Osteoarthritis and Cartilage 21 (2013) 535–543

Osteoarthritis and Cartilage

Correlations between radiographic assessments and MRI features of knee osteoarthritis – a cross-sectional study

H. Gudbergsen †, L.S. Lohmander ‡§‖, G. Jones ¶, R. Christensen †§, E.M. Bartels †, B. Danneskiold-Samsøe †#††, H. Bliddal †#††, M. Boesen †‡‡*

† The Parker Institute, Department of Rheumatology, Copenhagen University Hospital at Frederiksberg, Denmark
‡ Department of Orthopaedics, Clinical Sciences Lund, University of Lund, Sweden
§ Institute of Sports Science and Clinical Biomechanics, University of Southern Denmark, Denmark
‖ Department of Orthopaedics and Traumatology, University of Southern Denmark, Denmark
¶ Menzies Research Institute Tasmania, University of Tasmania, Australia
# Faculty of Health Sciences, University of Copenhagen, Denmark
†† SMI, Aalborg University, Denmark
‡‡ Department of Radiology, Copenhagen University Hospital at Frederiksberg, Denmark

ARTICLE INFO

Article history:
Received 15 March 2012
Accepted 18 December 2012

Key words:
MRI
Knee osteoarthritis
Radiography
X-ray
KOA
Kellgren & Lawrence
KL
BLOKS

SUMMARY

Objectives: To assess correlations between Kellgren & Lawrence (KL) gradings, minimum joint space width (mJSW) measurements and the Boston Leeds Osteoarthritis Knee Score (BLOKS) within a cohort of obese patients with knee osteoarthritis (KOA).
Methods: 192 Participants were recruited from an outpatient clinic (ClinicalTrials.gov: NCT00655941). Inclusion criteria were age ≥50 years, body mass index (BMI) ≥30 kg/m^2 plus symptomatic and verified KOA. 1.5 T magnetic resonance imaging (MRI) scans were assessed using BLOKS and bi-plane radiography by mJSW and KL. Statistics used were Spearman rank correlation coefficients.
Results: The average patient was 63 years of age, female and had a BMI of 37. KL gradings correlated to cartilage damage, bone marrow lesions and meniscus pathology ($r = 0.15–0.76$) and similar results were found for the relationship between BLOKS and mJSW. BLOKS assessed knee joint pathology co-segregated with compartment and grade specific KL ($P < 0.0001$). BLOKS variables were statistically significant correlated, particularly in the medial tibiofemoral compartment ($r = 0.42–0.80$). Adjusting for age, gender and BMI did not alter these associations.
Conclusion: Extensive pathological damage is present even in mild radiographic KOA and BLOKS gradings and KL scores increase together. Analyses of compartment specific KL scores revealed differences in their relationship to the assessed MRI variables. Our study displays the segregation of MRI gradings with respect to location and level of radiographic scores, reveals a high inter-dependency of MRI-assessed structures, and describes some redundancy of specific BLOKS variables.

Introduction

Osteoarthritis in the knee is a disabling condition frequently seen in elderly and obese patients[1,2]. It is diagnosed according to the American college of Rheumatology (ACR) criteria, and conventional radiography (CR) is often used for simple, fast, and low-cost assessments of structural change[3,4]. Structural damage may be radiographically assessed by measuring the joint space width (JSW), semi-quantitatively by using the Osteoarthritis research society international (OARSI) atlas or according to the Kellgren & Lawrence (KL) grading scheme[4–7]. According to the Food and Drug Administration, the only accepted endpoint for the assessment of structural damage in clinical trials of knee osteoarthritis (KOA) is to assess joint space loss by JSW measurements. However, KOA is phenotypically heterogeneous and current radiographic grading systems are not optimal outcome measures for specific structural changes[8–10].

Magnetic resonance imaging (MRI) is used to explore the structural changes in knee joint tissues. Much of the current

* Address correspondence and reprint requests to: M. Boesen, The Parker Institute, Department of Rheumatology, Copenhagen University Hospital at Frederiksberg, Nordre Fasanvej 57, Road 8, Entrance 19, DK-2000 Frederiksberg, Denmark. Tel: 45-38164154.
E-mail addresses: drhg@dadlnet.dk, henrikgudbergsen@hotmail.com (H. Gudbergsen), stefan.lohmander@med.lu.se (L.S. Lohmander), graeme.jones@utas.edu.au (G. Jones), robin.christensen@frh.regionh.dk (R. Christensen), emb@frh.regionh.dk (E.M. Bartels), bds@frh.regionh.dk (B. Danneskiold-Samsøe), henning.bliddal@frh.regionh.dk (H. Bliddal), parker@frh.regionh.dk, mikael.boesen@gmail.com (M. Boesen).

1063-4584/$ – see front matter © 2013 Published by Elsevier Ltd on behalf of Osteoarthritis Research Society International.
http://dx.doi.org/10.1016/j.joca.2012.12.010

research is focused on the development and validation of objective methods to assess joint structures, to diagnose and monitor joint diseases, and to determine the effect of interventions. Amongst these methods are ways of calculating cartilage volume, quantifying the content of glycosaminoglycans in the cartilage, evaluation of cartilage morphology, thickness, and surface curvatures, as well as an overall assessment of knee joint structures[11–16]. No report has yet presented data comparing the semi-quantitatively MRI score BLOKS (Boston Leeds Osteoarthritis Knee Score) with KL scores and JSW measurements, and neither has any whole organ MRI assessment been analysed based on a compartmental segregation of the knee[17–19]. MRI has still not replaced CR as a standard procedure, and a better understanding of the relationship between the two imaging modalities may lead to an improved use of the two in both daily clinic and research. The aim of this study was to assess correlations between radiographic gradings and MRI-assessed KOA features within a large cohort of obese elderly patients.

