International Medicine

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Original Article

Analysis of paraspinal muscle group density value changes on CT in patients with lumbar spondylolisthesis

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Received: 28 March 2021 / Accepted: 1 June 2021

Abstract

Background: The aim of this study is to evaluate the density changes and cross-sectional area (CSA) changes in the bilateral psoas muscles at the L3 level in cases with lumbar degenerative spondylolisthesis and to compare their relationship with the spondylolisthesis degree.

Methods: A total of 300 patients,150 patients in the control group and 150 patients with degenerative lumbar spondylolisthesis detected in computed tomography (CT) was included in the study. The patients' ages, gender, spondylolisthesis levels, spondylolisthesis degrees, right and left CSA of the psoas muscle at the L3 level, and right and left density region of interest (ROI) values of the psoas muscle were measured in terms of Hounsfield Unite (HU) and evaluated. Spondylolisthesis levels and degrees of the patients, psoas muscle bilateral CSA at the L3 level, bilateral psoas densities (HU) at the L3 level were measured on CT images and compared with the control group.

Results: The average age of the cases in the spondylolisthesis patient group was 55.11±10.90 years, and the average age of the participants in the control group was 54.67±11.00. The means of right psoas CSA, right psoas density, left psoas CSA, and left psoas density of cases in the patient group with spondylolisthesis were significantly lower than the averages of the control group participants ($p<0.05$). According to the Binary Logistic Regression Analysis, it was found that the increase in the right psoas density values significantly decreased the risk of the listhesis grade level being at the pathological level (OR=0.87; p=0.022).

Conclusions: In our study, it was found that the psoas muscle CSA and psoas muscle density measured at the L3 level in spondylolisthesis patients decreased significantly compared to the psoas muscle CSA and psoas muscle density of the control group participants. However, it was revealed that the degree of spondylolisthesis did not make a statistically significant difference in the CSA and density of the psoas muscle.

Keywords: degenerative; density; lumbar; psoas; spondylolisthesis

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DOI: 10.5455/im.77421

1. Introduction

Degenerative lumbar spondylolisthesis, an anterior displacement of a vertebra above the lower vertebra, is a common cause of low back pain [1]. Its incidence rate was 4.1% in the cadaver study and 28.6% in the clinical cohort study [2,3]. It is usually seen in those over the age of 50 and most often at the L4/L5 level. It is more common in women [4]. The muscles around the spine play an important role in the stabilization of the spine. Atrophy of these muscles can lead to the development of disc and facet joint diseases. A lateral radiograph is recommended to detect degenerative spondylolisthesis (DS). If symptoms of radiculopathy are present, magnetic resonance imaging (MRI) should be considered to confirm the diagnosis of DS [1]. In lumbar spondylolisthesis, effects on spondylolisthesis and lumbar disc herniation have been evaluated by measuring the cross-sectional areas (CSA) of the lumbar paraspinal muscles, which are especially necessary for spine stabilization and movement [5,6]. Measuring density and cross-sectional area in computed tomography (CT) has been shown to be a good indicator in the evaluation of muscle atrophy [7].

The most widely used classification for DS is the Meyerding grading system. It categorizes the severity of the spondylolisthesis according to the ratio of the listhetic part of the upper vertebral body to the anteroposterior length of the adjacent lower vertebral body. Subluxation of the superior corpus is graded as Stage 1 if it is up to half the width of a vertebra corpus, Stage 2 if up to three quarters, Stage 3 and Stage 4 if it is the width of the entire vertebra on lateral radiographs [8]. The majority of patients (75%) of degree is 1 [9].

The aim of this study is to evaluate the density changes and cross-sectional area changes in the bilateral psoas muscles at the L3 level in cases of lumbar degenerative spondylolisthesis and compare their relationship with the spondylolisthesis degree. These measurements will guide us in determining whether conservative or surgical treatment modalities should be used in DS patients.

