Journal of Korean Society of
Spine Surgery

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J Korean Soc Spine Surg 2018 Jun;25(2):47-53.
Originally published online June 30, 2018;
https://doi.org/10.4184/jkss.2018.25.2.47

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pISSN 2093-4378 eISSN 2093-4386

Original Article J Korean Soc Spine Surg. 2018 Jun;25(2):47-53. https://doi.org/10.4184/jkss.2018.25.2.47

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Study Design: Retrospective evaluation.
Objectives: To determine the relationship between lumbar disc degeneration and back muscle degeneration.
Summary of Literature Review: In the degenerative cascade of the spine described by Kirkaldy-Willis, degeneration of the disc and of the facet joint co-occur with aging. However, the muscles of the back are not included in this model. Several studies have reported significant correlations between back muscle degeneration and facet joint arthritis. The purpose of our study was to evaluate relationships between lumbar disc degeneration and fatty degeneration of the back muscles.
Materials and Methods: In this study, 65 patients over the age of 50 years who had undergone lumbar spine MRI in our orthopaedic clinic were recruited. Fatty degeneration of the back muscles was qualitatively graded from I to III by the degree of the fat signal in the muscle layer, including both the multifidus and erector spinae. Lumbar disc degeneration was graded from I to V according to the Pfirrmann grade. Correlations between the back muscle degeneration grade and radiological parameters were analyzed.
Results: The degeneration grade of the multifidus correlated positively with age and the grade of disc degeneration. Correlations with other radiologic parameters were not significant. The degeneration grade of the erector spinae correlated positively with age. Other radiologic parameters were not significant.
Conclusions: There was a significant correlation between lumbar disc degeneration and multifidus degeneration. Erector spinae degeneration was correlated with age, but not with lumbar disc degeneration. The degenerative cascade of the spine was accompanied by fatty changes of the multifidus with aging.

Key words: Back muscle degeneration, Lumbar disc degeneration, MRI

Introduction

The degenerative cascade of the spine, first described by Kirkaldy-Willis has been accepted as a basic mechanism for spine degeneration.[1] However, muscles of the back are not included in this model. There are studies that reported significant correlation between paraspinal muscle degeneration and facet joint arthritis.[2] Sarcopenia is an age-associated loss of muscle mass and function. Sarcopenia of back muscles is related with reduced quality of life, increased disability and ultimately risk of mortality.[3] There was a report stating that fatty infiltration of multifidus was higher in women with lumbar spine pathology than healthy controls and rate of fatty infiltration increased with aging.[4] To the best of our knowledge there are a few of studies that have directly analyzed the relationship between degeneration of back muscle with lumbar disc pathology. The purpose of our study is to evaluate the relationship between lumbar disc degeneration and degeneration of back muscles.

Received: December 10, 2017
Revised: January 3, 2018
Accepted: April 2, 2018
Published Online: June 30, 2018
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Materials and Methods

This study received an exemption by the Institutional Review Board of Gwangmyeong Sungae Hospital(KIRB-2017-N-009). We consecutively recruited patients over the age above 50 years who had taken lumbar spine MRI from January to December 2017 at our orthopaedic clinic. A total of 120 patients were recruited at the beginning of the study. We reviewed their chart and their main symptom was back pain, buttock pain and leg pain. 55 patients were excluded and 65 patients were evaluated.

I. Inclusion criteria

The patients who visited our outpatient orthopaedic clinic with

A. Age above 50 years

B. No history of spine surgery

C. No recent History of trauma within 3 months

D. Patient with back pain with or without radiculopathy of lower extremities

were included. We excluded patients who had vertebral fracture with kyphotic deformity, isthmic spondylolisthesis, kyphotic deformity, and uncompensated coronal imbalance on lumbar spine. Exclusion criteria for deformity were sagittal imbalance which is the sagittal vertical axis greater than 5 cm anterior to the normal position of the C7 plumb. And exclusion criteria for coronal imbalance was defined as 2 cm lateral deviation of the C7 plumb from the central sacral line in the frontal plane.

