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The prognostic and diagnostic value of FDG PET/CT for assessment of symptomatic osteoarthritis

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Abstract

Objective—The objective of this study was to assess the clinical significance of increased FDG uptake on PET/CT in joints for evaluation of symptomatic osteoarthritis (OA) and prediction of progression.

Methods—In this prospective study, shoulder, hip and knee joints were imaged in 65 patients undergoing routine FDG PET/CT imaging. Patients completed the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaire to assess joint pain, stiffness, and physical function. SUVs were measured in hip, knee, acromioclavicular (AC) and glenohumeral (GH) joints. Scout PET/CT images were evaluated for OA using the Kellgren and Lawrence (K/L) system. Patients were followed for five years to determine progression of OA based on follow-up imaging or surgical intervention.

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Results—SUV of knee ($r=0.309$, $p=0.0003$), hip ($r=0.260$, $p=0.0027$), AC ($r=0.186$, $p=0.0313$) and GH ($r=0.191$, $p=0.0271$) joints correlated with WOMAC overall scores. Furthermore, SUV of knee ($r=0.410$, $p<.0001$), hip ($r=0.203$, $p=0.0199$) and AC ($r=0.364$, $p<.0001$) joints correlated with K/L scores. SUV ROC AUCs were 0.734 (knee), 0.678 (hip), 0.661 (AC) and 0.544 (GH) for symptomatic OA detection based on WOMAC overall z-score greater or equal to 2. Compared with K/L score (HR=0.798, $p=0.5324$), age (HR=0.992, $p=0.8978$) and WOMAC overall score (HR=1.089, $p=0.1265$), only SUV (HR=5.653, $p=0.0229$) was an independent predictor of OA progression in the knees.

Conclusion—FDG PET/CT may be helpful with localization of painful abnormalities in the inflamed regions of the joints, which could potentially be used to direct individualized treatment in moderate and severe OA. Furthermore, SUV measurement on FDG PET/CT could serve as an inflammation activity index in the knees that may be predictive of outcomes and rate progression of OA.

Keywords

Osteoarthritis; SUV; Joint; FDG; PET; CT

Introduction

Osteoarthritis (OA) is a degenerative joint disease that involves cartilaginous degradation, subchondral bone sclerosis, and osteophyte formation [1]. OA affects millions of patients, resulting in mobility and pain symptoms, often involving the joints of the shoulders, hips, and knees [2]. More than 1 in 5 patients have self-reported and physician-diagnosed arthritis and this number is expected to increase by at least 25% in the next 20 years [3,4]. OA's effects on the large joints are particularly important, since treatment can require surgical intervention and it is the leading cause of surgical joint replacement [5]. Currently, the diagnosis of OA is based on self-reported clinical symptoms and physical and radiographic evaluation of the affected joints [6]. Various self-reporting questionnaires exist and have been evaluated, including the Western Ontario and McMaster University Osteoarthritis (WOMAC) Index, which is the most widely used and recommended index by the World Health Organization [7–9]. Radiographic evaluation is based on various measures, including joint space width, osteophyte formation, and subchondral sclerosis [6]. Multiple radiographic evaluation schemes have been used in the diagnosis and monitoring of OA. The Kellgren-Lawrence (K/L) grading system is a widely accepted standard radiographic measurement of joint degradation used for the radiographic diagnosis of OA [10,11].

OA of the major joints may be seen in patients with other morbid conditions, including those undergoing evaluation for malignant processes. 18-fluorodeoxyglucose (FDG) positron emission tomography (PET) has gained wide acceptance in clinical practice for staging, restaging and identifying recurrence of several malignancies [12–14]. FDG is a positron-emitting radiopharmaceutical that accumulates at sites of increased glucose metabolism [15]. Incidental uptake of FDG is frequently detected in the joints of patients undergoing PET evaluation and has been attributed to degenerative or inflammatory changes related to arthritis [16–18]. However, few studies have compared the symptomatic and radiologic findings of OA with FDG uptake on PET imaging, particularly using a well-accepted

questionnaire of OA diagnosis. Since the clinical significance of increased FDG uptake in the joints on PET/CT has not been well established, the purpose of this study is to evaluate the prognostic and diagnostic value of FDG PET for the identification and classification of OA of the shoulder, hip, and knee joints.

