Published in final edited form as:
Spine (Phila Pa 1976). 2009 July 15; 34(16): E579–E585. doi:10.1097/BRS.0b013e3181aa2acb.

Facet orientation and tropism: associations with facet joint osteoarthritis and degenerative spondylolisthesis

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Introduction

Back pain and its sequelae place an enormous burden on society, health care systems, and the economies of developed countries[7,17]. Degenerative changes in the spine can be a potential cause of back pain, and therefore an understanding of the relationship between pathoanatomic abnormality and advanced degeneration is of importance from a clinical and public health perspective. The purpose of this study was to investigate associations between facet joint tropism and facet joint orientation and two common lumbar degenerative spinal disorders: facet joint osteoarthritis (OA) and degenerative spondylolisthesis (DS).

The facet joints are the only synovial joints in the spine, with hyaline cartilage overlying subchondral bone, a synovial membrane and a joint capsule. Facet tropism and facet orientation may have a relationship to degenerative changes in the spine, either as the cause of degenerative changes or as the result of abnormal forces produced by degeneration. Facet orientation is the angle of the facet joint in the transverse plane relative to the sagittal plane (Figure 1). Facet tropism is defined as asymmetry of the left and right vertebral (zygapophyseal) facet-joint angles, with one joint having a more sagittal orientation than the other[4]. Despite extensive studies with some conflicting results[2,3,6,9,11,12,26], the clinical significance of facet tropism and orientation is not yet well established.

Facet tropism and facet orientation have been proposed as factors associated with lumbar facet joint OA. One cadaveric study examining this relationship found an association between facet tropism and facet sclerosis, though no association between facet tropism and a composite score of cartilage degeneration and sclerosis[12]. Conclusions from this study are limited due to the very small sample size involved (n=22) and the somewhat arbitrary criteria used to grade degeneration. Another study examining the relationship between facet

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Conflict of interest statement: None of the authors have any conflict of interest regarding the contents of this article.

orientation and facet joint OA in 111 patients[9] found a significant association between facet orientation and OA, but little association between facet tropism and OA. Prior studies also have found significant associations between facet orientation, facet tropism, and DS[2,3,6,9,11,26] in simple univariate analyses, but have largely failed to account for simple covariates such as age, sex and BMI. The relationship between facet tropism and orientation, and facet joint OA and DS, while adjusting for important covariates, has yet to be clearly defined.

Due to precise demonstration of osseous details[13,15,24] and relatively low cost, computed tomography (CT) is the preferred method for imaging lumbar facet joint OA. Abnormalities of the facet joints that can be demonstrated and categorized by CT include osteophyte formation, hypertrophy of articular processes, joint space narrowing, vacuum joint phenomenon, synovial and subchondral cysts, and calcification of the joint capsule[5,25]. CT also allows easy identification of spondylolisthesis, particularly when sagittal reformats are available.

The aims of the present study were: 1) to document the distribution of facet orientation and prevalence of facet tropism in the community based sample; 2) to evaluate the association between facet orientation and tropism and age, sex and BMI; and 3) to evaluate the association between facet orientation and tropism, and facet joint OA and DS.

Materials and Methods

Study design

Cross-sectional study.

Study Sample

This project was an ancillary project to the Framingham Heart Study. The Framingham Heart Study began in 1948 as a longitudinal population-based cohort study of the causes of heart disease. Initially, 5209 men and women between the ages of 30 and 60 years living in Framingham, Massachusetts were enrolled. Biennial examinations were conducted by trained research staff at the study clinic located in Framingham. In 1971, 5,124 offspring (and their spouses) of the original cohort were entered into the Offspring cohort. In 2002, 4095 men and women who were children of the Offspring cohort were enrolled in the Third Generation cohort. A description of the Offspring and Third Generation cohorts has been previously reported[8,27]. 3529 participants of the Framingham study (participants in both the Offspring and Third Generation cohorts) aged 40–80 years underwent abdominal and chest multi-detector MDCT to assess coronary and aortic calcification. The primary evaluation of the abdominal aorta, which lies immediately adjacent to the lumbar spine, offers excellent resolution for assessment of lumbar pathology; similar methods have been used previously in other studies of spondylolysis[1]. The recruitment and conduct of CT scanning have been previously reported[14,22]. During the latter part of the CT study, 191 participants were consecutively enrolled in this ancillary study to assess the association between radiographic features of the lumbosacral spine and LBP. Three individuals were not analyzed because of insufficient CT data.