II. Measures analyzed

Spino-pelvic parameters were measured on full spine radiographs in a standing position. The radiographs were measured using standard techniques recommended by the Scoliosis Research Society. Standard lateral radiographs obtained for sagittal balance are on a 3-foot long cassette. The patient stands upright with his or her arms positioned on a support in front of them with their head facing forward. The X-ray tube is positioned 72 inches from the patient.

The pelvic incidence, defined as the angle between the line perpendicular to the sacral plate at its midpoint and the line connecting this point to the axis of the femoral heads was measured in standing lateral radiograph.[5] The sacral slope and pelvic tilt was measured as usual manner.

Lumbar disc degeneration was measured based on a Magnetic Resonance Imaging grading System. Grading of disc degeneration of the 65 patients was performed by 2 spinal surgeons (observers) in a blinded fashion using the T2-weighted sagittal images. L4-5 lumbar levels were assessed on T2-weighted mid sagittal images.

This classification takes into account the nucleus signal intensity, the nucleus structure, the distinction between the nucleus pulposus and the annulus fibrosus, and the disc height from Grade I to V.[6]

The percentage of fat infiltrated area of multifidus and erector spinae was measured on T2-weighted mid axial image at L4-5 level using a pseudocoloring technique.[7] Then, back muscle degeneration was classified into three grades. In this qualitative method, paraspinal muscle was classified into 3 categories by the degree of fat signal in muscle layer

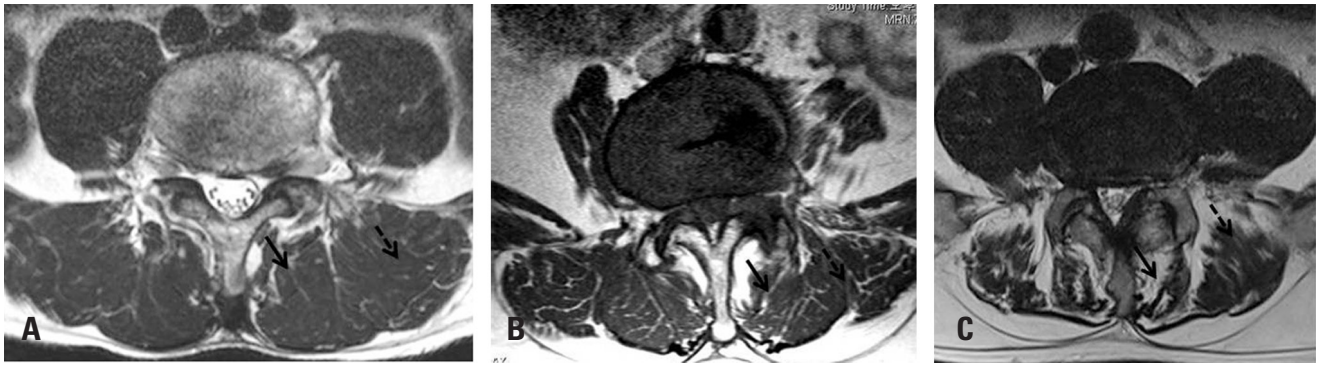

Fig. 1. Qualitative analysis of the fatty infiltration of lumbar back muscles. **(A)** Grade 1: mild (<10% fatty infiltration). **(B)** Grade 2: moderate (10-50% fatty infiltration). **(C)** Grade 3: severe (>50% fatty infiltration). Black arrow: multifidus, dotted arrow: erector spinae.

qualitatively including both multifidus and longissimus: grade 1 (mild) fatty infiltration (FI) below 10%, grade 2 (moderate) FI between 10% to 50%, and grade 3 (severe) FI above 50% (Fig. 1).[8] The grades of multifidus and erector spinae were measured separately.

