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Facet joint osteoarthritis and low back pain in the community-based population

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Abstract

Study Design—Cross-sectional study.

Objective—To evaluate the association between lumbar spine facet joint osteoarthritis (FJ OA) identified by multi-detector computed tomography (CT) and low back pain (LBP) in the community-based Framingham Heart Study.

Summary of Background Data—The association between lumbar FJ OA and LBP remains unclear.

Methods—This study was an ancillary project to the Framingham Heart Study. A sample of 3529 participants of the Framingham Heart Study aged 40–80 underwent multi-detector CT imaging to assess aortic calcification. One hundred eighty-eight individuals were consecutively enrolled in this ancillary study to assess radiographic features associated with LBP. LBP in the preceding 12 months was evaluated using a self-report questionnaire. FJ OA was evaluated on CT scans using a 4-grade scale. The association between FJ OA and LBP was examined used multiple logistic regression models, while adjusting for gender, age and BMI.

Results—CT imaging revealed a high prevalence of FJ OA (59.6% of males and 66.7% of females). Prevalence of FJ OA increases with age. By decade, FJ OA was present in 24.0% of <40-years-olds, 44.7% of 40–49-years-olds, 74.2% of 50–59-years-olds, 89.2% of 60–69-years-olds, and 69.2% of >70-years-olds. By spinal level the prevalence of FJ OA was: 15.1% at L2–L3, 30.6% at L3–L4, 45.1% at L4–L5 and 38.2% at L5-S1. In this community-based population, individuals with FJ OA at any spinal level showed no association with LBP.

Conclusions—There is a high prevalence of FJ OA in the community. Prevalence of FJ OA increases with age with the highest prevalence at the L4–L5 spinal level. At low spinal levels women have a higher prevalence of lumbar FJ OA than men. In the present study we failed to find

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an association between FJ OA, identified by multi-detector CT, at any spinal level and LBP in a community-based study population.

Keywords

low back pain; facet joints; osteoarthritis; computed tomography

Introduction

Lumbar spinal facet joints were first suggested in the medical literature as a source of low back and lower extremity pain in 1911 [1]. Since then, so-called "facetogenic back pain" has become a widely accepted, though still controversial entity in the radiologic and orthopedic literature [2–10]. Perhaps the strongest circumstantial support comes from investigations reporting successful relief of back pain following intra-articular or periarticular joint injections [2, 8].

Estimates of the prevalence of lumbar facet joint pain based on single diagnostic blocks have been reported to range from 7.7% to 75% among patients reporting back pain [11]. On the basis of controlled, local anesthetic diagnostic blocks, the prevalence of lumbar facet joint pain in a population of injured US workers with chronic low back pain (LBP) was shown to be 15% [8]. Similar studies have suggested the prevalence to be 40% to 45% in a pain management practice 9, 10. An Australian study reported a prevalence of 40% among patients with chronic LBP in a general rheumatology practice 12. However, the association between pain originating from the facet joints and radiographically observed degenerative changes in those joints has not been studied and remains controversial.

The majority of published clinical investigations report no correlation between the clinical symptoms of LBP and degenerative spinal changes observed on radiologic imaging studies, including radiographs, magnetic resonance imaging (MRI), computed tomography (CT), single photon emission computed tomography (SPECT), and radionuclide bone scanning [8–10, 12–20]. Specifically, the association between degenerative changes in the lumbar spine facet joints and symptomatic LBP remains unclear and a subject of ongoing debate [6–8].

In comparison with radiographs, CT improves anatomic evaluation of the facet joints due to its ability to provide cross-sectional images of the opposing joint surfaces in the axial plane [4]. Abnormalities of the facet joints that can be demonstrated and categorized by CT include osteophyte formation, hypertrophy of articular processes, articular cartilage thinning, vacuum joint phenomenon, synovial and subchondral cysts, and calcification of the joint capsule 4, 21. Due to precise its demonstration of osseous details 5, [22] and relatively low cost, CT is the preferred method for imaging lumbar facet joint osteoarthritis (FJ OA).

The efficacy of intra-articular or periarticular injection therapy on LBP potentially associated with FJ OA has not been clearly established. Despite the observation by Lewinnek and Warfield [2] that 96% of patients with CT-documented FJ OA responded to such injections, Schwarzer et al. [13] were not able to demonstrate a significant correlation between the degree of OA seen on CT and the pain score achieved following the intra-articular facet block.