Imaging parameters

Study participants were imaged with an eight-slice MDCT scanner (Lightspeed Ultra, GE, Milwaukee, WI, USA). Each subject underwent unenhanced abdominal CT that was performed using a sequential scan protocol with a slice collimation of 8 mm × 2.5 mm (120 KVp, 320/400 mA for 220 lbs body weight, respectively) during a single end-inspiratory

breath hold (typical duration 18 s). For the abdominal scan, thirty contiguous 2.5 mm thick slices of the abdomen were acquired covering 150 mm above the level of S1.

Evaluation of facet orientation and tropism

The facet joint angle relative to the sagittal plane at L3–L4, L4–5 and L5–S1 was measured on the axial CT images using bone windows using the method described by Noren et al.[21] (Figure 1). On an axial scan that bisected the intervertebral disk, one line was drawn in the midsagittal plane of the vertebra and one through each facet joint tangential to the superior articular process. Continuous facet joint tropism was defined as the absolute difference of the angles between the right and the left facet. In addition, according to the method described by Vanharanta et al. for categorical facet tropism[28], moderate tropism was defined as a difference of 7° to 15°, and severe tropism as more than 15°.

Facet Joint OA evaluation

FJ OA evaluation was performed using eFilm Workstation (Version 2.0.0) software. All CT studies were read blinded to clinical information and to the hypothesis assessed here. Lumbar facet joints were graded on both the left and right side at levels L3–L4, L4–L5, and L5–S1. Four grades of facet joint OA were defined using criteria similar to those published by Pathria et al.[23] and Weishaupt et al.[29] (Figure 2). This system grades facet joint OA according to the grading of the individual subcategories of joint space narrowing (JSN), osteophytes, articular process hypertrophy, sclerosis, subarticular erosions, subchondral cysts, and vacuum phenomenon. Specific examples of facet OA grading are presented in Figure 2.

The following criteria were used for facet joint OA evaluation:

Grade I (Normal): No joint space narrowing (2mm or greater); no osteophytes or possible small osteophytes; no articular process hypertrophy; no sclerosis or doubtful sclerosis; no subchondral erosions; no subchondral cysts; no joint space vacuum phenomenon.

Grade II (Mild): JSN (joint space 1–2 mm); and/or definite small osteophytes; and/or mild articular process hypertrophy; and/or definite sclerosis; no subchondral erosions; no subchondral cysts; no joint space vacuum phenomenon.

Grade III (Moderate): JSN (joint space ≤1 mm); and/or moderate osteophytes; and/or moderate articular process hypertrophy; and/or mild subchondral erosions; and/or mild subchondral cysts; and/or joint space vacuum phenomenon.

Grade IV (Severe): Severe JSN (bone to bone); and/or large osteophytes; and/or severe articular process hypertrophy; and/or severe articular erosions; and/or severe subchondral cysts; and/or joint space vacuum phenomenon.

Degenerative spondylolisthesis evaluation

Grading (I to IV) of spondylolisthesis (Meyerding[20] classification) was estimated using sagittal reformations. Spondylolisthesis observed in the absence of spondylolysis and presence of at least Grade III facet joint OA was considered degenerative spondylolisthesis, after confirmation of absence of fracture, tumor or other primary pathology of posterior elements of the spine.

Reliability of CT readings

The reader (LK) was trained by an experienced research musculoskeletal radiologist (AG). A reading protocol for evaluation of facet joint OA based on the above outlined grading

scheme was developed. Using this protocol, the intra- and inter-rater reliability was calculated for two readers (AG and LK). All CT scans were then analyzed in a blinded fashion. To evaluate for reader-drift, intra-rater reliability was periodically reassessed by inserting one repeated "reliability" scan for every 10 new scans. Before analyzing each new set of CT scans, 5 previously analyzed CTs were reevaluated to "recalibrate" the readings to a standard. All atypical cases were read by two readers. The intra-observer reliability for grading different facet joint OA indices varied between 0.64 and 0.91. The inter-observer reliability ranged from 0.59 to 0.94. For spondylolisthesis the intra-observer reliability varied at different levels between 0.95 and 1.00, and the inter-observer reliability ranged from 0.75 to 0.98. The intra-observer reliability for identification of spondylolysis, which was used for ascertaining DS, was 1.00. The inter-observer reliability was 0.98. This range of kappa statistics represents fair to excellent reproducibility.