Two independent observers classified each case twice within a 1-week interval to measure intra and inter-observer differences. Kappa statistics were used to evaluate inter- and intra-observer reliability.[9]

III. Statistical analysis

Correlations between back muscle degeneration grade and other parameters were analyzed using Pearson's correlation test. All statistical analyses were performed using the SPSS version 17.0.0 statistics package (SPSS, Inc., Chicago, IL). A p-value less than 0.05 was accepted as significant.

Results

Average age of all patients was 61.65(±7.01) years old (Table 1). The mean body mass index(BMI) of the subjects was 23.80 ±2.69 kg/m^2 (Table 1). Average pelvic tilt was 14.94(±11.31) degrees and average lumbar lordosis was 41.60(±12.24) degrees (Table 1). Average sacral slope was 35.51(±10.02) and average pelvic incidence was 48.80(±12.60) degrees (Table 1). Of 65 patients, 34 were male and 31 were female. Average percentage of fat infiltration of multifidus was 34.64(±12.55)%. And that of erector spinae was 25.58(±10.27)%.

In analysis of multifidus, 28 patients had fatty infiltration of grade 1, 30 patients grade 2 and 7 patients grade 3. Grade 2 degeneration was most frequent. Fatty degeneration of back muscle was correlated with age(p=0.044). BMI was not significantly correlated with back muscle degeneration. Lumbar lordosis, pelvic incidence, pelvic tilt and sacral slope was not correlated. Lumbar disc degeneration was significantly correlated with fatty degeneration of back muscle(p=0.020) (Table 2).

In analysis of erector spinae, 35 patients had grade 1 fatty infiltration, 27 patients grade 2 and 3 patients grade 3 (Table 3). Grade 1 degeneration was most frequent. Fatty degeneration of back muscle was correlated with age(p=0.034). BMI was not significantly correlated with back muscle degeneration. Lumbar lordosis, pelvic incidence, pelvic tilt and sacral slope showed no correlation. Lumbar disc degeneration was not significantly correlated with fatty degeneration of erector spinae muscle.

Results of reliability tests (kappa statistics) were as follows: the intra-observer reliability for lumbar disc degeneration

Table 1. Descriptive data of patients

Age (yr)	61.65±7.01
Weight (kg)	62.03±9.61
Height (cm)	161.12±6.93
BMI (kg/m^2)	23.80±2.69
Lumbar lordosis	41.60±12.24
Pelvic tilt	14.94±11.31
Sacral slope	35.51±10.02
Pelvic incidence	48.80±12.60
L2-3 degeneration	2.68±0.75
Multifidus FI (%)	34.64±12.55
Erector spinae FI (%)	25.58±10.27
Male/Female	34/31

BMI: body mass index, FI: fat infiltration.

Table 2. Correlation analysis between radiological factor and fat infiltration(FI) grade of multifidus

	Age	BMI	LL	PT	SS	PI	Disc deg
FI grade1	60.71±6.58	23.49±3.23	38.96±10.76	14.68±9.84	34.07±8.72	47.36±10.63	2.50±0.69
FI grade2	60.90±6.58	23.98±2.25	45.87±12.09	15.53±13.25	38.47±10.55	52.03±14.25	2.70±0.70
FI grade3	68.57±7.55	24.26±2.26	33.86±13.35	13.43±8.70	28.57±9.05	40.71±8.16	3.29±0.95
Pearson r	0.250	0.104	0.038	-0.007	-0.020	-0.030	0.288
p-value	0.044	0.410	0.766	0.957	0.877	0.811	0.020

BMI: body mass index, LL: lumbar lordosis, PT: pelvic tilt, SS: sacral slope, PI: pelvic incidence.