Materials and methods

Patients

Consecutive patients undergoing routine PET/CT imaging from December 2010 to December 2012 for various oncologic indications and satisfying the inclusion/exclusion criteria were enrolled in this prospective study. The inclusion criteria were: (a) agreement to complete a WOMAC Osteoarthritis Index questionnaire and (b) agreement to be imaged with PET/CT below the knees. Patients were excluded if they had indications that would interfere with FDG uptake measurements of the joint spaces, including known primary bone tumors, osseous metastases, Paget's disease, gout or hyperuricemia, rheumatoid arthritis, seronegative spondyloarthropathy, infectious arthritis, joint infection, previous osseous surgery or serious trauma of the evaluated joints, history of hypercalcemia or hyperparathyroidism, known collagen disorders or glucose > 200 mg/dL [19–26]. This HIPAA compliant study was approved by the Institutional Review Board and the Radiation Safety Committee. All patients undergoing PET/CT imaging at our institution signed informed consent documents.

Self-Assessment of Symptomatic Osteoarthritis

Patients were provided with a WOMAC Version LK3.1 questionnaire, combined with a self-assessment of shoulder osteoarthritis (SASO) questionnaire. The patients were asked to complete the questionnaires with questions divided into three sections: pain, stiffness, and physical function, for shoulders, hips, and knees. The Likert grading scale was used in both the WOMAC and SASO questionnaires with the following possible scores and responses: (0) none, (1) mild, (2) moderate, (3) severe, and (4) extreme. Sums of scores were calculated for each section.

PET/CT imaging

Patients were instructed to fast for 6 hours prior to injection of the [¹⁸F]-Fluorodeoxyglucose (FDG). Blood glucose levels were measured prior to injection of FDG. Measured glucose levels were recorded at 99.69 ± 19.78 mg/dL. Mean intravenous radiopharmaceutical dose of FDG was 629 ± 69.56 MBq. Standard PET/CT clinical imaging protocol was initiated 60 minutes after initial FDG radiopharmaceutical injection. The patients underwent PET/CT imaging using a Discovery VCT 64-slice multidetector scanner (General Electric Healthcare, Waukesha, WI). A CT scout image was obtained and included the top of the skull to below the knees. A low mA CT scan was then performed for attenuation correction of the PET images using a low-dose protocol (30–100 mAs, 140 kV, slice thickness of 3.7 mm), extending to include the entire knees. Static, 3D PET emission images were acquired (2–3 minutes per bed position). Transaxial, coronal, and sagittal images were corrected for dead-time, decay, and photon attenuation, and reconstructed in a 128×128 matrix. The images were reconstructed using two iterations and 20 subsets with a

6.0 mm full width half-maximum post-filter and a fully 3D maximum likelihood ordered subset expectation maximization reconstruction algorithm.

Radiographic and FDG PET/CT Evaluation of Joints

CT scout images were reviewed by two radiologists (4 years of experience and 2 years of experience) using AGFA Impax 6 (Agfa-Gevaert N.V., Mortsel, Belgium) to evaluate knee, hip, glenohumeral (GH) and acromioclavicular (AC) joints. Inconclusive findings were discussed with a third radiologist (over 10 years of experience) until agreement was reached. A modified K/L grading system was used to evaluate and score arthritic changes in the shoulders, hips, and knees to more closely approximate the Likert grading scale of the WOMAC questionnaire, as follows: (0) None - no degenerative changes; (1) Mild - minimal joint space narrowing (JSN) and/or early osteophyte formation (peaking of the tibial eminences); (2) Moderate – mild JSN, marginal osteophytosis and early subchondral sclerosis and/or cyst formation (curtain osteophytes on the femoral head or neck); (3) Severe - moderate JSN, marginal osteophytosis, more advanced subchondral sclerosis and cyst formation, +/- presence of intraarticular bodies; (4) Extreme – severe JSN, altered clavicular, acromial morphology, humeral, glenoid, femoral, acetabular and/or tibial morphology.

The two radiologists reviewed co-registered PET/CT images at least two weeks before or after reviewing the CT scout images. Joint spaces were identified in the AC, GH, hip and knee joints on coronal PET/CT images and maximal Standardized Uptake Values (SUV) normalized for body mass were measured in each joint by thresholding the PET images.