2. Methods

A total of 300 patients—150 patients in the control group and 150 patients with degenerative lumbar spondylolisthesis detected in CT at the Radiology Clinic of Adana City Training and Research Hospital, Health and Sciences University between 01/01/2018 and 25/12/2020—was included in the study. The complaint of all patients was lower back pain. Cases of previous spinal surgery, spinal stenosis, lumbar disc herniation, spinal mass, vertebral fracture, scoliosis, and contrast-enhanced lumbar CTs were not included in the study. The control group patients were determined in correlation with the age and gender of the patients in the patient group. The patients' ages, gender, spondylolisthesis levels, spondylolisthesis degrees, right and left cross-sectional areas of the psoas muscle at the L3 level, and right and left density region of interest (ROI) values of the psoas muscle were measured in terms of Hounsfield Unite (HU), and whether they were statistically significant within the control group was calculated. Fifty-two (34.7%) of the patients were male and 98 (65.3%) were female. The mean age of the patient group was 55.11 ± 10.90, and the age range was 31–77. The mean age of the control group was 54.67 ± 11.00 and the age range was 30–78 years. Spondylolisthesis levels and degrees of the patients, psoas muscle bilateral cross-sectional areas (mm^2) at the L3 level, and bilateral psoas densities (HU) at the L3 level were evaluated using CT images and were then compared with the control group. This study was approved by the ethics committee of our university hospital.

2.1. Imaging parameters

All CT studies were performed on a Philips Ingenuity CT (Philips Medical systems 595 Miner Road Cleveland, OH, USA) machine using an axial slice thickness of 3 mm, 325 mA, and kVp of 140. Coronal and sagittal reformations were obtained at 3-mm slice thickness.

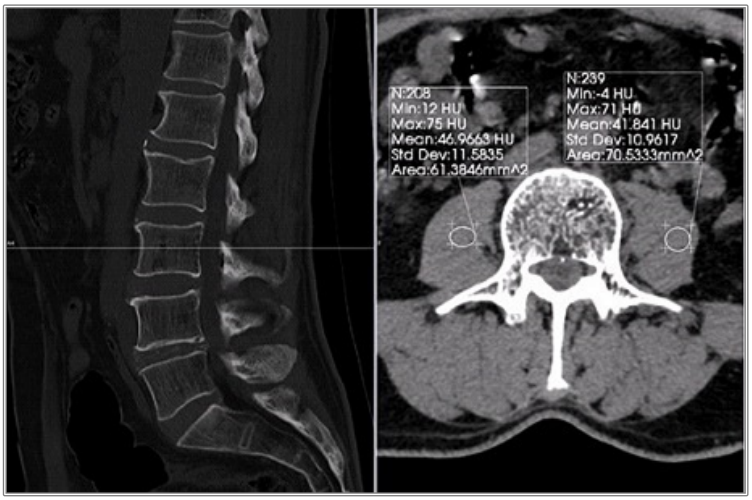

Figure 1. Demonstration of the measurement of the bilateral psoas muscle density at the L3 level.

2.2. Image analysis

The lumbar CT images were evaluated by an experienced neuroradiologist who was blind to the symptoms using a digital workstation. The measurements were done by one radiologist who repeated the measurements three times on different days to diminish bias. First, the largest possible ROI was placed in the muscle belly of each muscle, making sure the ROI was at least 10 mm^2, and that the standard deviation (SD) of the measurement was less than 20 HU [Figure 1]. The CSA of psoas muscles [Figure 2] was traced using the manual cursor technique. The CSA of bilateral psoas muscles was measured on both sides of the spine at level L3. Spondylolisthesis level and degree were determined by measuring from sagittal sections of non-contrast lumbar CTs.