Table 3. Correlation analysis between radiological factor and fat infiltration(FI) grade of erector spinae

	Age	BMI	LL	PT	SS	PI	Disc deg
FI grade1	60.11±6.20	23.54±3.16	39.09±10.31	15.49±9.90	34.34±8.21	48.31±10.23	2.51±0.66
FI grade2	63.04±7.31	24.08±2.01	46.37±12.07	14.26±13.13	38.04±11.25	50.44±15.28	2.85±0.82
FI grade3	67.00±10.58	24.23±2.61	28.00±19.98	14.67±13.32	26.33±13.65	39.67±10.21	3.00±1.00
Pearson r	0.264	0.101	0.102	-0.047	0.035	-0.022	0.235
p-value	0.034	0.422	0.418	0.711	0.782	0.863	0.060

BMI: body mass index, LL: lumbar lordosis, PT: pelvic tilt, SS: sacral slope, PI: pelvic incidence.

grade at different levels varied between 0.84 and 0.89. The inter-observer reliability ranged from 0.74 to 0.94, respectively. The intra-observer reliability for back muscle degeneration varied at different spinal levels between 0.82 and 0.90. The inter-observer reliability for back muscle degeneration ranged from 0.78 to 0.90.

Discussion

With increase in life expectancy, degenerative spondylopathy is on the rise. The pathophysiology theory proposed by Kirkaldy-Willis is generally recognized as a standard mechanism. Unfortunately effects of paraspinal muscles are not mentioned in this model. In the study of Kirkaldy-Willis et al, facet joint arthritis was described as one of the regression process of disc degeneration. Kalichman et al reported correlation of paraspinal muscle degeneration and facet joint arthritis.[2] In this sense, regardless of the sequence we hypothesized that there would be a relationship between paraspinal muscle degeneration and disc space degeneration.

Recent advances, in the understanding of the biomechanics of LBP have highlighted the importance of muscular stabilization of the "neutral zone" in the low back. The lumbar multifidus muscles are important stabilizers of this neutral zone, and dysfunction in these muscles is strongly associated with LBP. The dysfunction is a result of pain inhibition from the spine, and it tends to continue even after the pain has resolved, likely contributing to the high recurrence rate of LBP and spondylopathy. Persisting lumbar multifidus muscles dysfunction is identified by atrophic replacement of multifidus muscle with fat, a condition that is best seen on magnetic resonance imaging.[10] These result correspond with the our study.

There is a report that not only muscle mass, but also changes in property affect disc degenerative changes. Mannion AF described that healthy people the paraspinal muscles have been shown to contain more type I (slow twitch) fibers, compared to other musculoskeletal muscles. Patients with severe chronic LBP have a higher portion of type II (fast twitch).[11] Hence, the changes in fiber type, as seen in severe chronic LBP, could lead to lowered fatigue resistance of the paraspinal muscles which, in turn, results in higher vulnerability of the lumbar spine.

The Inclusive change of muscle mass and property can cause chronic pain, and could be a risk factor of disc degenerative change. So our study focused on these muscle changes related to disc degeneration disorder by measuring the grade of disc degeneration, muscle mass and related several parameters.

Muscle mass decreases with age in adults. Crawford RJ et al reported that lumbar paravertebral muscle fat content increased with aging, independent of volume, in healthy volunteers 20~62 years of age. Except aging, female sex, prior muscle pathology, high BMI, high pelvic tilt, smoking, prior spine surgery history, prior spondylopathy (spondylolysthesis) were a etiologies of back muscle degeneration.[14] Fat signal fraction of multifidus were higher in women with lumbar spine pathology than healthy people and men.[14] Back muscle injury and degeneration often occurs after posterior lumbar surgery, and the degeneration may be a cause of back pain. In that case type 2 (fatty) change was more frequent than type 3 (scar) or type 1 (inflammation or water-like) changes.[15]

Compared with normative controls, patients with isthmic spondylolisthesis suffer selective atrophy of their multifidus.[16] Nam WD reported that high pelvic tilt was the important predictive factor for lumbar back muscle degeneration.[17]

There was no correlation between pelvic tilt and back muscle degeneration in our study. We excluded patients with vertebral fracture, isthmic spondylolisthesis or deformity on lumbar spine that could have an effect on back muscle degeneration.