Body mass index (BMI)

BMI was computed as the ratio of weight (in kg) divided by height (in square meters).

Statistical analysis

We initially calculated the mean±SD angle of facet orientation and facet tropism by spinal level and sex. We also calculated the prevalence of facet tropism (difference>7°) at least at one spinal level and prevalence of facet joint OA in a studied sample.

We then evaluated the association of facet orientation and tropism with age and sex using univariate analyses; and with age, sex and BMI using multivariate (multiple regression) analysis.

At the third stage we evaluated the association between facet joint OA and facet orientation and facet tropism at the corresponding level using two types of analyses. In the first analytic approach we compared the facet orientation and tropism (continuous) in joints with and without OA at each of studied spinal levels. In the second analytic approach we used logistic regression models with facet joint OA at each specific level and side as the dependent variable and facet orientation of the same joint as well as facet tropism at the corresponding level and age, sex, and BMI, as independent variables.

The same approach was used to evaluate the association between DS and facet orientation and tropism at the corresponding level. Initially, the t-test was used to compare the facet joint orientation, and χ^2-test was used to compare facet tropism at the level of listhesis between the patients with DS and the normal subjects. We also used a logistic regression analysis with DS as the dependent variable and mean facet orientation as well as facet tropism at the corresponding level as well as age, sex and BMI, as independent variables.

All statistical analyses were performed using SAS software, (SAS Institute Inc, Cary, North Carolina, release 9.1).

Results

Descriptive statistics of the studied sample are shown in the Table 1. The mean age of the males and females was 51.90±11.25 and 53.61±10.20 respectively. Individuals were slightly overweight on average: BMI=27.95±4.16 for males and 27.71±5.98 for females. Facet orientation was similar in males and females, and became more coronally oriented in lower spinal segments. Prevalence of facet tropism (difference in facet angles >7°) was 76.7% in males and 66.3% in females, and facet joint osteoarthritis was prevalent in 60.2% of males and 70.0% of females.

Results of comparisons between males and females (Table 1) showed no sex differences in facet orientation at any studied level (p=0.57 at L3–L4; p=0.24 at L4–L5; and p=0.71 at L5–S1 spinal levels). As well, there were no significant differences between males and females in mean facet tropism (continuous) at any studied spinal level (p=0.72 at L3–L4 level, p=0.12 L4–L5 level, and p=0.43 at L5–S1 level). There was no significant difference in prevalence of facet joint OA at studied spinal levels between males and females (p=0.17).

In the present study there was no significant difference between age groups in mean values of facet orientation and tropism at each studied spinal level in the univariate analysis (Table 2). We can mention signs of trend toward more sagittally oriented facet joints at L3–L4 and L4–L5 spinal levels with age, but the differences between age group were not significant (p=0.13 for L3–L4, and p=0.18 for L4–L5 levels). In the multivariate analysis we evaluated the associations between facet orientation at the L3–L4, L4–L5 and L5–S1 spinal levels and age, sex and BMI. Sex and BMI were not associated with facet orientation at any studied spinal level. Age showed a statistically significant negative association (β=−0.28, p=0.03) with facet orientation at L4–L5 spinal level, suggesting that in older age the L4–L5 facets are more sagittally oriented. Multiple logistic regression analysis showed that there were no statistically significant associations between moderate or severe facet tropism and age, sex and BMI at each studied spinal level.

Table 3 presents the relation of facet OA to facet orientation and facet tropism at each studied spinal level. At each spinal level the facet joints with OA were more sagittally oriented, but the difference was statistically significant only at L4–L5 spinal level (p=0.0007). Facet tropism showed no significant difference between facet joints with and without OA at each studied spinal level.

Results of the multivariate analysis of the association between facet joint OA and facet orientation at the same side level, and facet tropism at the same level, while adjusting for age, sex, BMI are shown in Table 4. Facet orientation was significantly associated with facet joint OA only at the left side of the L4–L5 (OR(95%CI)=1.06(1.00, 1.13)) and L5–S1 (1.06(1.01–1.11) spinal levels. Facet tropism did not show an association with facet joint osteoarthritis at any spinal level.

