0 (0.0)	15 (33.3)	11 (36.7)	11 (57.9)	
	Heavy	0 (0.0)	7 (15.6)	1 (3.3)	1 (5.3)	
Level of spinal	L3-L4	0 (0.0)	11 (24.4)	2 (6.7)	2 (10.5)	
	L4-L5	2 (33.3)	23 (24.4)	23 (76.7)	14 (73.3)	0.031*
	L5-S1	4 (66.7)	11 (24.4)	5 (16.7)	3 (15.6)	

*Statistically significant if p-value less than 0.05

Table 7. Relationship between grading of fat infiltration of multifidus muscle and degree of facet joint arthropathy in patients with degenerative spondylolisthesis

Variables		Grading Facet joint arthropathy				p
		Grade 1	Grade 2	Grade 3	Grade 4	
Grading lumbar multifidus muscle fat infiltration	Grade I	4 (66.7)	18 (40.0)	3 (10.0)	0 (0.0)	< 0.001*
	Grade II	2 (33.3)	18 (40.0)	12 (40.0)	1 (5.3)	
	Grade III	0 (0.0)	9 (20.0)	7 (23.3)	9 (47.4)	
	Grade IV	0 (0.0)	0 (0.0)	8 (26.7)	9 (47.4)	

*Statistically significant if p-value less than 0.05

while degree 4 has the lowest at 17 samples (17%).

Table 4 details the frequency and percentage of samples based on facet joint osteoarthritis. The data indicates that degree 2, or moderate osteoarthritis, is the most common with 45 samples (45%), while degree 1, or normal, is the least common with 6 samples (6%).

Table 5 illustrates the relationship between gender, age, BMI, physiotherapy history, and activity level with lumbar multifidus muscle fat infiltration. In terms of gender, grade I fat infiltration is more

common in men (20 samples, 80%), while grades II, III, and IV are more prevalent in women with 24 samples (72.7%), 19 samples (76%), and 15 samples (88.2%), respectively. Statistical test results show a significant relationship between gender and lumbar multifidus muscle fat infiltration ($p < 0.001$).

In terms of age, grade I lumbar multifidus muscle fat infiltration is most common in the 56- 65 age group, with 11 samples (44%). Grade II is more frequent in the 46-55 age group, with 16 samples (48.5%). Grade III is also most common in the 56-65 age group, with 14 samples (56%). Similarly, grade IV is most prevalent in the 56-65 age group, with 10 samples (58.8%). Statistical test results show a significant relationship between age and lumbar multifidus muscle fat infiltration ($p = 0.035$).

For BMI, grade I lumbar multifidus muscle fat infiltration is most common among obese individuals, with 12 samples (48%). Grade II is also more prevalent in obesity, with 15 samples (45.5%). Grade III is most frequent among the obese, with 12 samples (48%). Grade IV is equally common in both obese and overweight individuals, with 7 samples (41.2%) each. Statistical test results indicate no significant relationship between BMI and lumbar multifidus muscle fat infiltration ($p = 0.994$).

In terms of activity, Grade I lumbar multifidus muscle fat infiltration was predominantly found in light activity, with 19 samples accounting for 76%. Grade II infiltration was also more common in light activity, with 17 samples making up 51.5%. Similarly, Grade III infiltration was more prevalent in light activity, with 13 samples representing 52%, and Grade IV infiltration was most frequent in activity, with 11 samples comprising 64.7%. The statistical test results showed a p-value of 0.074 ($p>0.05$), indicating that there is no significant relationship between activity level and lumbar multifidus muscle fat infiltration.

Regarding the spinal level history, Grade I lumbar multifidus muscle fat infiltration is most common at the L4-L5 level, with 12 samples (48%). Grade II infiltration is also more frequent at L4-L5, with 19 samples (57.6%). Similarly, Grade III infiltration is predominantly found at L4-L5, with 19 samples (76%), and Grade IV infiltration is more common at L4-L5, with 12 samples (70.6%). The statistical test results showed a p-value of 0.098 ($p>0.05$), indicating that there is no significant relationship between spinal level and lumbar multifidus muscle fat infiltration.