In March 2016, all patient medical records and images available on Picture Archiving and Communication System (PACS) were reviewed by the two radiologists blinded to PET and K/L grading system findings to evaluate for progression of OA using available radiographs, CT scout images and MRI images. An increase in K/L grading system or placement of new prosthesis constituted progression of OA. Inconclusive findings were discussed with the third radiologist until agreement was reached. The time from PET/CT imaging to OA progression was recorded.

Statistical Analysis

Mean K/L grading system scores and mean SUVs between the two observers were used in subsequent analyses. Pearson correlation coefficients and p values were calculated between the SUV and K/L, WOMAC pain, stiffness, physical function and overall scores using Matlab Statistics and Machine Learning Toolbox (MathWorks, Natick, Massachusetts).

Receiver operating characteristic (ROC) curves and respective areas under the curves (AUCs) were estimated using SPSS Statistics (IBM Corporation, Armonk, New York) for SUV and K/L in GH, AC, hip and knee joints for detection of joint pain, decreased function and stiffness and overall symptomatic OA. Decision thresholds (DT) for the calculation of AUCs in the detection of symptomatic OA were based on setting WOMAC z-scores at 0, 1 and 2.

A Cox proportional hazards model was generated with Matlab to determine predictors of OA progression by independently and then simultaneously entering patient age, SUV, K/L, age and WOMAC total score into the analysis for knee joints. Hazard ratios (HR) and p values were calculated. Kaplan Meier curve was generated for SUV of the knee joints with Matlab.

Interobserver agreement between the two radiologists was evaluated for SUV (categories $SUV \geq 2$ and $SUV < 2$, based on outcome results) and for K/L (categories grade 0 - 4) using Cohen's Kappa coefficient with SPSS Statistics.

Results

Patients and Joints Evaluated

79 patients agreed to participate in the study, complete the WOMAC survey and undergo PET/CT imaging that included the knees. Four patients were excluded due to bone metastases. One patient was excluded due to an overactive bone marrow observed on image analysis, which obscured the SUV findings within the joint space. One patient was excluded due to elevated glucose levels ≥ 200 mg/dL prior to PET/CT imaging. Eight patients were excluded due to inadequate questionnaire information or incomplete imaging. The final study group consisted of 65 patients (39 females, 26 males; mean age of 57, range 18-82 years; mean weight of 77.39 ± 18.09 kg; mean height 1.67 ± 0.01 m; mean joint K/L 0.76 ± 0.84 ; mean joint SUV 1.17 ± 0.51). A total of 130 knee joints and 130 hip joints were assessed. A total of 124 AC and 124 GH joints were evaluated. 234 joints were rated as K/L of 0 at baseline, 178 joints at 1, 83 joints at 2, 9 joints at 3, and 4 joints at 4.

Interobserver Agreement and Correlations

Interobserver agreement was moderate for SUV in assessment of the knees and substantial for SUV in evaluation of all other joints, as seen in Table 1. With the exception of WOMAC stiffness scores for AC and GH joints, all WOMAC scores correlated with joint SUVs, as depicted in Table 2. Furthermore, SUV correlated with K/L for all joints other than GH. Except for SUV of the hips, the SUV and K/L measurements correlated with age for all joints, as shown in Table 3.

ROC AUC and Outcome Results

SUV and K/L ROC AUCs for WOMAC pain, stiffness, physical function and total scores are shown in Tables 4 - 7 for all joints examined. With DTs set at WOMAC z-scores of 2, largest ROC AUCs for SUV were observed in the knee joints for WOMAC overall and pain results ($AUC = 0.743$) and in the hips for WOMAC overall results ($AUC = 0.678$). Largest ROC AUCs for K/L were observed in the knee joints for WOMAC overall and pain results ($AUC = 0.783$ and 0.845). Follow-up imaging was available for 19 knee joints. OA progressed in 6 knee joints and was stable in 13. SUV ($HR = 5.653$, $p = 0.0229$), K/L score ($HR = 0.798$, $p = 0.5324$), Age ($HR = 0.992$, $p = 0.8978$) and WOMAC score ($HR = 1.089$, $p = 0.1265$) variables were entered simultaneously into the Cox proportional hazards model and only SUV was found to be an independent predictor of OA progression in the knees. A Kaplan-Meier curve was generated to depict progression of OA in the knees over time for patients with $SUV < 2$ and $SUV \geq 2$, as shown in Figure 1. Figure 2 demonstrates FDG

PET/CT images of the right knee in a 67-year-old woman, showing increased FDG uptake in the knee joint and elevated K/L. The patient later underwent total right knee arthroplasty due to progression of OA.

