Klinik Çalışma - Araştırma / *Original Article*

Lumbar Disc and Facet Degeneration: Correlation with Age and Facet Orientation

Lomber Disk ve Faset Dejenerasyonu: Yaş ve Faset Oryantasyonunun Korelasyonu

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Objectives: The influence of age on orientation of the facet joint remains controversial. We aimed to examine facet joint degeneration, orientation and their relationships with disc degeneration in a group of patients in different age groups.

Patients and Methods: The study included 106 patients with low back pain and/or leg symptoms who had undergone magnetic resonance imaging of L1-S1 lumbar segments. For evaluation of osteoarthritis of the facet joints grading described by Weishaupt et al. and for evaluation of disc degenerations grading by Pfirmann et al. were used.

Results: Orientation of the facet joints were similar among age groups. Age was not correlated with facet joint orientation. Facet joint orientation was not correlated with facet or disc degeneration in neither female nor male patients. Age was positively correlated with facet degeneration at all spinal levels. At all levels except L3-4 level, facet joint degeneration was more prominent in male subjects.

Conclusion: This study have demonstrated that facet joint orientation is similar among different age groups. The finding of greater prevalence and degree of facet arthrosis in men at all lumbar levels is in accordance with some recent studies. Our study supported the notion that disc degeneration precedes facet arthrosis.

Key words: Facet joint; facet joint orientation; lumbar spine; MRI; osteoarthritis.

Amaç: Yaşın faset eklem oryantasyonu üzerindeki etkisi tam olarak aydınlatılmamıştır. Bu çalışmada faset eklemlerin dejenerasyonu, oryantasyonu ve disk dejenerasyonu ile ilişkisini farklı yaş gruplarındaki hastalarda incelemeyi amaçladık.

Hastalar ve Yöntemler: Bel ve/veya bacak ağrısı bulunan, L1-S1 lomber segmentler arasında manyetik rezonans görüntülemesi uygulanan 106 hasta çalışmaya alındı. Faset eklem dejenerasyonunun değerlendirilmesi için Weishaupt ve ark., disk dejenerasyonlarının değerlendirilmesi için Pfirmann ve ark. tarafından tanımlamış olan evrelendirmeler kullanıldı.

Bulgular: Yaş grupları arasında faset eklem oryantasyonları benzer bulundu. Faset eklem oryantasyon ve yaş arasında korelasyon saptanmadı. Erkek ve kadın hastalarda faset eklem oryantasyonunun faset eklem veya disk dejenerasyonu ile ilişkisi saptanmadı. Yaş tüm spinal seviyelerde faset dejenerasyonu ile korelasyon gösterdi. L3-4 düzeyi dışında tüm seviyelerde erkek hastalarda faset dejenerasyonu daha belirgindi.

Sonuç: Bu çalışmada faset oryantasyonunun farklı yaş gruplarında benzer olduğu gösterilmiştir. Erkeklerde faset artrozunun daha belirgin oluşu yakın tarihli bazı çalışmalarla uyumludur. Bu çalışma disk dejenerasyonunun faset artrozuna göre daha erken başladığı görüşünü desteklemektedir.

Anahtar sözcükler: Faset eklem; faset eklem oryantasyonu; lomber omurga; MRG, osteoartrit.

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Degeneration of the spine is a prevalent problem that generally advances with age, although its occurrence is not restricted to the elderly.[1] The two posteriorly located facet (zygapophyseal) joints (FJ) and the intervertebral disc (IVD) form a functional spinal unit. Degenerative changes of the FJ has been suggested as a potential cause of low back pain. Eubanks et al.[2] have suggested that nearly 60% of all adults show some signs of degenerative changes by the time they reach 30 years of age. Facet hypertrophy, apophyseal malalignment, and osteophyte formation may lead to narrowing of the spinal canal and/or lateral stenosis.[3] Orientation of the FJ has been suspected to result in degeneration of these joints.[4] Studies have addressed the relationship between age, FJ orientation, FJ asymmetry (trophism) and possible correlations with degeneration of FJ and IVD.