Table 5 shows the comparison of facet orientation and tropism at the level of listhesis between individuals with and without DS. The prevalence of facet tropism was not different in individuals with or without DS. However, facet orientation showed significant differences (p<0.0001) with more sagittal facet orientation in individuals with DS. Table 6 shows the associations between DS and facet orientation and tropism of the corresponding level while adjusted for age, sex and BMI. Facet orientation was significantly associated with DS (0.89 (0.84–0.94)), however facet tropism showed no association with DS.

Discussion

To our knowledge, this work represents the largest study to date to evaluate the association between facet orientation and tropism, and facet joint OA and DS. This cohort also includes the largest population of patients over the age of 50.

This study demonstrates that more sagittally oriented facets are associated with a slightly higher occurrence of facet joint osteoarthritis at the L4–L5 and L5–S1 spinal levels. This is in agreement with previous findings by Fujiwara[9]. The fact that we found a significant association with facet joint OA and facet orientation only at the L4–L5 spinal level can be explained by the fact that this is the most common level of facet joint OA[10,16,18]. Our study showed a statistically significant association between facet orientation and presence of DS as well as the difference in facet orientation between individuals with and without DS.

Individuals with DS have on average more sagittally oriented facet joints than individuals without DS. These results are in agreement with previously published studies[2,3,6,9,11,26].

We did not find an association between facet tropism and occurrence of facet joint OA or DS at the lower three spinal levels. This lack of association contradicts previously reported findings by Grogan et al.[12] and, to some extent, by Fujiwara et al.[9]. The discrepancy between Grogan's findings and ours may be explained by differences in methodology. Because previous studies and the preliminary calculations for the present study showed that facet joints with OA are more sagittally oriented, we decided to account for this by evaluating the association between facet tropism (at each spinal level) and side-specific facet joint OA separately in the multivariate analysis. If only one value of facet joint OA for each spinal segment is recorded[9,12], this could lead to false positive association with facet tropism. The side that has more prevalent or more severe OA would, most probably, have more sagittally oriented facets. Therefore, if facet joint OA is not symmetrical, and we have only one value of facet joint OA, we would find a false positive association between facet tropism and facet joint OA.

Due to the cross-sectional design, we cannot conclude if sagittally oriented joints predispose to the development of facet joint OA, or if sagittal orientation of the facets are the result of a remodeling process of OA. We did demonstrate a relationship between age and facet orientation particularly at the L4–L5 level, suggesting that orientation could change with remodeling over time, and underlining the importance of appropriately adjusting for age. We found that in older age facets are more sagittally oriented. L4–L5 spinal level is most common site of development of facet joint OA[16]. Our hypothesis that can explain this association is that facet orientation changes as a result of articular process remodeling during development of osteoarthritis. This assumption will need to be further examined in a longitudinal study.

We found no significant difference between males and females in facet orientation and tropism at any studied spinal level in agreement with study of Love et al.[19]. BMI was also not associated with facet orientation and tropism at any spinal level.

Conclusions

The current study confirms a significant association between sagittal orientation and OA of the lumbar facet joints and DS, albeit the relation was not strong. Previous strong relations may have inadequately adjusted for important confounders, in particular age. Facet tropism was not associated with the occurrence of facet joint OA or degenerative spondylolisthesis. Additional, longitudinal studies are needed to understand the causal relationship between facet joint morphology and OA.

Acknowledgments

From the Framingham Heart Study of the National Heart Lung and Blood Institute of the National Institutes of Health and Boston University School of Medicine. This work was supported by the National Heart, Lung and Blood Institute's Framingham Heart Study contract (No. N01-HC-25195) for the recruitment, enrollment, and examination of the Offspring and Third Generation Cohorts, and the imaging by computed tomography scan.

L.K. is supported by an Arthritis Foundation Postdoctoral Grant.

P.S. is supported by the Rehabilitation Medicine Scientist Training K12 Program (RMSTP) and National Institutes of Health (K12 HD 01097).

Appendix 1

Grades of osteoarthritic features of facet joints.

