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Using magnetic resonance imaging to determine the compartmental prevalence of knee joint structural damage

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Abstract

Objective—To describe the prevalence of magnetic resonance imaging (MRI) detected structural damage in the patellofemoral joint (PFJ) and tibiofemoral (TFJ) in a population-based cohort. A secondary aim was to evaluate the patterns of compartmental involvement in knees with pain, between men and women, and in different age and body mass index (BMI) categories.

Methods—We studied 970 knees, one knee per subject, from the Framingham Osteoarthritis Study, a population-based cohort study of persons 51–92 years old. Cartilage damage and bone marrow lesions (BMLs) were assessed using the Whole Organ Magnetic Resonance Imaging Score (WORMS). The prevalence of isolated PFJ, isolated TFJ, and mixed structural damage was determined using the following definitions: any cartilage damage, full thickness cartilage loss, any BML, and the combination of full thickness cartilage loss with any BML.

Results—The mean age and body mass index was 63.4 years and 28.6 m/kg^2, respectively; 57% were female. Isolated PFJ damage occurred in 15–20% of knees and isolated TFJ damage occurred in 8–17% of knees depending on the definition used. The prevalence of isolated PFJ damage was greater than isolated TFJ damage using all definitions except the any BML definition. This pattern was similar between genders and among age and BMI categories. In those with knee pain, isolated PFJ was at least as common as TFJ damage depending on the definition used.

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Contributions

All authors have contributed to the conception and design of the study; acquisition, analysis and interpretation of data; and drafting and final approval of the article. Dr Stefanik takes responsibility for the integrity of the work.

Competing interest statement

Dr. Guermazi has received consultancies, speaking fees, and/or honoraria from Genzyme, Stryker, Merck Serono, Novartis and Astra Zeneca. He is the President of Boston Imaging Core Lab (BICL), a company providing image assessment services. Dr. Roemer is Chief Medical Officer and shareholder of BICL and has received consultancies, speaking fees, and/or honoraria from Merck Serono and the National Institutes of Health.

Conclusion—Using MRI to assess knee joint structural damage, isolated PFJ damage was at least as common as, if not more common than, isolated TFJ damage.

Keywords

osteoarthritis; patellofemoral; magnetic resonance imaging

Introduction

Knee osteoarthritis (OA) occurs both in the patellofemoral (PFJ) and tibiofemoral joints (TFJ) and is a leading cause of disability and functional limitation [1]. It is important to know the compartmental distribution of knee joint structural damage so that treatments can be targeted to the affected compartment. Treatments that are effective for OA in the TFJ may not be effective for OA in the PFJ. Much research has focused on the TFJ OA including the development of rehabilitative and surgical treatments for knee OA. However, if PFJ involvement predominates, it may be important to focus more research efforts on this compartment and to identify subgroups with compartmental patterns to maximize treatment effectiveness.

Previous authors have described the compartmental prevalence and distribution of knee OA using radiographic assessment with different results as to which compartment is predominantly affected depending on the population studied (although only those with pain have been studied using radiographs). McAlindon, et al, found that isolated medial TFJ OA was more prevalent than isolated PFJ OA among men with knee pain, while isolated PFJ OA was more prevalent among women with knee pain [2]. In both men and women, mixed disease, i.e., combined TFJ and PFJ involvement, was the least common pattern. Davis, et al, using joint space width measurement of <3 millimeters (skyline for PFJ and posterior-anterior for TFJ) as a marker for OA, found among individuals with pain that isolated TFJ OA was the most common pattern followed by mixed disease; isolated PFJ OA was the least common pattern [3]. This pattern persisted when stratifying by gender. Duncan, et al, reported, isolated PFJ OA was more common than isolated TFJ OA among knees with pain, with the prevalence being 24% vs. 4%, respectively, with mixed disease being the most common pattern [4, 5].

The prevalence of PFJ and TFJ OA may be underestimated using radiographic assessment because of the inability to directly visualize cartilage and other soft tissues. Additionally, for the PFJ, the lateral radiographic view does not consistently allow for visualization of joint space narrowing, only osteophytes. Further, the sensitivity of the skyline view for the detection of PFJ OA is dependent on the angle of knee flexion and whether the beam angle is tangential to the patellar facets. Even more than the tibia in the TFJ, the cartilage covering PFJ is curved. This may make radiographs insensitive to detecting evidence of cartilage loss [6]. Magnetic resonance imaging (MRI) is able to provide images that permit detailed 3 dimensional tomographic assessment of the compartmental specific distribution of cartilage and bone marrow damage in both the TFJ and PFJ. Bone marrow lesions (BMLs) have been shown to be associated with cartilage damage and pain and are likely part of the OA disease process [7–10]. Therefore, we regard cartilage damage and BMLs as central features of OA for MRI assessment.