However, the influence of age on orientation of the FJ remains controversial.[3] We aimed to examine FJ degeneration, orientation and their relationships with disc degeneration in a group of patients in different age groups.

PATIENTS AND METHODS

Radiologic examinations

The study included 106 patients with low back pain and/or leg symptoms who underwent lumbar magnetic resonance imaging (MRI) examination between November 2007 - January 2008. Patients with congenital anomalies, infections, previous lumbar surgery, trauma, arthritis, spondylolysis, spondylolisthesis or history of malignancy were excluded. L1-S1 segments were imaged with a 1.5-T MR unit (30 mT/m) (Intera, Philips Medical Systems, Best, Netherlands) using a superficial spine coil. For measurements T2-weighted Turbo Spin Echo (TSE) (TR/TE: 3000/120 ms, section thickness: 4 mm, field of view: 300 mm and 256x256 matrix) axial and sagittal images were used. Image analysis was accomplished using PACS (Picture Archiving and Communication System) (Powerserver; Ramsoft Inc., Toronto, Canada). The measurements were made by one experienced spine radiologist blinded to the clinical findings of the patients.

For evaluation of osteoarthritis of the FJ grading described by Weishaupt et al.[5] was used in which grade 0: Normal FJ space (2-4 mm width), grade 1: Narrowing of FJ space (<2 mm) and/or small osteophytes and/or mild hypertrophy of the articular process, grade 2: Narrowing of FJ space and/or moderate osteophytes and/or moderate hypertrophy of the articular process and/or mild subarticular bone erosions, grade 3: Narrowing of FJ space and/or large osteophytes and/or severe hypertrophy of the articular process and/or severe subarticular bone erosions and/or subchondral cyst. When there was a difference in the severity of FJ osteoarthritis between right and left at the same motion segment, the worst grade was recorded.[6]

The evaluation of orientation of FJ was measured on the axial T2-weighted TSE images using the method described by Noren et al.[7] On an axial scan that bisected the intervertebral disc, one line was drawn in the midsagittal plane of the vertebra and one through each FJ tangential to the superior articular process. The angle between the sagittal plane and oblique lines drawn tangential to the superior articular process was measured. The mean of the right and left sides was calculated as a measure of the orientation of the joints (Fig. 1). The difference between right and left was noted. Facet trophism which is defined as an asymmetry in left and right FJ angles of the lumbar spine was calculated.[8]

For evaluation of the disc degenerations we used grading proposed by Pfirmann et al.[5] on T2-weighted sagittal images in which grade 1: Disc structure is homogeneous, bright white, distinction of nucleus and annulus is clear, signal intensity is hyperintense, isointense to cerebrospinal fluid and height of IVD is normal, grade 2: Disc structure is homogeneous, with or without horizontal bands, distinction of nucleus and annulus is clear, signal intensity is hyperintense, isointense to cerebrospinal fluid and height of IVD is normal, grade 3: Disc structure is inhomogeneous, grey, distinction of nucleus and annulus is unclear, signal intensity is intermediate, height of IVD is normal to slightly decreased, grade 4: Disc structure is

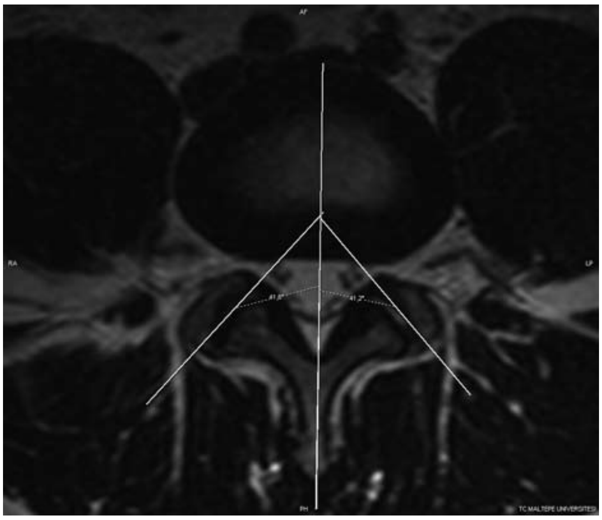

Fig. 1. *Axial MRI scans (T2-weighted TSE) demonstrates the measurement of the facet joint angles in this study at a disc level. On the left side angle is measured as 41° to the midsagittal plane and on the right angle is 41° to the midsagittal plane.*