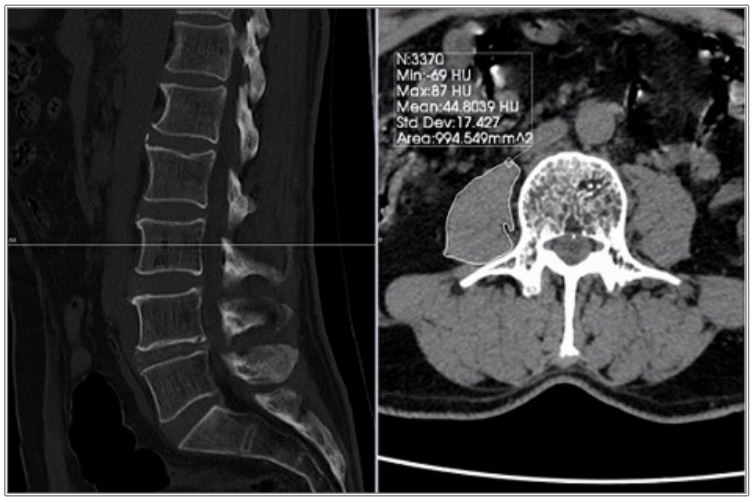

Figure 2. Demonstration of the measurement of the CSA of the psoas muscle at the L3 level.

2.3. Statistical analysis

In the study, the means of age and psoas values between the patients with spondylolisthesis and patients in the control group were compared using an independent groups t-test. In addition, psoas cross-sectional areas and psoas density values between men and women in the control group were compared using a Mann–Whitney U test. Relationships between age and psoas cross-sectional areas and psoas density values were analyzed using Pearson correlation analysis. Binary logistic regression analysis was used to investigate whether psoas cross-sectional areas and psoas density values increase the risk of listhesis grade pathology. The normal distribution compliance of the data was checked with kurtosis and skewness values (± 1.5). The significance level was set as $p<0.05$ for all analyses. IBM SPSS 22.0 was used in the application of the analysis.

3. Results

The average age of patients in the spondylolisthesis patient group evaluated in the study was 55.11 ± 10.90 years, and the average age of the participants in the control group was 54.67 ± 11.00. According to the independent groups t-test, the mean age of the spondylolisthesis patient group and the control group were statistically similar ($p = 0.804$). Ninety-eight (65.3%) of the cases in the spondylolisthesis patient group and 98 (65.3%) of the control participants were women, and the gender ratios were the same between the two groups [Table 1].

Table 1. Comparison of age and gender characteristics between patient and control groups

		Patient group		Control group		p
		Mean ± SD / n	Min-Max / %	Mean ± SD / n	Min-Max / %	
Age		55.11±10.90	31.00-77.00	54.67±11.00	30.00-78.00	0.804[a]
Gender	**Male**	26	34.7	26	34.7	1.000[b]
	Female	49	65.3	49	65.3	

[a]Independent groups t-test; [b]Pearson chi-square analysis.

According to the independent groups t-test, the mean values of right psoas cross-sectional area (p = 0.001), right psoas density (p <0.001), left psoas cross-sectional area (p = 0.001), and left psoas density (p <0.001) in the control group of patients with spondylolisthesis were found to be statistically significantly lower than the other group's averages [Table 2].

Table 2. Comparison of psoas scores between patient and control groups

	Patient group		Control group		
	Mean	**SD**	**Mean**	**SD**	**p[a]**
Psoas CSA (Right)	645.17	246.83	785.83	270.14	0.001
Psoas density (Right)	39.41	8.58	47.43	6.05	<0.001
Psoas CSA (Left)	654.60	245.33	791.07	260.97	0.001
Psoas density (Left)	39.40	8.28	46.41	6.00	<0.001

[a]Independent groups t-test.