The purpose of this study was to describe the prevalence of MRI-detected structural damage in the PFJ and TFJ in a population-based cohort. In order to compare our estimates to previous studies, a secondary aim was to evaluate the patterns of compartmental involvement in knees with pain. We will also describe the prevalence between men and women, and in different body mass index (BMI) and age categories.

Methods

Knees for this study were selected from the Framingham Osteoarthritis (FOA) Study Community Cohort. In brief, the FOA study is a population-based sample of individuals over the age of 50 and ambulatory. Subjects were recruited by random digit dialing without regard for knee pain and those with inflammatory arthritis, bilateral total knee replacement, dementia, terminal cancer, or contraindications to MRI were excluded [11–14]. Of the 2582 individuals contacted, 1830 expressed interest initially, and 1039 were examined between 2002–2005. MRI scans of both knees were acquired using a 1.5-Tesla scanner (Siemens Medical Systems, Erlangen, Germany) with an eight-channel phased-array knee coil. Due to costs, only the right knees were read. Images from four pulse sequences were used in the assessment of OA features: axial, sagittal and coronal fat-suppression, proton density-weighted, turbo spin echo sequences (repetition time, 3610 msec; echo time, 40 msec; slice thickness, 3.5 mm; interslice gap, 0 mm; echo spacing, 13.2 msec; turbo factor, 7; field of view, 140 mm × 140mm; matrix 256 × 256) and sagittal T1-weighted spin echo sequence without fat-suppression (repetition time, 475 msec; echo time 24 msec; slice thickness, 3.5 mm; interslice gap, 0 mm; field of view, 140 mm × 140 mm; matrix, 256 × 256). Cartilage morphology and subchondral BMLs were assessed by two trained and experienced musculoskeletal radiologists (AG and FR) using the Whole Organ Magnetic Resonance Imaging Score (WORMS) [15]. The WORMS scoring system includes 5 subregions in the medial and lateral tibiofemoral compartments and 4 subregions in the patellofemoral compartment, for a total of 14 subregions. Cartilage signal and morphology are scored according to WORMS from 0 to 6 in the 14 articular surface regions: 0=normal thickness and signal; 1=normal thickness but increased signal on T2 weighted images; 2.0=partial thickness focal defect <1 cm in greatest width; 2.5=full thickness focal defect <1 cm in greatest width; 3=multiple areas of partial-thickness (Grade 2.0) defects intermixed with areas of normal thickness, or a Grade 2.0 defect wider than 1 cm but <75% of the region; 4=diffuse (≥75% of the region) partial-thickness loss; 5=multiple areas of full-thickness loss (grade 2.5) or a grade 2.5 lesion wider than 1 cm but <75% of the region; 6=diffuse (≥75% of the region) full-thickness loss. BMLs were assessed on fat-suppressed images; volume of BMLs was scored from 0–3 based on the extent of regional involvement (0=none; 1 = <25% of the subregion, 2 = 25–50% of the subregion; 3 = >50% of the subregion). The inter-rater weighted kappa for cartilage and BMLs were 0.73 and 0.67, respectively.

Compartmental involvement of structural damage visualized on MRI was defined in 5 ways: 1) any cartilage damage (WORMS ≥2; focal cartilage defect or superficial cartilage loss not extending to bone); 2) full thickness cartilage loss (WORMS 2.5, ≥5; cartilage loss extending to bone); 3) any bone marrow lesion (WORMS ≥1); 4) the combination of any cartilage damage with any BML 5) the combination of full thickness cartilage loss with any BML. The PFJ included the medial and lateral patellar and anterior femoral (trochlear) subregions. The TFJ included the medial and lateral tibial plateaus (central, anterior, and posterior subregions) and opposing central and posterior subregions of the femur. We determined the prevalence of structural damage as isolated PFJ, isolated TFJ, mixed (both PFJ and TFJ), or no damage. A compartment was determined to have structural damage if any subregion within a compartment met the above definitions.