	Joint Space Narrowing (JSN)		**Subchondral Sclerosis**
Normal	No JSN (2mm or greater)	Normal	No sclerosis
	Mild JSN (1–2 mm)		Doubtful sclerosis
	Moderate JSN (<1mm)	Abnormal	Definite sclerosis
Severe	Severe JSN (bone-to bone)		**Articular Process Hypertrophy**
	Osteophytes	Normal	No hypertrophy
Normal	No osteophytes		Mild hypertrophy
	Possible small osteophytes		Moderate hypertrophy
	Definite small osteophytes	Severe	Severe hypertrophy
	Moderate osteophytes		**Joint Space Vacuum Phenomenon**
Severe	Severe osteophytes	Normal	No vacuum phenomenon
	Subchondral Cysts	Abnormal	Present vacuum phenomenon
Normal	No subchondral cysts		**Subchondral Erosions**
	Mild (focal) subchondral cysts	Normal	No erosions
	Severe (diffuse or multiple focal) subchondral cysts		Mild (focal) erosion
Severe		Severe	Severe (diffuse or multiple focal) erosion

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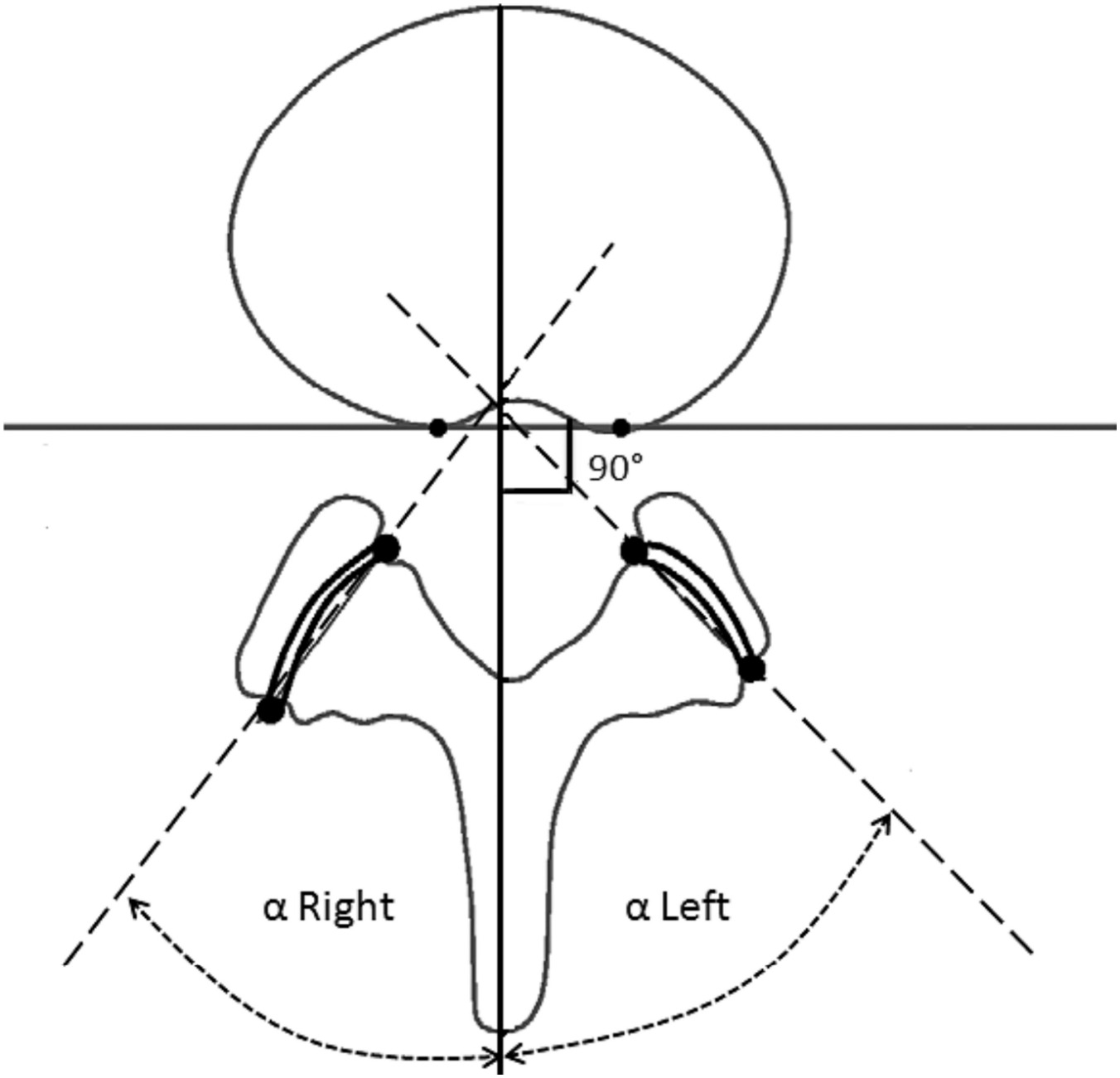

Figure 1.
Schema of facet orientation measurement. Reference plane was defined by posterior aspect of vertebral body. Sagittal line was drawn though spinous process, 90° to the reference plane. Facet orientation (α) was measured automatically at each side by the software between sagittal line and line drawn though the margins of the facet joint.