Table 6 outlines the factors associated with facet joint arthropathy. In terms of gender, degree I (normal) arthropathy was more common in males, with 4 samples (66.7%). Degree II (mild) was more frequent in females, with 23 samples (51.1%). Degree III (moderate) was also more prevalent in females, with 22 samples (73.3%), and degree IV (severe) was predominantly found in females, with 16 samples (84.2%). Statistical test results showed a p-value of 0.026 ($p < 0.05$), indicating a significant relationship between gender and changes in facet joint arthropathy.

Regarding age, degree I (normal) arthropathy was most common in the 46-55 and 56-65 age ranges, with 3 samples each (50%). Degree II (mild) was most prevalent in the 56-65 age range, with 23 samples (51.1%). Degree III (moderate) was also most common in the 56-65 age range, with 14 samples (46.7%), and degree IV (severe) was most prevalent in the 56-65 age range, with 9 samples (47.4%). The statistical test results showed a p-value of 0.568 ($p > 0.05$), indicating no significant relationship between age and facet joint osteoarthritis.

Based on BMI, degree I (normal) facet joint arthropathy is most prevalent in individuals with obesity and those with a normal BMI, each having 3 samples (50%). Degree II (mild) arthropathy is most common in obese individuals, with 20 samples (44.4%). Degree III (moderate) arthropathy is most frequent in overweight individuals, with 9 samples (30%), and degree IV (severe) arthropathy is most prevalent in obese individuals, with 9 samples (47.4%). Statistical test results showed a p-value of 0.751 ($p > 0.05$), indicating no significant relationship between BMI and facet joint osteoarthritis.

In terms of activity, degree I (normal) facet joint arthropathy is most common in individuals with a history of physiotherapy, with 4 samples (66.7%). Degree II (mild) arthropathy is most prevalent in those without a history of physiotherapy, with 35 samples (77.8%). Degree III (moderate) arthropathy is also most common in those without a history of physiotherapy, with 19 samples (63.3%), and degree IV (severe) arthropathy is most prevalent in individuals without a history of physiotherapy, with 13 samples (68.4%). The statistical test results showed a p-value of 0.060 ($p > 0.05$), indicating no significant relationship between activity and facet joint osteoarthritis.

At the spinal level, degree I (normal) facet joint arthropathy is most common at the L5-S1 level, with 4 samples (66.7%). Degree II (mild) arthropathy is most prevalent at the L4-L5 level, with 23 samples (51.1%). Degree III (moderate) arthropathy is also most common at the L4-L5 level, with 23 samples (76.7%), and degree IV (severe) arthropathy is most prevalent at the L4-L5 level, with 14 samples (73.7%). Statistical test results showed a p-value of 0.031 ($p < 0.05$), indicating a significant relationship between spinal level and facet joint arthropathy.

Table 7 illustrates the relationship between the grading of fatty infiltration in the musculus multifidus and the degree of facet joint arthropathy in patients with degenerative spondylolisthesis. Using Chi-Square or Fisher Exact test analysis, it was determined that there is an association between the grading of fatty infiltration in the musculus multifidus and the degree of facet joint arthropathy in these patients. Further analysis with the Spearman test revealed a strong positive correlation between the grading of fatty infiltration and the degree of facet joint arthropathy, with a p-value of less than 0.001 ($p < 0.05$) and a correlation coefficient (r) of 0.641.