Discussion

This study assessed the diagnostic performance of increased FDG uptake on PET/CT in the joints for evaluation of OA. In the 130 knee joints studied, both SUV and K/L exhibited high to moderate utility for detection of symptomatic joint dysfunction related to OA. SUV demonstrated an ROC AUC of 0.734 for detection of overall knee joint dysfunction and also for identification of joint pain based on the WOMAC questionnaire. Similarly, Hong et al. studied changes on PET/CT in 166 knees, showing that SUV_{mean} of joint and the intra-articular SUV_{max} exhibit higher values in clinical and radiological OA than in normal joints ($p < 0.01$) [27]. In the 130 hip joints and 124 AC and GH joints included in this study, the SUV exhibited moderate utility for detection of symptomatic joint dysfunction related to OA and K/L score demonstrated moderate to low utility. SUV ROC AUCs in the hips were greater or equal to 0.65 for all WOMAC scores. Prior studies, for example by Kobayashi et al., demonstrated that 18F-fluoride PET shows a significantly higher SUV_{max} for progressive-stage OA cases with higher K/L than for early-stage cases and significantly higher SUV_{max} in cases with severe pain [28, 29]. However, these authors did not explore the relationship between FDG uptake and K/L or symptoms to compare with our results. Overall, little work has been done to assess the significance of FDG uptake in the joints and our results demonstrate that SUV could serve as a useful inflammation activity index in the assessment of symptomatic OA.

OA can be diagnosed with reasonable certainty based on history and physical examination while radiographs may be used to confirm the diagnosis [30, 31]. Due to greater cost of PET/CT compared to X-rays, it would be much less likely for FDG SUV to be used as a screening tool or first-line imaging test compared with less expensive modalities for the diagnosis of OA, particularly when the symptoms are mild. Instead, a potential role of FDG PET/CT could be to improve localization of painful abnormalities in the inflamed joints to direct individualized treatment in moderate and severe OA. In this study, the ROC AUCs were largest for FDG PET/CT in the detection of more severe OA (greater WOMAC z-scores, Tables 4–7) and PET images often demonstrated focal or localized rather than diffuse uptake in the joints. Although the pathologic process of OA cannot be reversed using current clinically available therapies, symptoms can be managed with general and individualized therapies. Mild (WOMAC z-score from 0 to 1) and even moderate (WOMAC z-score of 1 to 2) OA symptoms of pain and stiffness can typically be relieved with lifestyle changes such as weight loss and exercise as well as medications such as nonsteroidal anti-inflammatory drugs, acetaminophen and tramadol according to ACR guidelines [32]. For these systemic therapies, exact localization of pain within a joint is not important and the same treatment is applied to the general patient population with mild to moderate OA. However, in patients who have failed to respond to medications or have severe OA (WOMAC z-score of 2 or greater), invasive procedures such as intra-articular corticosteroid injections, osteotomies to shift weight away from the symptomatic part of the joint, and partial or complete joint replacement may be necessary to relieve the symptoms. For these invasive procedures,

knowledge of the location of pain in the joint may be helpful in directing therapy and improving the effectiveness of the treatment. If a single region within a joint, for example, is responsible for pain, that area of inflammation could potentially be localized with PET/CT at the site of most intense FDG uptake and targeted with an injection. If surgery is required, it would be to the patient's greatest benefit to salvage as much of the native joint as possible rather than proceeding to a complete joint replacement and FDG PET/CT could potentially locate the inflamed region of the joint that should be replaced. Nevertheless, prospective multi-center clinical trials would be needed to assess the effectiveness of FDG PET/CT in directing individualized therapies for severe OA.