In addition to estimating the population based prevalence of structural damage in the PFJ vs. TFJ, we also further evaluated the prevalence of compartment-specific structural damage in knees with pain on most days of the month, between males and females, across BMI categories (<25, 25–29, 30–34, >35), and age categories (50–59, 60–69, 70+).

Chi-square tests were used to compare the prevalence of compartmental distribution (isolated PFJ vs. isolated TFJ; isolated PFJ vs. mixed; isolated TFJ vs. mixed) of structural damage.

Results

970 knees, one knee per subject with complete MRI data, were used in the current study. The mean age and BMI was 63.4 (±8.8) years (range: 51–92) and 28.6 (±5.6) m/kg^2 (range: 16.6–55.6), respectively; 57% were female. Isolated PFJ damage occurred in 20, 19, 18, 20, and 15% of knees and isolated TFJ damage occurred in 10, 8, 17, 12, and 9% of knees using the five MRI-based definitions, respectively (Table 1).

Isolated PFJ damage was more common than isolated TFJ damage ($p<0.0001$) using all definitions except the any BML definition (Table 1). Additionally, when using the full-thickness cartilage damage (WORMS 2.5, ≥5) and the definitions of structural damage requiring a combination of cartilage damage and any BML, isolated PFJ damage was more common ($p<0.0002$) than mixed involvement (damage in both the PFJ and TFJ). Mixed damage was more common than isolated PFJ damage and isolated TFJ damage when using the any cartilage damage ($p<0.0001$) and any BML definition ($p<0.04$). When mixed damage was the most common pattern, we further evaluated which compartment was predominantly affected and found that the most severe lesion was more often in the PFJ rather than the TFJ.

Knees with pain had a similar prevalence of isolated PFJ and isolated TFJ structural damage using definitions that included a BML (Table 2). In knees with pain using the full thickness cartilage loss definition, isolated PFJ damage was greater than isolated TFJ damage (23.6 vs. 15.9, respectively; $p=0.05$) and mixed involvement (23.6 vs. 15.4, respectively; $p=0.04$) (Table 2). In general using all definitions, in knees without pain and in males and females, we found a similar pattern to the main analysis with isolated PFJ damage being greater than isolated TFJ damage (Table 2). Among BMI and age categories, isolated PFJ damage was more common than isolated TFJ damage for all definitions except the any BML definition (Table 3). Additionally, isolated PFJ damage was more common than mixed using more severe definitions that included full thickness cartilage loss.

Discussion

Using MRI to determine the distribution of structural features of OA (cartilage damage and BMLs), we have found that isolated PFJ structural damage is more common than isolated TFJ damage, with mixed damage the least common pattern. This pattern was similar between males and females and within BMI and age categories. In knees with pain the prevalence of isolated PFJ and isolated TFJ structural damage was similar using definitions that included BMLs while in the definitions using cartilage damage alone isolated PFJ damage was more common than isolated TFJ damage. While the high prevalence and impact of PFJ has been recognized before [1–3], our data suggest it may be the predominant compartment affected by knee OA.

Cartilage damage and BMLs may be the result of increased loading and stress in a joint. Joint stress is determined by the force transmitted through the joint per unit area (contact area). It is not known if or by what degree forces differ between the PFJ and TFJ during activities. A recent study has estimated PFJ forces using a musculoskeletal model and found that PFJ forces reached or exceeded TFJ forces during sit to stand activities and squatting [16]. PFJ forces exceeded three times the subjects' body weight during these activities. The anatomy of the PFJ would also suggest that there is significantly less contact area to spread

forces across compared to the TFJ. As a result of this decreased contact area, joint stress may be higher in the PFJ and this increased stress would over time cause damage to cartilage and underlying bone. For this reason, it is plausible that PFJ structural damage would be more common than TFJ damage.