Methods

Patient population

192 Participants were recruited November 2007–August 2008 from the outpatient clinic at the Department of Rheumatology, Frederiksberg Hospital, Denmark, to take part in a clinical trial (ClinicalTrials.gov identifier: NCT00655941)[20]. Patients were recruited by referral from general practitioners (GPs) in the local community, from advertisements brought in local papers and from the local department of rheumatology. Screening of possible participants was performed by a formalized telephone interview. Of the 388 screened subjects 187 patients were ineligible and nine patients declined to participate in the trial. 192 Patients remained for inclusion; further details have been published[20].

To be eligible for inclusion individuals had to be over 50 years of age, have a body mass index (BMI) $\geq$30 kg/m^2, and show primary KOA diagnosed according to the ACR-criteria with clinical symptoms as well as a verified diagnosis obtained from either radiographs or arthroscopy[21]. All patients signed and approved the informed consent, and radiographs, clinical examinations, MRI, as well as blood- and joint-fluid samples, were performed after inclusion. All image analyses were performed on MRI scans and radiographs obtained subsequent to inclusion.

Patients were not included if any of the following criteria were present: lack of motivation for weight reduction; insufficient verbal or intellectual understanding; planned anti-obesity operation; former or planned knee joint replacement; in pharmacologic treatment for obesity; medical disease that prevents physical training; active joint disease besides KOA; significant hip osteoarthirtis; toe or foot deformity which influences gait analysis; use of morphine (non-steroidal anti-inflammatory drugs, acetylsalicylic acid and/or paracetamol were accepted and registered for each patient). No patient was excluded due to their medical disease.

The study was approved by the local ethical committee of The Capital Region of Denmark [H-B-2007-088] and was carried out in accordance with the Helsinki Declaration II and the European Guidelines for Good Clinical Practise.

Conventional radiographic measurements

Bi-plane weight-bearing non-fluoroscopic semi-flexed radiographs were taken at baseline of the target knee using a Philips Optimus apparatus with a film-focus distance of 1.5 m. One radiograph was taken in the postero-anterior view in which the patients bend their legs approximately 20°. All patients had their feet rotated outwards, leaned their knees forward on the film cassette and had the tip of their big toe vertically aligned with this cassette. Another radiograph was taken in the lateral view, and the protocol ensured that all cases had their legs bend 10° and that all weight was leaned on to the target knee. In case of bilateral symptoms we used the most symptomatic knee.

Radiographs were scored according to the OARSI atlas and KOA staging according to the KL grading scheme was performed by MB[3]. The three knee compartments (the medial and lateral tibiofemoral (TF) and the patellofemoral (PF)) were graded separately. While the original grading by KL did not deal with the assessment of the PF compartment we aimed to perform and explore a radiographic assessment of all three compartments and thus applied the KL criteria for TF KOA to the PF compartment[10]. HG performed all the assessments of the TF minimum JSW (mJSW) in the most affected compartment[22].

MRI acquisition

Baseline MRI was obtained of the target knee using an MRI (1.5 T) whole body scanner (Philips Intera; software release 12.1.5.0). Patients were positioned supine, and a send/receive flex medium or large coil was wrapped around the patient's knee. We used the flex coils because most patients' knees were too big to fit the standard knee coil. The following five sequences were carried out:

Gradient-echo scout (10 mm slices, repetition time (TR) 12.3 ms, echo time (TE) 6.6 ms, 50° flip angle, field of view (FOV) 300 × 300, matrix 256 × 256). Sagittal 3D T1-FFE gradient-echo (GRE) cartilage sequence (TR 21 ms, TE 8.4 ms, 20° flip angle, FOV 160 mm × 160 mm, matrix 512 × 512) with subsequent 3 mm 3D MPR reconstruction. Sagittal dual-echo proton density (PD) weighted/T2 weighted sequence (4 mm slices, TR 2531.3 ms, TE 15.5/100 ms, FOV 170 × 170, matrix 256 × 256). Coronal T1 turbo spin echo (TSE) sequence (3 mm slices, TR 500 ms, TE 17 ms, FOV 150 mm × 150 mm, matrix 512 × 512 mm). Coronal STIR (short tau inversion recovery) sequence 3 mm slices (TR 1797.9 ms, TE 55 ms, FOV 150 × 150, matrix 512 × 512). Scan time was 37 min.

MRI assessment

MRI scans were graded according to the description in the BLOKS paper by MB and HG[13]. Initial reliability assessments of the BLOKS were carried out by scoring 20 consecutively selected scans from the 187 completed MRI examinations. Selection was performed according to a pre-established protocol, so that the analyses were completed on ten females and males, respectively. The chosen cases represented all levels of KOA joint damage, evaluated by the medial compartment KL grade (two patients having KL grade 0, six patients having KL 1, four patients having KL 2, six patients having KL 3, and two patients having KL 4)[13]. Discrepancies in the initial training period were resolved at meetings held by MB and HG. MB is a trained musculoskeletal radiologist (7 years) and he supervised the training of HG, a non-specialized MD, who has a total experience of 3 years full time work within the field of MSK radiology. The inter-reader and intra-reader analyses showed kappa values comparable to published data[13,23].

Cartilage assessments were performed on the sagittal GRE sequence which was transformed to a 3D multiplanar reconstruction with near isotropic voxels[24,25]. The BLOKS incorporates a region specific cartilage score I with two sub scores (overall loss and full thickness loss) and a point-specific cartilage score II. Bone marrow lesions (BMLs) appear as ill-defined signal intensity changes in the sub-chondral bone that are hypo-intense on T1w images and hyper-intense on STIR images. All areas and all