In our study, lumbar disc degeneration was correlated with degeneration of multifidus, but not with erector spinae. This can be explained by anatomical difference of paraspinal muscle innervations. Multifidus receives direct innervations from a single medial branch of posterior ramus.[12] If there is a pathology in the spinal segment, multifidus can be denervated easily compared to erector spinae which is innervated by multisegment spinal roots. This anatomical feature may contribute to the difference in degeneration of multifidus and erector spinae. Ohtori et al reported that atrophy in chronic low back pain was seen in the multifidus but not in the erector spinae.[13] Crawford RJ stated that Multifidus showed a trend for faster decline than erector spinae.[14]

There are some limitations in our study. First, our study is a cross sectional study, so the exact sequence between muscle change and disc degenerative change cannot be fully established. Muscle change may be a result of spinal disc disorder or old age. Future study with long term follow up may be needed after selecting patients with multifidus dysfunction, but no disc degenerative changes. Second, this study included only radiologic evaluation with not clinical correlation. In spinal conditions, radiologic results do not fully reflect clinical outcomes. Therefore, results must be interpreted considering the clinical symptoms.

Conclusions

There is significant correlation between lumbar disc degeneration and multifidus degeneration. Erector spinae degeneration was correlated with age ,but not correlated with lumbar disc degeneration. The degenerative cascade of the spine is accompanied by fatty change of multifidus with aging.

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Original Article J Korean Soc Spine Surg. 2018 Jun;25(2):47-53. https://doi.org/10.4184/jkss.2018.25.2.53

요추간판 퇴행과 등 근육 변성의 관계

송경섭 • 이승환 • 박병문 • 이수건 • 이모세 • 염지웅 • 이창욱 • 이환모*

광명성애병원 정형외과, *연세대학교 의과대학 정형외과학교실

연구 계획: 후향적 연구

목적: 요추간판 퇴행과 등 근육의 지방 변성의 관계를 분석하고자 하였다.

선행 연구문헌의 요약: Kirkaldy-Willis가 제시한 척추 퇴행의 단계에는 추간판과 후관절의 퇴행이 함께 진행한다. 그러나 등 근육은 모형에서 제외되어 있다. 등 근육과 후관절의 퇴행이 상관 관계가 있다는 연구들은 있었다. 본 연구에서는 요추간판과 등 근육의 지방 변성의 관계를 분석하고자 하였다.

대상 및 방법: 50세 이상에서 요추부 MRI를 촬영한 65명의 환자를 대상으로 하였다. 등 근육의 지방 변성은 다열근과 척추 기립근에서 지방 변성의 정도에 따라 I에서 III단계로 분류하였다. 요추간판의 퇴행성 변화는 Pfirrmann 분류에 따라 I에서 V등급으로 분류하였다. 등 근육의 지방 변성등급과 다른 방사선학적 인자와의 상관 관계를 분석하였다.

결과: 다열근의 지방 변성은 연령 및 요추간판 퇴행과 양의 상관 관계를 가졌다. 다열근에서 다른 방사선학적 인자와의 상관 관계는 없었다. 척추 기립근의 퇴행 변화는 연령과 양의 상관 관계를 가졌다. 척추 기립근에서도 다른 방사선학적 인자와의 상관 관계는 없었다.

결론: 요추간판 퇴행과 다열근의 지방 변성은 유의한 양의 상관 관계를 가졌다. 기립근의 변성은연령과 양의 상관 관계를 가졌으나, 요추간판 퇴행과는 관련이 없었다. 연령이 증가하면서 생기는 척추 퇴행의 단계에서 다열근의 지방 변성도 함께 진행한다고 할 수 있다.

색인 단어: 등 근육 지방변성, 요추간판 퇴행, MRI

약칭 제목: 요추간판 퇴행과 등 근육

접수일: 2017 12월 10일 **수정일:** 2018년 1월 3일 **게재확정일:** 2018년 4월 2일

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