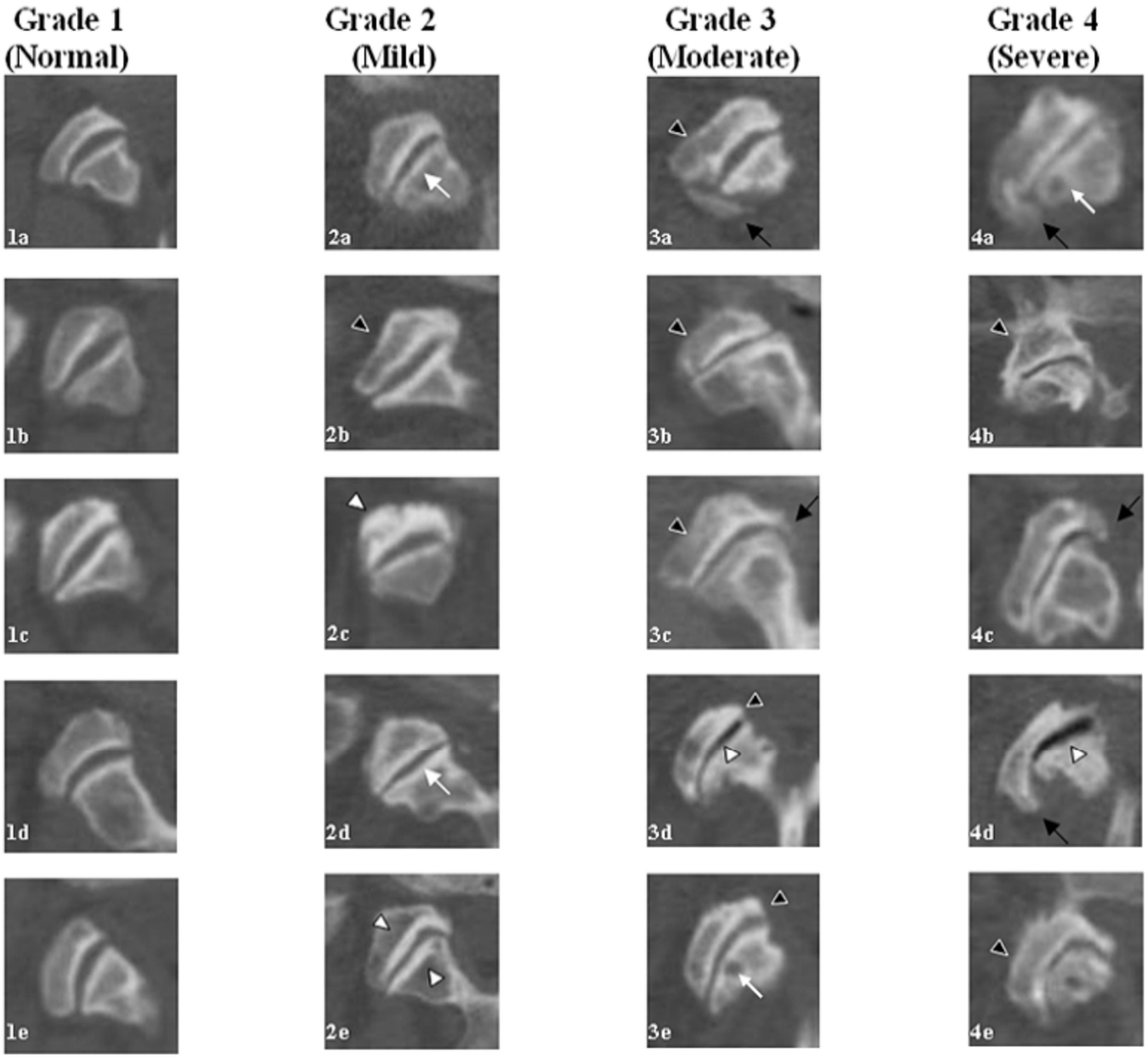

Figure 2.