DISCUSSION

In this study, 100 patients with degenerative spondylolisthesis who underwent lumbosacral magnetic resonance imaging examinations were analyzed. The sample included 63 women (63%) and 37 men (37%), reflecting the higher prevalence of degenerative spondylolisthesis in women with a gender ratio of 6.4:1.[7,8] In terms of age distribution, the highest percentage was in the 56-65 years age

group, comprising 49 samples (49%), while the fewest were aged over 65 years, with 17 samples (17%). Another study similarly reported the largest group in the 60-69 years age range, accounting for 59% of their 22 samples.[9] Regarding BMI, the majority were classified as obese, with 46 samples (46%), while the fewest were underweight, with 3 samples (3%). Jacobsen et al., also found a BMI above 24.4, categorizing as obese, in patients with degenerative spondylolisthesis.[10] In terms of activity level, the highest percentage of patients engaged in light activities, with 54 samples (54%), and the lowest in heavy activities, with 9 samples (9%). Research by Ishimoto et al., identified drivers and farmers/fishermen, who often perform heavy activities, as the most affected occupations.[11] Additionally, narrative research by Akkawi et al., indicated that L4/L5 is the most common spinal level for spondylolisthesis, which was consistent with the findings of this study.[12]

This study presents the percentage of samples based on the grading of degenerative spondylolisthesis. The results indicate that grade 1 has the highest occurrence, with 98 samples (98%), while grade 2 is the least common, with only 2 samples (2%). Narrative research by Akkawi et al.,[12] supports these findings, showing that vertebral slip in degenerative spondylolisthesis rarely exceeds 30% and is most frequently found in grade I, with grade II being quite uncommon.

In this study, the distribution of samples based on lumbar multifidus muscle fat infiltration showed that grade 2 had the highest number of samples, with 33 samples (33%), while grade 4 had the fewest, with 17 samples (17%). Contrastingly, research by Wahyudhy et al., found that grade III was present in 11 out of 20 samples.[9] Additionally, Faur et al., reported that the gender distribution in multifidus fat infiltration indicated a higher percentage of women in the group with mild fat infiltration, equivalent to grade II Goutallier.[13]

This study found that the highest percentage of samples based on facet joint arthropathy was in degree 2 (moderate), with 45 samples (45%), while the lowest was degree 1 (normal), with 6 samples (6%). In contrast, Wahyudhy et al., reported that degree 4 was the most common, with 15 out of 20 samples.[9] However, Chou et al., found that degree 2 was the most prevalent, with 196 out of 440 samples.[14]

This study concludes that there is a significant relationship between gender and age with lumbar multifidus muscle fat infiltration. Faur et al., observed that women had a higher percentage of mild fat infiltration in the multifidus muscle, corresponding to grade II Goutallier.[13] There are gender-specific differences in muscle fatty infiltration: in women, paraspinal muscle degeneration, characterized by greater intramuscular fat infiltration, tends to begin in the fourth decade of life, while in men, it begins in the fifth decade. This suggests an earlier onset of muscle fat infiltration in women and a sex-dependent decline in muscle quality with age. Additionally, general fat distribution varies significantly between sexes and by age, with women having higher abdominal subcutaneous adipose tissue and men having higher visceral adipose tissue.[15,16]

Oxidative stress in the degeneration process causes muscle atrophy. This is proven by a study in their research stating that the multifidus muscle experiences changes related to age, such as a decrease in size and an increase in fatty infiltration. Fat infiltration of the multifidus muscle occurs when a certain amount of fatty tissue replaces the normal architecture of the muscle and

accumulates between the multifidus muscle and the vertebral endplate.[13] In research by Chou et al., also mentioned that the risk of multifidus muscle fat atrophy increases with age.[14]

This study found a significant correlation between gender and spinal level in relation to facet joint arthropathy. Tiwari et al., reported that facet joint osteoarthritis is more prevalent in women (80%) compared to men (68.8%).[17] Kalichman et al., observed that 66.7% of women and 59.6% of men suffer from this condition.[18] Another study by Ko et al., also identified a gender- related difference in facet joint osteoarthritis.[19] Dzefi-Tettey et al., strengthen these findings, showing that lumbar facet joint arthrosis is more frequent in women than in men.[20] The hormonal changes during menopause, such as reduced estrogen levels, contribute to cartilage loss and a higher risk of arthritis, including lumbar facet joint arthrosis.