inhomogeneous, grey to black, distinction of nucleus and annulus is lost, signal intensity is intermediate to hypointense, height of IVD is normal to moderately decreased, grade 5: Disc structure is inhomogeneous, black, distinction of nucleus and annulus is lost, signal intensity is hypointense, collapsed disc space.

Statistical analyses

Since data was not normally distributed, non-parametric tests were chosen. For comparison of female and male patients we used Mann-Whitney U test and for comparisons among age groups we used Kruskal-Wallis test. In addition we used the chi-square test for nominal variables. For comparison of facet and disc degeneration chi-square test was used. P<0.05 was considered to be statistically significant. Values are expressed as mean±SEM unless otherwise indicated. The intra-rater reliability of all measures (facet orientation, facet degeneration and disc degeneration) were drawn from a sample of 25 patients and were found to be high (intra-class correlation>0.9).

Table 1. Characteristics of the study group

	Study group (years)	Female patients (years)	Male patients (years)
Mean	50.53	51.79	49.48
25%	38.75	42.25	38
Median	49	50	46.5
75%	62	63.5	61.25

RESULTS

Forty-eight women (45.3%) and 58 men (54.7%) were included in the study. Characteristics of the study group are summarized in Table 1. The mean age of the male and female subjects was statistically similar (p=0.26). Facet orientation and trophism was similar among female and male subjects (p>0.05).

Progressive increase of facet angle to the mid-sagittal plane was evident while moving from L1 to S1. Facet orientation and facet trophism according to each spinal level was summarized in the age groups (Table 2). Orientation of the FJ was similar among age groups except L5-S1 level (Table 2). Facet orientation and trophism was not correlated with facet or disc degeneration in neither female nor male patients.

Age was positively correlated with facet degeneration at all spinal levels (L1: r=0.509, p=0.0001; L2: r=0.546, p=0.0001; L3: r=0.687, p=0.0001; L4: r=0.570, p=0.0001; L5-S1: r=0.458, p=0.0001). Facet degeneration was more common in L4-5 and L5-S1 levels (p=0.0001). Age was correlated with disc degeneration at all levels except L5-S1 (L1: r=0.750, p=0.0001; L2: r=0.750, p=0.0001; L3: r=0.707, p=0.0001; L4: r=0.560, p=0.0001; L5-S1: r=0.144, p=0.141).

Facet degeneration was correlated with disc degeneration at all levels except L5-S1 level (L1-L2: r=0.577, p=0.0001, L2-L3: r=0.343, p=0.0001, L3-L4: r=0.515, p=0.0001, L4-L5: r=0.332, p=0.001, L5-S1: r=106, p=0.281). Facet and disc degeneration at each spinal level was compared between male and female patients (Table 3). Except L3-4 level which was similar between female and male subjects (p=0.217) at all other levels facet degeneration was more prominent in male subjects (Table 3). Except L3-4 (p=0.118) and L5-S1 (p=0.864) levels; disc degeneration was more prominent in female subjects (Table 3).

At all levels examined except L5-S1, disc degeneration was found in the absence of facet