There are very few published studies regarding the prevalence of FJ OA. Eubanks et al. [23] in a recent study of 647 cadaveric lumbar spines found that FJ OA is a universal finding. Characteristic features of OA begin to appear early, with more than one half of adults younger than 30 years demonstrating arthritic changes in the facets. The most common arthritic level appears to be L4–L5.

The aims of the present study were: 1) to evaluate the prevalence of FJ OA in different age groups and at different lumbar spinal levels in a community-based population; and 2) to evaluate the association between FJ OA, observed on CT, and the risk of experiencing LBP in the community-based Framingham Heart Study.

Materials and Methods

Study design

Cross-sectional 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 [24, 25]. 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 CT scanning to assess coronary and aortic calcification. The recruitment and conduct of CT scanning have been previously reported [26, 27]. During the later part of the CT study, one hundred eighty-eight participants were consecutively enrolled in this ancillary study to assess the association between radiographic features of the lumbosacral spine and LBP.

LBP evaluation

All study participants undergoing multi-detector CT scan were asked to complete the modified Nordic Low Back Questionnaire [28]. The first question on this questionnaire was: "Have you had low back pain on most days of at least one month in the last 12 months?" Individuals' who answered "yes" or "no" on the above question, were used in the present study as the back pain outcome (dichotomous index). Similar methods are widely used in studies of work related low back pain [29–31].

CES-D measurement

The CES-D scale is a subjective report of depressive symptoms that has been shown to have valid and reliable psychometric properties [32, 33].

Imaging parameters

Study participants were imaged with an eight-slice multi-detector CT scanner (Lightspeed Ultra, GE, Milwaukee, WI, USA). Each subject underwent unenhanced abdominal multi-detector CT 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 5 mm thick slices of the abdomen were acquired covering 150 mm above the level of S1.

FJ OA evaluation

FJ OA evaluation was performed using eFilm Workstation (Version 2.0.0) software. All CT studies were read in blinded fashion. Lumbar facet joints were graded on both the left and

right side at levels L2–L3, L3–L4, L4–L5, and L5-S1. Four grades of FJ OA were defined using criteria similar to those published by Pathria et al. [34] and Weishaupt et al. 35:

grade 0 - normal;

grade 1 - mild degenerative disease (narrowing of the joint space (<2 mm.) and/or small osteophytes and/or mild hypertrophy of the articular process);

grade 2 – moderate degenerative disease (narrowing of the joint space (<1 mm.) and/or moderate osteophytes and/or moderate hypertrophy of the articular process and/or mild subarticular bone erosions);

grade 3 – severe degenerative disease (severe narrowing of the joint space and/or large osteophytes and/or severe hypertrophy of the articular process and/or severe subarticular bone erosions and/or subchondral cysts and/or vacuum phenomenon in the joints).

Reliability of CT readings

All readers were trained by an experienced research musculoskeletal radiologist (AG). A reading protocol for evaluation of FJ OA based on the above outlined grading scheme was developed. Using this protocol, the intra- and inter-rater reliability was calculated for two readers. All CT scans were then analyzed in 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. The intra-observer reliability for grading different FJ OA indices varied between 0.64 and 0.91. The inter-observer reliability ranged from 0.59 to 0.94. 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

Before the analysis, the study population was dichotomized on the basis of FJ OA for the presence or absence of facet joint disease (≥grade 2) on any side at any level. The population was then divided into 5 age strata: <40, 40–49, 50–59, 60–69, ≥70 years. The prevalence of FJ OA between males and females was compared according to age group and according to spinal level involved using chi-square test. The prevalence of FJ OA was calculated by age group and sex and compared between individuals with and without LBP. Multiple logistic regression models were used to examine the association between FJ OA and LBP, while adjusting for gender, age, BMI and CES-D score. We also assessed the association between FJ OA and CES-D score, while adjusting for gender, age and BMI. All statistical analyses were performed using SAS software, (SAS Institute Inc, Cary, North Carolina, release 9.1).

Results

Table 1 lists the demographic characteristics of the 188 study participants. The study sample included 104 males (average age 51.90) and 84 females (average age 53.61). Mean BMI was 27.95 for males and 27.71 for females. 62 men and 56 women demonstrated at least one joint at spinal levels L2-S1 affected by FJ OA (grade≥2). Twenty men and 18 women reported LBP.