The study by Fujiwara et al., supports the idea that gender differences affect the occurrence of facet joint arthrosis, indicating that women are more susceptible to the condition.[21] This research involved a cadaveric analysis comparing lumbar spine motion segments between men and women with similar clinical profiles. The findings revealed that women's motion segments displayed greater movement during lateral bending, flexion, and extension. Increased motion of spinal segments has been linked to excessive wear, potentially leading to a higher incidence of facet joint arthrosis.[22] Similarly, Chua et al., identified female gender as an independent risk factor for facet arthropathy, noting a significant rise in the prevalence of facet joint osteoarthritis in women, particularly around menopause.[23] Estrogen deficiency was found to accelerate facet degeneration and multifidus muscle atrophy in women with lumbar spinal stenosis, contributing to clinical progression.

Kalichman et al., also observed that the prevalence of lumbar facet joint osteoarthritis increases with age, with the highest occurrence at the L4-L5 level.[18] The first discovery of vertebral synovial or subchondral cysts was made by Von Gruker in 1880 during a postmortem examination. These cysts are most frequently found at the L4-L5 facet joint (65%), but also appear at the L5-S1 (31%) and L3-L4 (4%) levels.[21,24] A study also revealed a significant relationship between spinal level and the degree of facet joint arthropathy.[25] Fujiwara et al., further supported this by finding that the median level of facet joint arthropathy at L4-L5 was significantly higher than at L3-L4 ($p<0.05$), while no significant differences were found between L3-L4 and L5-S1 or between L4- L5 and L5-S1.[21] Several publications indicate that degenerative spondylolisthesis, typically associated with facet joint arthropathy, predominantly occurs at the L4-L5 level and, to a lesser extent, at the L5-S1 level.[21,26]

In this study, a strong positive

correlation ($p<0.05$, $r=0.641$) was found between multifidus muscle grading and the degree of facet joint arthropathy in patients with degenerative spondylolisthesis. This correlation is attributed to the similar innervation of the lumbar facet joint and the multifidus muscle, both of which are innervated by the medial branch of the lumbar vertebral dorsal ramus.[6] Chua et al., also demonstrated a strong relationship between facet overhang and the deep part of the multifidus muscle.[23] Their study indicated that higher degrees of facet joint osteoarthritis were associated with greater multifidus muscle fat atrophy, particularly at the L4-5 level. This finding is expected to enhance the understanding of the pathophysiology and epidemiology of lumbar spine degeneration. Further, Cui et al., also showed that multifidus fat infiltration grading is strongly associated with facet joint osteoarthritis in the lower lumbar spine, regardless of age and gender. While the multifidus cross-sectional area is not independently linked to facet joint osteoarthritis, it has limited value as an indicator of low back pain or spinal pathology. The current findings suggest that facet joint osteoarthritis should be viewed as a failure of the entire joint structure, including adjacent ligaments and muscles, rather than merely as a failure of the facet joint cartilage. Additionally, the study reported that bilateral multifidus muscle size asymmetry is independently associated with facet joint osteoarthritis, specifically at the L5-S1 level.[26]

Limitation of the study, including the following: this study utilized non-weight-bearing MRI, which may introduce bias in measuring the degree of vertebral slip, potentially leading to errors in grading spondylolisthesis; it employed a qualitative approach to determine multifidus muscle grading, resulting in a high potential for bias; and it used a retrospective design, which is prone to selective bias. Therefore, further research is recommended using weight-bearing MRI to minimize bias in measuring vertebral slip in spondylolisthesis. Future studies should adopt a prospective design to avoid selective bias. Additionally, quantitative measurement of multifidus muscle fat infiltration is suggested to achieve more accurate grading. Future research could also incorporate control variables or focus on non-degenerative spondylolisthesis to identify factors associated with degenerative spondylolisthesis, which can be analyzed using the multivariate logistic regression method.

CONCLUSION

In conclusion, the majority of patients with degenerative spondylolisthesis in our study are obese women aged 56-65 years who engage in light activity, with most cases involving degeneration at the L4-L5 level. Most patients exhibited grade I degenerative spondylolisthesis, with no cases of grade III-V observed. The grading distribution of multifidus muscle fat infiltration in these patients is evenly spread across grades I-IV, while the highest percentage of facet joint arthropathy is at grade 2 (45%). Factors associated with lumbar multifidus muscle fat infiltration include gender and age, while those associated with facet joint arthropathy include gender and spinal level. There is a strong, positive, and significant correlation between the grading of multifidus muscle and the degree of facet joint arthropathy in patients with degenerative spondylolisthesis.