Table 2. Facet orientation and trophism according to the age groups

Age groups	<39 (n=31)	40-49 (n=23)	50-59 (n=19)	>60 (n=33)	*p*
Facet orientation (mean±SEM) (degrees)					
L1-2	24.80±0.78	23.34±1.63	24.42±1.50	24.52±1.06	0.464
L2-3	26.29±1.09	29.21±1.93	27.16±1.91	26.52±0.99	0.534
L3-4	33.42±1.55	32.26±1.87	33.0±2.12	33.39±1.76	0.991
L4-5	41.35±1.70	43.04±1.77	39.52±1.98	44.0±1.63	0.385
L5-S1	45.09±1.21	49.43±2.19	47.68±2.11	51.94±1.73	0.046*
Facet trophism (mean±SEM) (degrees)					
L1-2	1.29±0.45	1.48±0.38	1.47±0.37	0.97±0.33	0.212
L2-3	0.87±0.24	1.13±0.31	1.0±0.29	1.06±0.26	0.918
L3-4	2.26±0.66	1.65±0.34	1.11±0.29	1.39±0.33	0.480
L4-5	1.84±0.44	2.83±0.65	2.74±0.64	2.12±0.47	0.481
L5-S1	3.13±1.67	3.61±0.57	3.58±0.89	4.12±0.74	0.036*

*p<0.05, statistically significant.

degeneration (L1-2: χ^2=0.002, p=0.002; L2-3: χ^2=0.019, p=0.016; L3-4: χ^2=0.0001, p=0.0001; L4-5: χ^2=0.036, p=0.005; L5-S1: χ^2=0.529, p=0.521). Mean age of the patients for each grade of facet and disc degeneration is summarized in Table 4. These findings suggested that disc degeneration precedes facet arthrosis.

DISCUSSION

In this study we aimed to address controversial issues such as age and facet orientation, relationship between sex and FJ osteoarthritis and temporal relationship between facet and disc degeneration. Facet degeneration was found to be more prevalent in the male patients, however, disc degeneration was relatively more prominent in the female patients. Age was positively correlated with facet orientation and trophism only at L5-S1 level, however, facet orientation and trophism was not correlated with facet or disc degeneration. In this study it was suggested that disc degeneration begins earlier when compared to facet degeneration.

Studies have shown that facet arthrosis frequently appears early in the third decade[9-11] and increases with age. Lewin,[12] in his comprehensive anatomic review of lumbar synovial joints, stated that FJs showed only minor chondral changes before the age of 45. After that age, advanced chondral changes, subchondral sclerosis and osteophytes became common phenomena.[6] FJ osteoarthritis is commonly encountered in L4-5 and L5-S1 spinal levels,[6,12,13] however in most studies L1-2 and L2-3 levels are not included in the analysis.[3] Similar to previous findings FJ osteoarthritis was more common in L4-5 and L5-S1 levels in our patients.

Table 3. Facet and disc degeneration in female and male patients according to spinal levels

	Female (n=48)	Male (n=58)	*p*
Fascet degeneration (mean±SEM)			
L1-2	0.0417±0.0291	0.3966±0.085	0.0001*
L2-3	0.0833±0.0403	0.4138±0.0888	0.003*
L3-4	0.4792±0.0987	0.7069±0.1127	0.217
L4-5	0.7917±0.094	1.31±0.1185	0.002*
L5-S1	0.7292±0.088	1.3966±0.1152	0.0001*
Disc degeneration (mean±SEM)			
L1-2	2.3542±0.2178	1.8103±0.1564	0.043*
L2-3	3.2083±0.6631	2.0345±0.1686	0.027*
L3-4	2.7917±0.1574	2.4310±0.1741	0.118
L4-5	3.5±0.1397	2.7414±0.1714	0.003*
L5-S1	3.25±0.1617	3.2759±0.1532	0.864

*p<0.05, statistically significant.

Table 4. The mean age of the patients according to each grade of facet and disc degeneration

		Grade 0	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	*p*
L1-2	FD	47.07	63.27	72.2	-	-	-	0.002*
	DD	-	41.66	54.09	58.36	69.93	62.43	
L2-3	FD	46.57	63.56	71.17	-	-	-	0.002*
	DD	-	39.48	51.76	53.27	69.13	65.86	
L3-4	FD	42.84	57.42	66.1	-	-	-	0.0001*
	DD	-	39.1	43.88	52.24	66.85	60.5	
L4-5	FD	42.07	47.9	61.22	69.5	-	-	0.036*
	DD	-	37.69	43.53	49.67	57.18	60.55	
L5-S1	FD	41.92	50.02	56.83	66.83	-	-	0.529
	DD	-	41.86	52.87	45.2	52.08	56.43	

FD: Facet degeneration; DD: Disc degeneration; *p<0.05, statistically significant.