In addition to the evaluation of diagnostic performance of SUV and K/L score on FDG PET/CTs for detection of symptomatic OA in the joints, the aim of this study was to also assess their prognostic significance. Follow-up imaging was available for knee joints and our results indicate that only SUV was an independent predictor of OA progression in the knees, when compared with K/L score, age and WOMAC score. Specifically, progression of OA in the knees was greater for patients with SUV ≥ 2 , as shown in Figure 1. These results suggest that SUV may be a useful biomarker for detection of the rate of OA progression as well as symptomatic severity while K/L score is more representative of the severity of OA at the time of imaging. Our findings are consistent with a reported rat study in which Paquet et al. showed that FDG uptake increased with the progression of arthritis in a rat arthritis model. In this animal study FDG accumulation in arthritis reflected proliferating pannus and inflammatory activity enhanced by inflammatory cytokines, suggesting that FDG PET was effective for quantifying the inflammatory activity of arthritis and/or its therapeutic response [33]. This molecular mechanism may contribute to increased FDG uptake in OA, reflecting the rate of disease progression.

The main limitation of this study was related to the method of anatomical assessment of bony changes of the joints using CT scout images, particularly for the knees, since the CT scout images are non-weight bearing. Though the K/L grading system of knee joints was originally developed for X-ray images, few patients enrolled in the study had X-rays of the joints initially available for review on PACS. Furthermore, only coronal PET/CT images were used for measuring SUV in the joint spaces. Nevertheless, coronal images are the easiest to use in order to localize the region of highest FDG uptake in the joint space.

In conclusion, increased FDG uptake in the joints on FDG PET/CT could be helpful with localization of painful abnormalities in the inflamed regions of the joints to direct individualized treatment in moderate and severe OA. Furthermore, SUV measurement on FDG PET/CT in the knees may serve as a biomarker for rate of progression of OA.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Fig. 1.
Knee joint Kaplan-Meier curve showing progression of OA in the knees for patients with SUV < 2 (continuous line) and SUV ≥ 2 (dashed line)

Fig. 2.

(a-i) PET/CT coronal (a-c) and sagittal images (d-f) of the right knee, obtained after injection of 620.1 MBq (16.76 mCi) of FDG in a 67-year-old woman with Non-Hodgkin's lymphoma demonstrate increased FDG uptake in the knee joint with SUV of 2.2. K/L grade was 3 on PET/CT scout image (g). 441 days later, weight bearing diagnostic radiographs (h) were obtained to evaluate severe right knee pain and showed degenerative joint disease, most severe in medial femorotibial compartment with varus angulation. 69 days later, patient underwent total right knee arthroplasty and radiograph (i) demonstrated normal appearance of the prosthesis. WOMAC scores for the right knee were: pain = 3/20, stiffness = 0/8, physical function = 8/68, overall = 11/96.

Table 1

Cohen's kappa coefficients between two observers for SUV and K/L. Fair agreement is defined as kappa 0.21-0.40. Moderate agreement is defined as kappa 0.41-0.60. Substantial agreement is defined as kappa 0.61-0.80.

	SUV	K/L (Weighted)
Knee	0.549	0.759
Hip	0.659	0.506
Acromioclavicular	0.699	0.587
Glenohumeral	0.792	0.381

SUV, Standardized Uptake Value; K/L, Kellgren/Lawrence

Table 2

Pearson correlation coefficients between joint SUVs and K/L, WOMAC pain, stiffness, physical function and total scores with corresponding p values.

	Knee SUV		Hip SUV		AC SUV		GH SUV	
	r	p	r	p	r	p	r	p
K/L	0.410	<0001	0.203	0.0199	0.364	<0001	0.170	0.0514
WOMAC Pain	0.340	<0001	0.190	0.0295	0.206	0.0170	0.231	0.0071
WOMAC Stiffness	0.294	0.0007	0.184	0.0357	0.118	0.1745	0.086	0.3253
WOMAC Physical Function	0.296	0.0006	0.283	0.0011	0.180	0.0369	0.188	0.0299
WOMAC Total Score	0.309	0.0003	0.260	0.0027	0.186	0.0313	0.191	0.0271

SUV, Standardized Uptake Value; K/L, Kellgren/Lawrence; WOMAC, Western Ontario and McMaster University Osteoarthritis Index; r, Pearson correlation coefficient; AC, Acromioclavicular; GH, Glenohumeral

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Table 3

Pearson correlation coefficients between patient age and joint SUVs and K/L with corresponding p values.