Radiographic assessment of PFJ OA can be limited depending on the number and type of views used. The lateral view best visualizes patellar osteophytes but not joint space narrowing. A tangential (or skyline) view is needed to determine joint space narrowing in the PFJ, however these are difficult to acquire consistently in a large study population [17]. McAlindon, et al, using a PA and lateral view, reported the prevalence of isolated PFJ OA to be 11.0% and 24.3% in males and females with knee pain, respectively [2]. Duncan, et al, using three views (PA, lateral, and skyline) reported isolated PFJ OA to be 24% in males and females with knee pain [4, 5]. It is expected that using a skyline view the prevalence of PFJ ROA would be higher. Using MRI, we were able to directly visualize structural damage; therefore, the prevalence we report may accurately reflect the true compartmental distribution of knee joint structural damage. The population-based prevalence of isolated PFJ structural damage using MRI features of OA ranged from 15–20%. Using the full-thickness cartilage loss and combined full-thickness cartilage loss and BML definitions, isolated PFJ structural damage was not only more common than isolated TFJ damage but also more common than mixed disease. These definitions using more severe cartilage damage and the combination of cartilage and bone damage likely represent the OA disease process more than the any cartilage and any BML definition. These results suggest that the PFJ may be the most commonly affected compartment in knee OA. Additionally, our sample was recruited from the general population and not for the presence of knee pain as was done in the previous studies, and may be more generalizeable to the population.

Unlike our analyses of all knees, in knees with pain the pattern varied depending on the definition used. Isolated PFJ and TFJ damage were comparable when using definitions including a BML, either in isolation or with cartilage damage. Using the full thickness cartilage damage definition, isolated PFJ damage was more prevalent than isolated TFJ damage (23.6% vs. 15.9%, respectively; p=0.05). Our findings suggest that isolated PFJ damage is at least as common, if not greater than, isolated TFJ damage in knees with pain. Similar to our results, other studies have demonstrated in knees with pain that radiographic features of OA were more prevalent in the PFJ than in the TFJ [5, 18]. Furthermore, isolated radiographic PFJ OA [4] and decreased cartilage volume in the patella (but not tibia or femur) [19] has been shown to be associated with knee pain.

Our results combined with results from past studies suggest that PFJ OA may be at least as common as TFJ OA and if treatments for OA are going to be successful, the PFJ should be a target for intervention. Different patterns of knee OA may respond differently to the same treatments. Future studies should identify specific knee OA patterns and not assume a homogenous distribution of disease and determine treatments that are effective for different subgroups.

We recognize limitations to the current study. Currently there is no accepted and validated definition for knee OA on MRI. A MRI based definition of OA has been proposed [20], which uses different definitions for PFJ and TFJ OA and therefore was not usable for our purposes, we used the same definition to compare the prevalence between compartments. Since osteophytes are included in radiographic definitions of OA, we could have also included them here, but osteophytes are present on MRI in 74% of knees in this community based sample [21] and their prevalence would not have helped distinguish aspects of disease. We have used several definitions of structural damage and have found robust results with similar patterns among all of them.

In summary, isolated PFJ damage was more common than isolated TFJ damage using MRI to directly visualize structural damage (cartilage and bone) that is part of the OA disease process. Additionally, when mixed disease was the most common pattern, the PFJ had more severe damage. This pattern was similar between genders and BMI and age categories. In knees with pain, isolated PFJ damage is at least as common as isolated TFJ damage depending on the definition used. Intervention studies should identify sub-groups of knee OA patterns as these groups may respond differently to the same treatment regimen.

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Table 1

Compartmental prevalence (% of knees) of MRI-based definitions of structural damage (all knees, n=970)

	Prevalence (95% CI) of compartment involvement			p-value from Chi-square test		
Definition	**Isolated PFJ**	**Isolated TFJ**	**Mixed**	**PFJ vs. TFJ**	**PFJ vs. Mixed**	**TFJ vs. Mixed**
1.Any cartilage damage	20.4(17.9,22.9)	10.4(8.5,12.3)	44.2(44.1,47.4)	<0.0001	<0.0001	<0.0001
2.Full- thickness cartilage damage	18.6(16.1,21.0)	8.0(6.3,9.8)	7.8(6.1,9.5)	<0.0001	<0.0001	0.86
3. Any BML	17.9(15.5,20.4)	16.5(14.2,18.8)	21.8(19.2,24.3)	0.4	0.04	0.003
4. Any cartilage damage + any BML	20.1(17.6, 22.6)	11.9(9.8, 13.9)	17.8(15.4, 20.2)	<0.0001	0.2	0.0002
5. Full- thickness cartilage damage + any BML	15.2(12.9,17.4)	8.8(7.0,10.5)	4.4(3.1,5.7)	<0.0001	<0.0001	0.0001

CI=Confidence Interval, PFJ=Patellofemoral joint, TFJ=Tibiofemoral joint, BML=Bone marrow lesion