Table 2 presents the prevalence of FJ OA by age group and sex. No statistically significant differences were found with respect to the prevalence of FJ OA between males and females in any age group. However, a strong statistically significant pattern emerged for an increasing prevalence of FJ OA with increasing age. This relationship was observed for males, females and the total sample ($p=0.0070$, $p<0.0001$, $p<0.0001$, respectively). Interestingly, the highest prevalence of FJ OA was found in age group 60–69, where it reached 89.2.9% in total sample.

Table 3 shows the prevalence of FJ OA by spinal level in males, females and in the combined sample. The highest prevalence of FJ OA was found at the L4–L5 spinal level (38.24%, 53.75% and 45.05%, respectively). The second most prevalent level was L5-S1, followed by L3–L4 and L2–L3 levels. There was a trend towards more prevalent FJ OA in females at every spinal level, except L2–L3. Chi-square test demonstrated no statistically significant difference ($p>0.1$) between males and females at the L2–L3 and L3–L4 spinal levels. However, a significant difference was observed at spinal level L4–L5 ($\chi^2=7.01$, $P=0.037$) and the difference approached significance at level L5-S1 ($\chi^2=4.77$, $P=0.071$). Women demonstrated a higher prevalence of FJ OA compared to men at both the L4–L5 and L5-S1 levels.

Table 4 shows the prevalence of FJ OA among individuals with and without LBP subdivided by age group. No significant difference in the prevalence of FJ OA was identified between individuals with and without LBP for the study population as a whole or following subgroup analysis on the basis of age or sex.

Table 5 shows the results of multiple logistic regression analysis where LBP was a dependent variable and FJ OA at each spinal level, sex, age group, BMI and CES-D score were included as independent variables. There were no statistically significant associations found between LBP and the aforementioned predicting variables (p-value >0.05 for each association). In addition, no statistically significant associations were found while CES-D score was used as a dependent variable.

Discussion

This is the first cross-sectional study to describe the prevalence of lumbar FJ OA in a community-based population. The results show a high prevalence of FJ OA in men (59.6%) and women (66.7%).

The study also evaluates the association between FJ OA, identified by multi-detector CT imaging, and LBP in the community. We found no association between FJ OA at any spinal levels and the occurrence of LBP. This study supports similar negative results of a previous CT study [13] and several facet joint injection studies [12, 15, 36]. Based on the results of the present study, the use of CT as a single diagnostic modality for pain originating from facet joints cannot be supported.

The observation that the L4–L5 spinal level is associated with the highest prevalence of FJ OA is not surprising. Several previous studies [23, 37–40] have shown that facet joint degeneration develops much more rapidly at the L4–L5 motion segment than at any other level. Fujiwara et al. [34] found that the median grade of FJ OA at L4–5 was significantly higher than that at other lumbar spinal levels. It has been well-established that degenerative spondylolisthesis is associated with FJ OA and occurs most commonly at the L4–L5 level [39, 41]. A possible reason for the high prevalence and severity of FJ OA at the L4–L5 spinal level may be the relatively greater stability of the L5-S1 spinal segment compared to L4–L5. Greater stability arises from a more coronal orientation of the L5-S1 joints as opposed to the more sagittal orientation of the L4–L5 facet joints [42, 43], an increased pedicle-facet angle at

the L5-S1 level [43–45] and additional anatomic stability provided the fifth lumbar vertebra by large transverse processes supported by strong iliolumbar ligaments [46].

This study clearly shows that the prevalence of FJ OA increases with increasing age. This is in agreement with Lewin's [37] comprehensive anatomic review of lumbar synovial joints, which stated that the facet joints showed only minor cartilage changes before the age of 45. After age 45, advanced cartilage changes, subchondral sclerosis and osteophytes become common phenomena. Those findings were also confirmed in more recent studies [38, 40, 47–49]. However, the occurrence of FJ OA was found in this study even in individuals younger than 40. Tischer et al. 50 in a cadaveric study found significant cartilage changes in the lumbar spinal facet joints in young (<30) individuals suffering from LBP. Gries et al. [51] as well, in a histological study of young individuals (<40, mean age 29.1), found instances of partial or total loss of cartilage as well as cartilage replacement by pannus tissue in some cases. An even higher prevalence was reported by Eubanks et al. 23 in a recent cadaveric study in which FJ OA was present in 57% of 20- to 29-year-olds, 82% of 30- to 39-year-olds, 93% of 40- to 49-year-olds, 97% in 50- to 59-year-olds, and 100% in those >60 years old.