Examples of CT-evaluated facet joint osteoarthritis grades. Numbers on the images indicate grades of facet joint OA. Letters **a** to **e** present different examples of the same grade.

Grade 1: Normal right L4–L5 and L5–S1 facet joints. There is no joint space narrowing, no sclerosis, no osteophytes, and no facet hypertrophy.

Grade 2: Mild osteoarthritis of the right L4–L5 and L5–S1 facet joints. Joint space narrowing (*white arrows*), sclerosis (*white arrowheads*), and facet hypertrophy (*black arrowheads*) are indicated.

Grade 3: Moderate osteoarthritis of the right L4–L5 and L5–S1 facet joints. Joint space narrowing is present throughout. Osteophytes (*black arrows*), facet hypertrophy (*black arrowheads*), subchondral cysts (*white arrows*), and vacuum phenomenon (*white arrowheads*) are indicated.

Grade 4: Severe osteoarthritis of the right L4–L5 and L5–S1 facet joints. Advanced joint space narrowing is present throughout. Large osteophytes (*black arrows*), facet hypertrophy (*black arrowheads*), subchondral cysts (*white arrows*), and vacuum phenomenon (*white arrowheads*) are indicated.

Table 1

Descriptive Statistics of the Studied Sample. Mean ± SD (n = 188)

	Males	Females	Males *vs.* Females* *P*
N	104	84	
Age (yrs)	51.90 ± 11.25	53.61 ± 10.20	0.3072
BMI (kg/m^2)	27.95 ± 4.16	27.71 ± 5.98	0.7282
Facet orientation L3–L4†	37.48 ± 7.75	38.11 ± 9.12	0.6132
Facet orientation L4–L5†	46.59 ± 9.11	45.72 ± 9.93	0.5398
Facet orientation L5–S1†	47.95 ± 10.65	48.55 ± 10.99	0.7135
Facet tropism L3–L4	5.95 ± 4.35	6.23 ± 5.61	0.7193
Facet tropism L4–L5	7.48 ± 6.92	6.13 ± 4.75	0.1225
Facet tropism L5–S1	7.67 ± 7.91	6.68 ± 8.68	0.4282
Prevalence of facet tropism (difference >7°) in at least one spinal level	79 (76.7%)	53 (66.3%)	0.5189
Prevalence of facet joint osteoarthritis (grade ≥2 at L3–S1 level)	62 (60.2%)	56 (70.0%)	0.1692

*Results of *t* test continuous variables and χ^2 test for categorical variables.

†Relative to sagittal plane.

Table 2

Association Between Facet Orientation and Tropism and Age

	<50	50–59	60+	Comparison*
Facet Orientation L3–L4†	39.07 ± 7.58	37.66 ± 7.49	35.94 ± 10.19	0.1329
Facet Orientation L4–L5†	47.70 ± 9.11	45.79 ± 9.61	44.48 ± 9.62	0.1838
Facet Orientation L5–S1†	47.98 ± 9.83	48.55 ± 9.80	48.09 ± 13.47	0.9518
Facet tropism L3–L4	6.17 ± 4.71	5.73 ± 4.76	6.38 ± 5.51	0.7771
Facet tropism L4–L5	7.54 ± 7.32	6.17 ± 4.94	6.91 ± 5.46	0.4335
Facet tropism L5–S1	7.0 ± 6.78	6.78 ± 7.57	8.27 ± 10.99	0.6251
Prevalence of facet tropism L3–L4	30 (42.3%)	23 (35.9%)	16 (33.3%)	0.5766
Prevalence of facet tropism L4–L5	26 (36.6%)	24 (37.5%)	19 (42.2%)	0.8208
Prevalence of facet tropism L5–S1	26 (36.6%)	29 (46.0%)	16 (36.4%)	0.4639

*Results of *t* test for continuous variables and χ^2 test for categorical variables.

†Relative to sagittal plane.