Table 2

Compartmental prevalence (% of knees) of MRI-based definitions* among knees with/without pain, males and females

		Prevalence (95% CI) of compartment involvement			p-value from Chi-square test		
	Knees	**Isolated PFJ**	**Isolated TFJ**	**Mixed**	**PFJ vs. TFJ**	**PFJ vs. Mixed**	**TFJ vs. Mixed**
Knees with pain	208 **						
Definition 1		13.5(8.8,18.1)	8.2(4.5,11.9)	64.4(57.9,70.9)	0.08	<0.0001	<0.0001
Definition 2		23.6(17.8,29.3)	15.9(10.9,20.8)	15.4(10.5,20.3)	0.05	0.04	0.90
Definition 3		17.3(12.2,22.4)	18.8(13.4,24.1)	34.6(28.2,41.1)	0.71	<0.0001	0.0003
Definition 4		20.2(14.7,25.6)	16.3(11.3,21.4)	30.8(24.5,37.0)	0.31	0.01	0.0005
Definition 5		18.8(13.4,24.1)	19.2(13.9,24.6)	9.1(5.2,13.0)	0.90	0.005	0.0032
Knees without pain	738 **						
Definition 1		22.8(19.7,25.8)	11.1(8.8,13.4)	38.2(34.7,41.7)	<0.0001	<0.0001	<0.0001
Definition 2		17.2(14.5,19.9)	5.7(4.0,7.4)	5.4(3.8,7.1)	<0.0001	<0.0001	0.82
Definition 3		18.2(15.4,20.9)	15.9(13.2,18.5)	17.9(15.1,20.7)	0.24	0.90	0.30
Definition 4		20.2(17.3,23.1)	10.6(8.4,12.8)	14.0(11.5,16.5)	<0.0001	0.002	0.05
Definition 5		14.2(11.7,16.7)	5.6(3.9,7.2)	3.0(1.8,4.2)	<0.0001	<0.0001	0.01
Male	415						
Definition 1		16.1(12.6,19.7)	13.3(10.0,16.5)	45.5(40.8,50.3)	0.24	<0.0001	<0.0001
Definition 2		15.2(11.7,18.6)	9.6(6.8,12.5)	7.5(4.9,10.0)	0.02	0.0005	0.26
Definition 3		14.9(11.5,18.4)	19.5(15.7,23.3)	21.4(17.5,25.4)	0.08	0.02	0.49
Definition 4		17.6(13.9,21.3)	15.9(12.4,19.4)	17.6(13.9,21.3)	0.52	1.0000	0.52
Definition 5		13.0(9.8,16.2)	9.6(6.8,12.5)	4.8(2.8,6.9)	0.13	<0.0001	0.007
Female	555						
Definition 1		16.1(12.6,19.7)	13.3(10.0,16.5)	45.5(40.8,50.3)	0.24	<0.0001	<0.0001
Definition 2		21.1(17.7,24.5)	6.8(4.7,8.9)	8.1(5.8,10.4)	<0.0001	<0.0001	0.42
Definition 3		20.2(16.8,23.5)	14.2(11.3,17.1)	22.0(18.5,25.4)	0.009	0.46	0.0008
Definition 4		22.0(18.5,25.4)	8.8(6.5,11.2)	18.0(14.8,21.2)	<0.0001	0.1	<0.0001
Definition 5		16.8(13.6,19.9)	8.1(5.8,10.4)	4.1(2.5,5.8)	<0.0001	<0.0001	0.006

* Definitions: 1) any cartilage damage (WORMS ≥2; focal cartilage defect or superficial cartilage loss not extending to bone); 2) full thickness cartilage loss (WORMS 2.5, ≥5; cartilage loss extending to bone); 3) any bone marrow lesion (WORMS ≥1); 4) the combination of any cartilage damage with any BML; 5) the combination of full thickness cartilage loss with any BML

** Pain assessment missing in 24 knees

Table 3

Compartmental prevalence (% of knees) of MRI-based definitions* among BMI and age categories