According to the Mann–Whitney U test, the averages of the right psoas cross-sectional area (p <0.001), right psoas density (p = 0.003), left psoas cross-sectional area (p <0.001), and left psoas density (p = 0,002) of men in the patient group with spondylolisthesis were statistically significantly higher than the averages of the women in the control group. Furthermore, the averages of the right psoas cross-sectional area (p = 0.003), right psoas density (p = 0.014), left psoas cross-sectional area (p = 0.002), and left psoas density (p = 0.009) of men in the patient group with spondylolisthesis were statistically significantly lower than the averages of the men in the control group. The averages of the right psoas cross-sectional area (p <0.001), left psoas cross-sectional area (p <0.001), and left psoas density (p = 0.022) of men in the control group were also significantly higher than the mean of women in the control group. According to the independent groups t-test, the means of right psoas cross-sectional area (p <0.001), right psoas density (p <0.001), left Psoas cross-sectional area (p <0.001), and left psoas density (p <0.001) of women in the control group were found be statistically significantly lower than the mean of women in the other group [Table 3].

Table 3. Comparison of psoas scores by gender

	Patient group				Control group							
	Male (I)		Female (II)		Male (III)		Female (IV)		p			
	Mean	**Med.**	**Mean**	**Med.**	**Mean**	**Med.**	**Mean**	**Med.**	**I-II[a]**	**I-III[a]**	**III-IV[a]**	**II-IV[b]**
Psoas CSA (Right)	916.35	902.50	501.29	494.00	1095.08	1086.50	621.73	620.00	<0.001	0.003	<0.001	<0.001
Psoas density (Right)	42.58	45.00	37.73	39.00	48.46	48.50	46.88	48.00	0.003	0.014	0.241	<0.001
Psoas CSA (Left)	935.54	945.50	505.53	505.00	1094.00	1074.00	630.33	613.00	<0.001	0.002	<0.001	<0.001
Psoas density (Left)	42.15	42.50	37.94	38.00	47.04	47.00	46.08	46.00	0.022	0.009	0.022	<0.001

[a]Mann–Whitney U test; [b]Independent groups t-test.

According to the Pearson correlation analysis, it was found that there was a statistically significant (p <0.05) negative correlation between age in the spondylolisthesis patient group and the right and left psoas cross-sectional values between -0.356 and -0.599. In addition, a statistically significant (p <0.05) negative correlation was found between the age of participants in the control group and the values of the right and left psoas cross-sectional area between -0.360 and -0.507 [Table 4].

The listhesis grade level of cases in the control group evaluated in the study was found to be pathological (1 and above) and the listhesis grade level of cases in the control group was found to be normal (0). Therefore, in the binary logistic regression analysis, which includes all cases in the patient group with spondylolisthesis and all cases in the control group, only the increase in the right psoas density values significantly reduced the risk of the listhesis grade level being at the pathological level (OR = 0.87, p = 0.022; CI = 0.78-0.98) were found [Model 1; Table 5]. In the spondylolisthesis patient group, it was found that 104 (69.3%) of the cases had listhesis Grade 1, 44 (29.3%) had listhesis Grade 2, and 2 (1.3%) cases had listhesis Grade 3. Therefore, the effectiveness of psoas scores in increasing the risk of

listhesis Grade 2 or above in 75 cases in Model 2 was investigated. In Model 2, it was found that psoas values were not statistically effective factors in increasing the grade of spondylolisthesis in patients (p <0.05) [Table 2].

Table 4. Relationships between age and psoas scores

		Patient group, age	Control group, age
Psoas CSA	**r**	-0.356	-0.369
	p	0.002	0.001
Psoas density	**r**	-0.599	-0.507
	p	<0.001	<0.001
Psoas CSA	**r**	-0.360	-0.360
	p	0.002	0.002
Psoas density	**r**	-0.475	-0.414
	p	<0.001	<0.001