In the present study the highest prevalence of FJ OA was in the age group 60–69 with a slightly lower prevalence observed in individuals older than 70. This unexpected finding is most likely explained by random error due to the relatively small group of participants within the highest age group. Another more speculative explanation is the possible indirect association between FJ OA and decreased life expectancy. Previously, the prevalence of hand osteoarthritis has been found to be inversely correlated with survival rates [52]. Published data also suggest that osteoarthritis may be associated with risks for comorbid conditions such as cardiovascular disease/death [52–55], hypertension, chronic pulmonary disease [56, 57], peptic ulcer and renal diseases [58], gastritis and phlebitis [54, 55]. Possibly, the slightly lower prevalence of FJ OA in the oldest age group reflects these associations.

In the present sample we did not find statistically significant differences in any age group between males and females in terms of the general prevalence of lumbar FJ OA. This finding is in agreement with the study by Alperovitch-Najenson [49] that similarly found no sex difference in the prevalence of lumbar FJ OA. Fujiwara et al. [40] in a MRI study of 14 patients with degenerative disc disease also found no significant sex difference in the grade of FJ OA at each lumbar spinal level. In terms of specific spinal levels, however, the present study did reveal statistically significant differences in the prevalence of FJ OA between males and females of all ages at the L4–L5 spinal level with females demonstrating a significantly higher prevalence of FJ OA than males. This study supports the conclusions drawn by the meta-analysis of Srikanth et al. [57] that there is a gender difference in the prevalence and incidence of OA affecting the hand and knees, with females generally at higher risk. The findings are in contrast to another study suggesting that men have a greater prevalence of FJ OA than women at all lumbar levels [23].

A potential gender based difference in the prevalence of FJ OA is possible based on the fact that cartilage is a sex-hormone-sensitive tissue [60]. Ha et al. [61] performed an immunohistochemical study of the lumbar facet joints and demonstrated estrogen receptors in the facet cartilage and found that increased expression of estrogen receptors correlated directly with the severity of FJ OA. Fujiwara et al. [62] performed a cadaveric study in which lumbar spinal motion segments were compared between males and females with similar age, grade of disk degeneration, cartilage degeneration, and osteophytes. The female motion segments showed significantly greater motion in lateral bending, flexion and extension. Greater motion in spinal segment can lead to excessive wear and tear and therefore to higher prevalence of FL OA in females.

There are some limitations of the present study that are worthy of mention. This is a cross sectional sample and inferences of increasing facet joint prevalence with age are inferred by looking at individuals in different age groups rather than following them longitudinally. At present we have not adjusted for the presence of other important covariates such as prior spine surgery and occupation which could influence the presence of LBP. This would be important n future analyses.

Conclusions

This is the first CT-based study that describes the prevalence of lumbar FJ OA at different spinal levels in community-based population. The results of this study show a high prevalence of FJ OA (59.6% of males and 66.7% of females) that increases with age. The highest prevalence was observed at the L4–L5 spinal level. At lower spinal levels women have higher prevalence of lumbar FJ OA than men. In the present study no significant association was observed between FJ OA, identified by CT, at any spinal level and LBP.

Key points

- There is a high prevalence of FJ OA in the community-based population (59.6% of males and 6.7% of females).
- Prevalence of FJ OA increases with age and reaches 89.2% in individuals 60–69 years old.
- The highest prevalence of FJ OA is in L4–L5 spinal level.
- Individuals with FJ OA identified by CT at any spinal level showed no association with LBP.

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Table 1

Descriptive statistics of the studied sample. (n=188)

Frequencies	Males	Females
N	104	84
Age group <40	16	9
40–49	30	17
50–59	33	33
60–69	18	19
≥70	7	6
LBP	20	18
FJ OA (Grade≥2 at L2-S1 levels)	62 (59.61%)	56 (66.66%)
Mean values		
Age (years)	51.90	53.61
BMI (kg/m^2)	27.95	27.71
Depression (CES-D) score	6.31	9.03

Table 2

The prevalence of facet joint OA by age group and sex.