		Prevalence (95% CI) of compartment involvement		
	Knees	**Isolated PFJ**	**Isolated TFJ**	**Mixed**
BMI Categories				
Definition 1				
<25	261	22.6(17.5,27.7)	8.8(5.4,12.3)	39.5(33.5,45.4)
25-29	383	20.4(16.3,24.4)	12.0(8.8,15.3)	43.9(38.9,48.8)
30-34	197	18.8(13.3,24.2)	10.7(6.4,15.0)	45.7(38.7,52.6)
>35	116	17.2(10.4,24.1)	8.6(3.5,13.7)	54.3(45.2,63.4)
Definition 2				
<25	261	16.9(12.3,21.4)	6.5(3.5,9.5)	4.2(1.8,6.7)
25-29	383	18.0(14.2,21.9)	9.1(6.3,12.0)	7.0(4.5,9.6)
30-34	197	21.3(15.6,27.0)	6.1(2.8,9.4)	9.6(5.5,13.8)
>35	116	19.0(11.8,26.1)	11.2(5.5,16.9)	14.7(8.2,21.1)
Definition 3				
<25	261	16.5(12.0,21.0)	16.1(11.6,20.5)	19.5(14.7,24.4)
25-29	383	18.3(14.4,22.1)	18.5(14.6,22.4)	21.1(17.1,25.2)
30-34	197	18.3(12.9,23.7)	18.3(12.9,23.7)	21.8(16.1,27.6)
>35	116	18.1(11.1,25.1)	7.8(2.9,12.6)	30.2(21.8,38.5)
Definition 4				
<25	261	19.9(15.1,24.8)	11.5(7.6,15.4)	16.9(12.3,21.4)
25-29	383	19.8(15.8,23.8)	14.9(11.3,18.4)	18.8(14.9,22.7)
30-34	197	19.8(14.2,25.4)	14.7(9.8,19.7)	20.3(14.7,25.9)
>35	116	21.6(14.1,29.0)	6.9(2.3,11.5)	27.6(19.5,35.7)
Definition 5				
<25	261	13.0(8.9,17.1)	6.5(3.5,9.5)	3.4(1.2,5.7)
25-30	383	15.7(12.0,19.3)	9.1(6.3,12.0)	5.5(3.2,7.8)
30-35	197	18.8(13.3,24.2)	8.6(4.7,12.6)	5.1(2.0,8.1)
>35	116	17.2(10.4,24.1)	11.2(5.5,16.9)	9.5(4.2,14.8)
Age Categories				
Definition 1				
50-59	389	22.9(18.7,27.1)	10.0(7.0,13.0)	32.4(27.7,37.0)
60-69	340	20.0(15.7,24.3)	10.9(7.6,14.2)	47.9(42.6,53.3)
>70	241	17.0(12.3,21.8)	10.4(6.5,14.2)	58.1(51.9,64.3)
Definition 2				
50-59	261	16.7(13.0,20.4)	4.9(2.7,7.0)	4.1(2.1,6.1)
60-69	383	18.8(14.7,23.0)	9.4(6.3,12.5)	9.4(6.3,12.5)
>70	241	21.2(16.0,26.3)	11.2(7.2,15.2)	11.6(7.6,15.7)
Definition 3				
50-59	389	18.3(14.4,22.1)	16.2(12.5,19.9)	13.9(10.4,17.3)
60-69	340	17.9(13.9,22.0)	16.2(12.3,20.1)	24.4(19.8,29.0)

		Prevalence (95% CI) of compartment involvement		
	Knees	**Isolated PFJ**	**Isolated TFJ**	**Mixed**
>70	241	17.4(12.6,22.2)	17.4(12.6,22.2)	30.7(24.9,36.5)
Definition 4				
50-59	389	20.6(16.5,24.6)	10.3(7.3,13.3)	10.8(7.7,13.9)
60-69	340	20.6(16.3,24.9)	13.2(9.6,16.8)	22.6(18.2,27.1)
>70	241	19.1(14.1,24.0)	17.0(12.3,21.8)	29.0(23.3,34.8)
Definition 5				
50-59	389	14.7(11.1,18.2)	5.4(3.2,7.6)	2.1(0.6,3.5)
60-69	340	15.3(1.5,19.1)	9.7(6.6,12.9)	7.1(4.3,9.8)
>70	241	18.7(13.8,23.6)	12.4(8.3,16.6)	8.3(4.8,11.8)

*Definitions: 1) any cartilage damage (WORMS ≥2; focal cartilage defect or superficial cartilage loss not extending to bone); 2) full thickness cartilage loss (WORMS 2.5, ≥5; cartilage loss extending to bone); 3) any bone marrow lesion (WORMS ≥1); 4) the combination of any cartilage damage with any BML; 5) the combination of full thickness cartilage loss with any BML