Table 5. Effectiveness of psoas values in predicting listhesis grade cases

Model 1	**B**	**SE**	**Wald**	**df**	**p**	**Odds ratio**	**95% CI**	
							LL	**UL**
Psoas CSA (Right)	0.00	0.00	0.33	1	0.566	1.00	0.99	1.01
Psoas density (Right)	-0.14	0.06	5.24	1	0.022	0.87	0.78	0.98
Psoas CSA (Left)	0.00	0.00	0.14	1	0.712	1.00	0.99	1.01
Psoas density (Left)	-0.02	0.06	0.11	1	0.736	0.98	0.88	1.10
N=150, X2=42.43, p<0.001, Nagelkerke R2=0.33, Overall Percentage=67.3								
Model 2	**B**	**SE**	**Wald**	**df**	**p**	**Odds ratio**	**95% CI**	
							LL	**UL**
Psoas CSA (Right)	0.00	0.01	0.01	1	0.927	1.00	0.99	1.01
Psoas density (Right)	-0.07	0.07	1.02	1	0.312	0.93	0.81	1.07
Psoas CSA (Left)	0.00	0.01	0.11	1	0.746	1.00	0.98	1.01
Psoas density (Left)	0.02	0.06	0.10	1	0.754	1.02	0.88	1.17
N=75, X2=6.11, p=0.191, Nagelkerke R2=0.11, Overall Percentage=74.7								

4. Discussion

Various muscles, such as long and short paraspinal muscles, quadratus lumborum and psoas, play an important role in the movement and stabilization of the spine. Atrophy in these muscles plays a role in DS etiology. The psoas muscle is the most important of these muscles. Radiological methods used in evaluating the paraspinal muscles are MRI and CT. While the cross-sectional area of the paraspinal muscles is evaluated in MRI, the density of the muscles is measured for evaluation in CT [10,11].

Few studies in the literature have examined changes in lumbar paraspinal muscle cross-sectional areas. However, none of these studies have evaluated the listhesis degree in patients with degenerative spondylolisthesis by comparing the cross-sectional areas of the psoas muscle and the density of the psoas muscles together. Our study showed that psoas muscle density is higher in men than women and decreases with age. These results are consistent with a small number of publications describing gender differences in muscle density as assessed by CT and density changes with age [11,12]. In our study, we found that the averages of right psoas density and left psoas density in men and women in the spondylolisthesis patient group were statistically significantly lower than the averages of men and women in the control group.

Keller et al. found that the cross-sectional area of the paraspinal muscles in women is smaller than in men [13]. Mannion et al. found that the cross-sectional area decreases with age [14]. In our study, in accordance with the literature, we found that the means of right psoas cross-sectional area (p <0.001) and left psoas cross-sectional area (p <0.001) of men in the control group were statistically significantly higher than the mean of women in the control group according to the Mann–Whitney U test.

The lack of a study in the literature comparing listhesis degree with psoas muscle cross-sectional area and psoas muscle density in degenerative spondylolisthesis patients makes our study important. In our study, we found that the averages of the right psoas cross-sectional area, right psoas density, left psoas cross-sectional area, and left psoas density of the patients in the patient group with spondylolisthesis were statistically significantly lower (p <0.05) than the averages of the control group participants. According to the binary

logistic regression analysis, we found that the increase in the right psoas density values significantly reduced the risk of the listhesis grade level being at the pathological level (OR=0.87; p=0.022).

The limitations of our study were that the BMI indexes of the patients were not known, the measurement parameters that would evaluate lumbar stability other than the cross-sectional muscle areas of the patients were not evaluated, and the cross-sectional area comparison before and after the surgery was not performed.

Regarding clinical outcomes, more research is needed to define optimal radiological outcomes to be used in comparative studies. Radiological parameters may be the most important determinants when determining surgical or medical treatment modalities of patients. Therefore, it is necessary to define optimal values in order to determine the most appropriate treatment modality for the patient.

In our study, it was found that the psoas muscle cross-sectional area and psoas muscle density measured at the L3 level in spondylolisthesis patients decreased statistically significantly compared to the psoas muscle cross-sectional area and psoas muscle density of control group participants. However, it was revealed that the degree of spondylolisthesis did not make a statistically significant difference in the cross-sectional area and density of the psoas muscle. We think that evaluating the psoas muscle density and cross-sectional area with further studies can be used as a guiding parameter in the selection of conservative or surgical treatment modality in treatment planning in DS cases.

Conflict of interest

The authors declare no conflict of interest.

Funding

The authors declare no financial support.

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