	Knee		Hip		AC		GH	
	r	p	r	p	r	p	r	p
SUV	0.303	0.0007	0.033	0.7153	0.448	<.0001	0.387	<.0001
K/L	0.220	0.0204	0.397	<.0001	0.512	<.0001	0.330	0.0001

SUV, Standardized Uptake Value; K/L, Kellgren/Lawrence; r, Pearson correlation coefficient; AC, Acromioclavicular; GH, Glenohumeral

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Knee joint ROC AUCs for SUV and K/L rating in the detection of pain, stiffness and decreased physical function based on WOMAC results. z-scores of 0, 1 and 2 were used as DTs for WOMAC to calculate ROC AUCs.

Table 4

WOMAC z-score	Knee WOMAC Overall (/96)			Knee WOMAC Pain (/20)			Knee WOMAC Stiffness (/8)			Knee WOMAC Physical Function (/68)		
	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC
0	15	0.631	0.657	3	0.633	0.656	1	0.611	0.617	11	0.589	0.64
1	38	0.628	0.623	8	0.68	0.635	3	0.616	0.627	27	0.573	0.623
2	61	0.734	0.783	13	0.734	0.845	5	0.657	0.646	44	0.639	0.577

ROC-AUC, Receiver Operating Curve-Area Under Curve; SUV, Standardized Uptake Value; K/L, Kellgren/Lawrence; WOMAC, Western Ontario and McMaster University Osteoarthritis Index; DT, Decision threshold

Hip joint ROC AUCs for SUV and K/L rating in the detection of pain, stiffness and decreased physical function based on WOMAC results. z-scores of 0, 1 and 2 were used as DTs for WOMAC to calculate ROC AUCs.

Table 5

WOMAC z-score	Hip WOMAC Overall (/96)			Hip WOMAC Pain (/20)			Hip WOMAC Stiffness (/8)			Hip WOMAC Physical Function (/68)		
	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC
0	11	0.601	0.569	2	0.598	0.545	1	0.552	0.539	8	0.601	0.569
1	30	0.658	0.526	6	0.584	0.554	3	0.594	0.541	21	0.675	0.488
2	48	0.678	0.536	10	0.653	0.458	4	0.651	0.530	35	0.649	0.482

ROC-AUC, Receiver Operating Curve-Area Under Curve; SUV, Standardized Uptake Value; K/L, Kelgren/Lawrence; WOMAC, Western Ontario and McMaster University Osteoarthritis Index; DT, Decision threshold

Table 6

Acromioclavicular joint ROC AUCs for SUV and K/L rating in the detection of pain, stiffness and decreased physical function based on WOMAC results. z-scores of 0, 1 and 2 were used as DTs for WOMAC to calculate ROC AUCs.

WOMAC z-score	AC WOMAC Overall (/96)			AC WOMAC Pain (/20)			AC WOMAC Stiffness (/8)			AC WOMAC Physical Function (/68)		
	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC
0	6	0.565	0.435	1	0.616	0.511	1	0.558	0.425	4	0.565	0.425
1	16	0.607	0.461	3	0.623	0.468	2	0.571	0.454	11	0.659	0.456
2	25	0.661	0.448	5	0.600	0.402	4	0.603	0.439	17	0.630	0.418

ROC-AUC, Receiver Operating Curve-Area Under Curve; SUV, Standardized Uptake Value; K/L, Kelgren/Lawrence; WOMAC, Western Ontario and McMaster University Osteoarthritis Index; DT, Decision threshold; AC, Acromioclavicular

Table 7

Glenohumeral joint ROC AUCs for SUV and K/L rating in the detection of pain, stiffness and decreased physical function based on WOMAC results. z-scores of 0, 1 and 2 were used as DTs for WOMAC to calculate ROC AUCs.

WOMAC z-score	GH WOMAC Overall (/96)			GH WOMAC Pain (/20)			GH WOMAC Stiffness (/8)			GH WOMAC Physical Function (/68)		
	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC	DT	SUV AUC	K/L AUC
0	6	0.526	0.382	1	0.615	0.454	1	0.531	0.454	4	0.519	0.362
1	16	0.590	0.370	3	0.618	0.408	2	0.516	0.434	11	0.615	0.374
2	25	0.544	0.382	5	0.630	0.373	4	0.540	0.460	17	0.565	0.367

ROC-AUC, Receiver Operating Curve-Area Under Curve; SUV, Standardized Uptake Value; K/L, Kellgren/Lawrence; WOMAC, Western Ontario and McMaster University Osteoarthritis Index; DT, Decision threshold; AC, Glenohumeral