Age group	Males		Females		Total sample		χ^2-test (males vs. females by age group)
	N	%	N	%	N	%	
<40	5	31.3	1	12.5	6	24.0	P=0.6214
40–49	15	50.0	6	35.3	21	44.7	P=0.3299
50–59	22	66.7	27	84.4	49	74.2	P=0.1401
60–69	16	88.9	17	89.5	33	89.2	P=1.0000
≥70	4	57.1	5	83.3	9	69.2	P=0.2045
χ^2-test (Age groups)	**P=0.0070**		**P<0.0001**		**P<0.0001**		

Statistically significant at level p<0.05 marked bold.

Spine (Phila Pa 1976). Author manuscript; available in PMC 2011 January 17.

Spine (Phila Pa 1976). Author manuscript; available in PMC 2011 January 17.

Table 3

The prevalence of FJ OA by spinal level in males, females and in community-based population.

Spinal level	Males		Females		Total sample		χ2-test (males vs. females by spinal level)
	N	%	N	%	N	%	
L2–L3	17	16.50	11	13.75	28	15.05	P=0.6076
L3–L4	27	26.21	29	36.25	56	30.60	P=0.1439
L4–L5	39	38.24	43	53.75	82	45.05	**P=0.0368**
L5-S1	32	32.32	36	45.57	68	38.2	*P=0.0707*
χ2-test (spinal levels)	**P=0.0045**		**P<0.0001**		**P<0.0001**		

Statistically significant at level p<0.05 marked **bold**.

Statistically significant at level p<0.10 marked *Italic*.

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Table 4

The prevalence of facet joint OA by age group in individuals with and without LBP.

Age group	Males		Fisher's exact test (LBP vs. non-LBP by age groups for males)	Females		Fisher's exact test (LBP vs. non-LBP by age groups for females)	Total sample		Fisher's exact test (LBP vs. non-LBP by age groups)
	With LBP	Without LBP		With LBP	Without LBP		With LBP	Without LBP	
<40	1(33.3)	4(30.8)	P=1.0000	0(0.0)	1(14.3)	P=1.0000	1(25.0)	5(25.0)	P=1.0000
40–49	2(100.0)	13(46.4)	P=0.4828	1(50.0)	5(33.3)	P=1.0000	3(75.0)	18(41.9)	P=0.3112
50–59	4(44.4)	18(78.3)	P=0.0960	7(77.8)	20(87.0)	P=0.6042	11(61.1)	38(82.6)	P=0.1003
60–69	2(100.0)	14(87.5)	P=1.0000	6(100.0)	11(91.7)	P=1.0000	8(100.0)	25(89.3)	P=1.0000
≥70	0(0.0)	4(66.7)	P=0.4286	1(100.0)	4(100.0)	*	1(50.0)	8(80.0)	P=0.4545
All ages	9(52.94)	53(61.63)	P=0.5038**	15(78.95)	41(67.21)	P=0.3297***	24(64.86)	95(63.76)	P=0.9001

* Row or column sum is zero. No statistics computed for this table

** FJ OA by LBP for males

*** FJ OA by LBP for females

Table 5

Results of the multiple logistic regression analysis, where LBP (Yes vs. No) was used as a dependent variable.

Parameter	Odds Ratio Estimates		P-value
	Point Estimate	95% Wald Confidence Limits	
FJ OA L2L3 (Yes vs. No)	1.630	(0.547, 4.856)	0.3800
FJ OA L3L4 (Yes vs. No)	0.630	(0.221, 1.795)	0.3870
FJ OA L4L5 (Yes vs. No)	0.869	(0.336, 2.250)	0.7723
FJ OA L5S1 (Yes vs. No)	0.989	(0.413, 2.372)	0.9806
Sex (Female vs. Male)	1.465	(0.672, 3.196)	0.3368
Age group 70+ (vs. <40)	1.157	(0.162, 8.234)	0.9794
Age group 60–69 (vs. <40)	1.743	(0.372, 8.116)	0.3729
Age group 50–59 (vs. <40)	2.206	(0.605, 8.043)	0.0606
Age group 40–49 (vs. <40)	0.507	(0.112, 2.288)	0.0842
Depression (CES-D) score	0.998	(0.923, 1.079)	0.9593
BMI	1.043	(0.971, 1.121)	0.2437