Table 3

Facet Orientation in Joint With and Without OA

Spinal Level	Facet Joint OA (Present)	Facet Joint OA (Absent)	Comparison (*t* Test)
Facet Orientation L3–L4*	36.04 ± 10.07	38.61 ± 7.32	0.0865
Facet Orientation L4–L5*	43.76 ± 9.49	48.51 ± 9.09	**0.0007**
Facet Orientation L5–S1*	47.10 ± 13.13	48.84 ± 9.13	0.3417
Facet tropism L3–L4	6.74 ± 5.23	5.77 ± 4.75	0.2150
Facet tropism L4–L5	7.67 ± 7.21	6.35 ± 5.06	0.1668
Facet tropism L5–S1	8.24 ± 11.01	6.72 ± 5.97	0.3017
Prevalence of facet tropism L3–L4	44 (37.0%)	26 (38.8%)	0.8045
Prevalence of facet tropism L4–L5	48 (41.0%)	23 (34.9%)	0.4102
Prevalence of facet tropism L5–S1	44 (38.3%)	28 (42.4%)	0.5817

Statistically significant association at $P < 0.05$ level marked bold.

*Relative to sagittal plane.

Table 4

Association Between Facet Joint OA and Facet Orientation and Tropism (Results of Multiple Logistic Regression Analysis)

Dependent Variable	Independent Variable	OR	95% CI	
Facet joint osteoarthritis right L3–L4	Age	**1.09**	**1.06**	**1.13**
	Sex*	0.57	0.29	1.12
	BMI	1.06	0.99	1.14
	Facet orientation L3–L4 (right)	0.98	0.95	1.02
	Facet tropism (continuous) L3–L4	1.03	0.97	1.11
Facet joint osteoarthritis left L3–L4	Age	**1.10**	**1.06**	**1.14**
	Sex*	1.26	0.65	2.43
	BMI	1.02	0.95	1.09
	Facer orientation L3–L4 (left)	0.98	0.95	1.02
	Facer tropism (continuous) L3–L4	1.00	0.93	1.07
Facet joint osteoarthritis right L4–L5	Age	**1.11**	**1.07**	**1.16**
	Sex*	**2.16**	**1.04**	**4.47**
	BMI	**1.12**	**1.02**	**1.22**
	Facer orientation L4–L5 (right)	0.97	0.94	1.00
	Facet tripism (continuous) L4–L5	1.02	0.96	1.08
Facet joint osteoarthritis left L4–L5	Age	**1.09**	**1.05**	**1.13**
	Sex*	1.11	0.57	2.19
	BMI	1.05	0.98	1.13
	Facet orientation L4–L5 (left)	**1.06**	**1.00**	**1.13**
	Facet tropism (continuous) L4–L5	0.97	0.94	1.00
Facet joint osteoarthritis right L5–S1	Age	**1.07**	**1.03**	**1.10**
	Sex*	**3.03**	**1.52**	**6.05**
	BMI	1.00	0.93	1.07
	Facet orientation L5–S1 (right)	0.98	0.95	1.01
	Facet tropism (continuous) L5–S1	1.02	0.98	1.07
Facet joint osteoarthritis left L5–S1	Age	**1.12**	**1.07**	**1.17**
	Sex*	**3.58**	**1.72**	**7.45**
	BMI	0.96	0.90	1.04
	Facet orientation L5–S1 (left)	**1.06**	**1.01**	**1.11**
	Facet tropism (continuous) L5–S1	0.97	0.94	1.00

*Sex: Male as reference group; statistically significant association marked bold.

Table 5

Comparison of the Facet Angle and Tropism at the Level of Listhesis Between the Individuals With and Without Degeneration Spondylolisthesis

	Individuals With DS (n = 23)	Individuals Without DS (n = 165)	Comparison
Facet orientation	34.67 ± 11.79	48.74 ± 18.42	***P* < 0.0001**[*]
Prevalence of facet tropism (difference >7°)	9 (39.1%)	61 (38.1%)	$P = 0.9261$[†]

[*] Results of *t* test.

[†] Results of χ^2 test; statistically significant association at $P < 0.05$ level marked bold.

Table 6

Association Between Degenerative Spondylolisthesis and Facet Orientation and Tropism at the Same Level, Adjusted for Age, Sex, and BMI. Results of Multiple Logistic Regression Analysis

Dependent Variable	Independent Variable	OR	95% CI	
Degenerative spondylolisthesis	Age	**1.09**	**1.03**	**1.16**
	Sex*	**3.05**	**1.02**	**9.18**
	BMI	1.03	0.93	1.14
	Facet orientation†	**0.89**	**0.84**	**0.94**
	Facet tropism	0.99	0.90	1.09

*Sex: Male as reference group; statistically significant association marked bold.

†Mean value of facet orientation, between left and right sides.