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Brief Report

The relationship of bone properties using high resolution peripheral quantitative computed tomography to radiographic components of hip osteoarthritis

M.H. Edwards † ‡ [a], J. Paccou † [a], K.A. Ward † §, K.A. Jameson †, C. Moss †, J. Woolston §, M.K. Javaid ||, C. Cooper † || ¶ * [b], E.M. Dennison † # [b]

† *MRC Lifecourse Epidemiology Unit, University of Southampton, Southampton General Hospital, Southampton SO16 6YD, UK*
‡ *Portsmouth Hospitals NHS Trust, Portsmouth, UK*
§ *MRC Human Nutrition Research, Elsie Widdowson Laboratory, 120 Fulbourn Road, Cambridge CB1 9NL, UK*
|| *NIHR Musculoskeletal Biomedical Research Unit, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Science, University of Oxford, Oxford OX3 5UG, UK*
¶ *NIHR Nutrition Biomedical Research Centre, University of Southampton and University Hospital Southampton NHS Trust, Southampton General Hospital, Southampton SO16 6YD, UK*
# *Victoria University, Wellington, New Zealand*

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SUMMARY

Objective: Positive associations between radiographic osteoarthritis (OA) and areal bone mineral density (BMD) have been demonstrated and appear strongest when bony features of OA are considered. To date, these associations have not been assessed using HRpQCT.

Design: A total of 318 participants (170 men and 148 women), aged 72.1–81.4 years from a non-selected cohort, underwent HRpQCT of the distal radius and tibia along with hip radiography. Differences in bone microarchitecture were assessed between those with and without osteophytes, sclerosis or joint space narrowing (JSN) in either hip.

Results: Men with osteophytes alone had significantly higher radial trabecular volumetric BMD (Tb.vBMD) and radial and tibial trabecular thickness (Tb.Th). Men with both sclerosis and osteophytes had significantly higher cortical volumetric BMD (Ct.vBMD) and cortical thickness (Ct.Th) at the distal tibia than those with osteophytes alone ($P < 0.05$). These relationships were maintained after adjustment for age and Body Mass Index (BMI), and were not replicated in women. Bone microarchitecture did not differ significantly in those with JSN from those without it in men or women.

Conclusions: Our findings suggest higher Tb.vBMD and Tb.Th in men with osteophytosis but higher tibial Ct.vBMD and Ct.Th in men with hip joint sclerosis. These results do however require replication in other cohorts.

Introduction

Osteoarthritis (OA) is the most common joint disorder in the elderly and is characterized by cartilage degradation, new bone formation, and changes in subchondral bone[1] with bone playing a key role in pathogenesis. Population-based studies have established that patients with radiological findings of hip and knee OA have an elevated bone mass of 3–6% (depending on site of OA and areal bone mineral density (BMD) measurement) compared with control subjects[2]. Furthermore, some studies show patients with OA to have a decreased risk of fracture[3,4] although others demonstrate no association or even an increased fracture risk[5].

* Address correspondence and reprint requests to: C. Cooper, MRC Lifecourse Epidemiology Unit, University of Southampton, Southampton General Hospital, Southampton SO16 6YD, UK. Fax: 44-(0)23-8070-4021.
E-mail addresses: me@mrc.soton.ac.uk (M.H. Edwards), julien.paccou@chru-lille.fr (J. Paccou), kw@mrc.soton.ac.uk (K.A. Ward), kaj@mrc.soton.ac.uk (K.A. Jameson), cm@mrc.soton.ac.uk (C. Moss), jennifer.woolston@mrc-hnr.cam.ac.uk (J. Woolston), kassim.javaid@ndorms.ox.ac.uk (M.K. Javaid), cc@mrc.soton.ac.uk (C. Cooper), emd@mrc.soton.ac.uk (E.M. Dennison).
[a] MHE and JP are joint first author.
[b] CC and EMD are joint senior author.