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CONFLICT OF INTEREST

The Authors declare that they have no conflict of interest.

ETHICS CONSIDERATION

This study research meets ethical requirements and received approval to be carried out from the Ethics Committee for Biomedical Health Research in humans, Faculty of Medicine, Hasanuddin University, Makassar. Number: 233/UN4.6.4.5.31/PP36/2024. Data collected are secondary data from the radiology system of Dr. Wahidin Sudirohusodo General Hospital.

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AUTHOR CONTRIBUTION

All authors contribute equally to this study from the conceptual framework, data acquisition, and data analysis until the study are interpreted through publication.

REFERENCES

1. Wang YXJ, Káplár Z, Deng M, Leung JCS. Lumbar degenerative spondylolisthesis epidemiology: A systematic review with a focus on gender-specific and age-specific prevalence. J Orthop Translat. 2016;11:39-52. doi:10.1016/j.jot.2016.11.001.
2. Barreras MT. Disc Degeneration and Facet Joint Arthritis. In: Spinal Degeneration Process and Aging. AOSpine International: Switzerland, 2006:1-12.
3. Lee ET, Lee SA, Soh Y, Yoo MC, Lee JH, Chon J. Association of Lumbar Paraspinal Muscle Morphometry with Degenerative Spondylolisthesis. Int J Environ Res Public Health. 2021;18(8):4037. doi:10.3390/ijerph18084037.
4. Gellhorn AC, Katz JN, Suri P. Osteoarthritis of the spine: the facet joints. Nat Rev Rheumatol. 2013;9(4):216-224. doi:10.1038/nrrheum.2012.199.
5. Perolat R, Kastler A, Nicot B, Pellat JM, Tahon F, Attye A, et al. Facet joint syndrome: from diagnosis to interventional management. Insights Imaging. 2018;9(5):773-89. doi:10.1007/s13244-018-0638-x.
6. Kapetanakis S, Gkantsinikoudis N. Anatomy of lumbar facet joint: a comprehensive review. Folia Morphol (Warsz). 2021;80(4):799-805. doi:10.5603/FM.a2020.0122.
7. Wang X, Jia R, Li J, Zhu Y, Liu H, Wang W, et al. Research Progress on the Mechanism of Lumbarmultifidus Injury and Degeneration. Oxid Med Cell Longev. 2021;2021:6629037. doi:10.1155/2021/6629037.
8. Bydon M, Alvi MA, Goyal A. Degenerative Lumbar Spondylolisthesis: Definition, Natural History, Conservative Management, and Surgical Treatment. Neurosurg Clin N Am. 2019;30(3):299-304. doi:10.1016/j.nec.2019.02.003.
9. Utama HW, Rahardjo P, Setiawati R. Degenerative Spondylolisthesis Factors at Level L4–5: MR Imaging Findings. IJRP. 2022;105(1):644-653. doi:10.47119/IJRP1001051720223627.
10. Jacobsen S, Sonne-Holm S, Rovsing H, Monrad H, Gebuhr P. Degenerative lumbar spondylolisthesis: an epidemiological perspective: the Copenhagen Osteoarthritis Study. Spine (Phila Pa 1976). 2007;32(1):120-125. doi:10.1097/01.brs.0000250979.12398.96.
11. Ishimoto Y, Cooper C, Ntani G, et al. Is radiographic lumbar spondylolisthesis associated with occupational exposures? Findings from a nested case control study within