The relationship between FJ osteoarthritis and sex remains controversial. Fujiwara et al.[6] have failed to demonstrate any sex difference in the prevalence of FJ osteoarthritis. Ha et al.[14] have demonstrated significantly increased expression of estrogen receptors in the facet cartilage. Since cartilage is a sex-hormone-sensitive tissue[15] this finding was held responsible for the sex differences. Recently Eubanks et al.[2] have found a greater prevalence and degree of facet arthrosis in men at all lumbar levels similar to our findings. Except L3-4 level which was similar between female and male subjects at other levels, facet degeneration was prominent in male subjects.

In the natural history of degeneration the spine has been a matter of debate. It is generally believed that degenerative process of the spine begins in the IVD, however, some studies have suggested FJ arthrosis as the primary event in spinal degeneration.[9] Desiccation in the disc leads to loss of disc space height and subsequent increase in the pressure leading to FJ osteoarthrosis.[6,16-18] Also in our patients disc degeneration was encountered earlier when compared to FJ degeneration. Facet degeneration was correlated with disc degeneration at all levels except L5-S1. This finding may be explained by coronal orientation of facet joints in our study group since a significant association between sagittal orientation and osteoarthritis of the facet joints have already been demonstrated.[4]

Articular facet orientation can be important in providing stability to the spine and controlling its motion under complex loading in the upright bipedal human mechanism.[3] In a normal state, the sagittally oriented lumbar facets facilitate anteroposterior movement (flexion and extension of spine) while limiting axial rotation.[19] In pathologic conditions, the lumbar facets are oriented either more frontally or more sagittally compared to norm.[20] The facets of T12-L2 are oriented closer to the midsagittal plane of the vertebral body (mean range 26-34º), while the facets of L3-5 are oriented away from that plane (mean range 40-56º).[21] These angle measurements are perfectly similar to our findings (Table 1). Love et al.[22] found that older adults have a significantly greater mean sagittal angle of the FJ than those in the younger group. Other studies were unable to demonstrate any association between age and FJ orientation.[21,23] In our study group patients of both sexes had similar facet orientation and facet trophism among age groups. On the contrary to ours, some studies concerning FJ orientation and morphology have been carried out in the cadaveric samples and patients with spondylolisthesis. Moreover, in the most of the studies researchers have failed to include L1-2 and L2-3 levels, these levels were included in our study and similar findings with other levels were observed.

In the literature there is a discrepancy concerning facet trophism definition. Moderate trophism has been defined as 7°-15° and severe tropism as >15°.[23] Karacan et al.[24] in their study defined facet trophism as 3.32 since their intraobserver error (IE) was found as ±1.66° and they defined tropism as 2IE. Some studies have suggested even lower values such as 5°[7] and 1°.[25] So rather than using a cut-off value we used the difference between two sides in correlation analysis.

The study has certain limitations. Magnetic resonance imaging has been suggested to underestimate the severity of osteoarthritis as compared with computerized tomography because it is less sensitive in depicting the bony cortex margin, and thinning of the cartilage can not be measured accurately with MRI because of partial volume effect and chemical-shift artifact.[26,27] However, since MRI allows excellent soft tissue visualization[28] it has gained popularity and for the most part MRI can be a substitute for computerized tomography in assessing osteoarthritis of the lumbar FJs.[6] This study has included a convenient sample of patients with low back pain, a similar study may be conducted on patients without low back pain.

Our study have investigated the orientation of the FJs in relation to age, sex and degeneration of both FJs and IVDs in a group of patients with low back pain. As a result, facet orientation was found to be similar among age groups in all levels except L5-S1. Facet orientation and trophism was not correlated with facet or disc degeneration in neither female nor male patients. Our findings suggested that disc degeneration precedes facet arthrosis. Our study has evaluated patients with low back pain as a convenient sample. Population-based studies involving subjects without low back pain complaints may further enhance our understanding with the correlation of age and FJ orientation.

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