the Wakayama spine study. BMC Musculoskelet Disord. 2019;20(1):618.. doi:10.1186/s12891-019-2994-1.
12. Akkawi I, Zmerly H. Degenerative Spondylolisthesis: A Narrative Review. Acta Biomed. 2022;92(6):e2021313. doi:10.23750/abm.v92i6.10526.
13. Faur C, Patrascu JM, Haragus H, Anglitoiu B. Correlation between multifidus fatty atrophy and lumbar disc degeneration in low back pain. BMC Musculoskelet Disord. 2019;20(1):414. doi:10.1186/s12891-019-2786-7.
14. Chou PH, Lin HH, Yao YC, Wang ST, Chang MC, Liu CL. Preoperative facet joint arthropathy does not impact long-term clinical outcomes after lumbar-stability-preserving decompression and dynesys fixation. Sci Rep. 2021;11(1):11299. doi:10.1038/s41598-021-90967-0.
15. Yang Q, Yan D, Wang L, Li K, Liang W, Zhang W, et al. Muscle fat infiltration but not muscle cross-sectional area is independently associated with bone mineral density at the lumbar spine. Br J Radiol. 2022;95(1134):20210371. doi:10.1259/bjr.20210371.
16. Zeng P, Wu S, Han Y, et al. Differences in body composition and physical functions associated with sarcopenia in Chinese elderly: reference values and prevalence. Arch Gerontol Geriatr. 2015;60(1):118-123. doi:10.1016/j.archger.2014.08.010.
17. Tiwari P, Kaur H, Kaur H, Jha V, Singh N, Ashraf A. Prevalence of facet joint arthritis and its association with spinal pain in mountain population - A cross-sectional study. J Craniovertebr Junction Spine. 2020;11(1):36-45. doi:10.4103/jcvjs.JCVJS_121_19.
18. Kalichman L, Kim DH, Li L, Guermazi A, Hunter DJ. Computed tomography-evaluated features of spinal degeneration: prevalence, intercorrelation, and association with self-reported low back pain. Spine J. 2010;10(3):200-208. doi:10.1016/j.spinee.2009.10.018.
19. Ko S, Vaccaro AR, Lee S, Lee J, Chang H. The prevalence of lumbar spine facet joint osteoarthritis and its association with low back pain in selected Korean populations. Clin Orthop Surg. 2014;6(4):385-391. doi:10.4055/cios.2014.6.4.385.
20. Dzefi-Tettey K, Edzie EKM, Mensah SK, et al. Lumbar facet joint arthrosis on magnetic resonance imaging and its association with low back pain in a selected Ghanaian population. J Neurosci Rural Pract. 2023;14(4):681-685. doi:10.25259/JNRP_94_2023.
21. Fujiwara A, Lim TH, An HS, Tanaka N, Jeon CH, Andersson GB, et al. The effect of disc degeneration and facet joint osteoarthritis on the segmental flexibility of the lumbar spine. Spine (Phila Pa 1976). 2000;25(23):3036-3044. doi:10.1097/00007632-200012010-00011.
22. Frost BA, Camarero-Espinosa S, Foster EJ. Materials for the Spine: Anatomy, Problems, and Solutions. Materials (Basel). 2019;12(2):253. doi:10.3390/ma12020253
23. Chua M, Salame K, Khashan M, Ofir D, Hochberg U, Ankory R, et al. Facet overhang: A novel parameter in the pathophysiology of multifidus muscle atrophy. Clin Anat. 2022;35(8):1123-1129. doi:10.1002/ca.23923.
24. Pendleton B, Carl B, Pollay M. Spinal extradural benign synovial or ganglion cyst: case report and review of the literature. Neurosurgery. 1983;13(3):322-6. doi:10.1227/00006123-198309000-00021.
25. Anastasia A, Sukmaningtyas H, Priambodo A, Setiawati E. Analysis of risk factors affecting lumbal facet joint osteoarthritis in MRI scan. DMJ. 2022;11(1):19–23. doi:10.14710/dmj.v11i1.32588.
26. Cui J, Zhou R, Tian N, Sui X, Huang M, Hao D et al. Correlation between lower lumbar multifidus muscles fatty atrophy and corresponding level degenerative diseases in patients with low back pain using MRI. Chin J Acad Radiol 2021;4:63–70. doi: 10.1007/s42058-021-00054-6.