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Associations between aBMD and radiographic OA appear strongest for the bony features of OA, such as osteophytes, rather than with joint space narrowing (JSN)[5,6]. Similarly, features of OA reflecting excess bone formation (osteophytes and sclerosis) were also more strongly associated with high bone mass[7]. Taken together, these results suggest that the relationship between OA and bone health may be driven mainly through associations with osteophytes and sclerosis.

As higher aBMD in individuals with OA is not only found within the affected joint, we hypothesised that volumetric BMD (vBMD) at sites distant to the hip would be higher and bone microarchitecture may be modified in participants with radiographic osteophytes and sclerosis, reflecting a tendency towards a systemic bone-forming phenotype. Furthermore, in this exploratory study, we aimed to investigate whether these differences would be found solely within weight bearing bones, such as the tibia, or additionally in non-weight bearing bones, such as the radius.

Method

Study population

The Hertfordshire Cohort Study (HCS) is a population-based UK cohort of older adults. Study design and recruitment have been described in detail previously[8]. In brief, we traced men and women born between 1931 and 1939 in Hertfordshire and who still lived there in 1998–2003 when a nurse-administered questionnaire and clinic visit were carried out. Participants were not selected on the basis of musculoskeletal pathology, but represented individuals born in a geographic region who continued to live there. In 2011–2012, 592 men and women from the geographical area of East Hertfordshire were invited to take part in an OA study that was designed to consider the personal burden of OA. A home visit which included a structured interview was conducted in 443 patients and bilateral hip radiographs were performed. Of these, 350 agreed to have a HRpQCT scan one year later (in 2012–2013). A total of 318 participants had both hip radiographs and HRpQCT undertaken. The East and North Hertfordshire Ethical Committees granted approval for the study.

Radiographic assessment and definition of hip OA

Bilateral radiographs of the hips (standing anteroposterior) were obtained and graded by experienced reviewers following focussed training. Semi-quantitative scores for the Croft grade were converted to binary variables for analysis; a Croft grade of $\geq$3 defined the presence of radiographic OA. The presence of JSN, sclerosis and osteophytes were assessed in accordance with the OARSI atlas as binary variables[9]. Hip X-rays were assessed by four experienced reviewers. For hip OA, inter-observer agreement was 72% with a kappa statistic of 0.46 consistent with moderate agreement. For individual components of OA, inter-observer agreement ranged from 67 to 100% with between fair and perfect agreement.

High-resolution peripheral quantitative computed tomography (HRpQCT)

Distal radial and tibial HRpQCT (XtremeCT, Scanco Medical AG, Switzerland) scans were carried out of the non-dominant side except when it had previously fractured. Antero-posterior 2D scout views were performed to determine the region to be imaged. All scans were acquired in keeping with the manufacturer's guidelines and as described by Boutroy *et al.*[10], assessed for motion artefact and repeated if necessary. Eight tibial scans and 39 radial scans were excluded due to excessive motion artefact.

Image analysis was carried out using the standard manufacturer's method which has been described in detail previously[11]. Standard morphologic analysis produced trabecular BMD (Tb.vBMD, mg/cm^3), trabecular number (Tb.N, per cm), trabecular thickness (Tb.Th, μm) and trabecular separation (Tb.Sp, μm). Each measure has been validated against micro-CT imaging. Further analysis was performed using an automated segmentation algorithm. Assessments were made of cortical area (Ct. Area, mm^2), cortical density (Ct.vBMD, mg/cm^3), and cortical porosity (Ct.Po, %). Cortical thickness (Ct.Th, μm) was determined from the threshold cortex image using a distance transform after removal of intracortical pores. Short term precision values (% CV) for cortical and trabecular BMD have been shown to range from 0.3 to 1.2[12]. The effective dose to the subject during each scan was <3 μSv.

Assessment of demographic and lifestyle variables

Height was measured to the nearest 0.1 cm using a wall-mounted SECA stadiometer and weight using electronic scales to the nearest 0.1 kg, on the day of scanning. Body Mass Index (BMI) was calculated as weight/height^2 (kg/m^2). Smoking status and alcohol consumption were available from the nurse-administered questionnaire as part of the OA study.

Statistical methods

Statistical analyses were performed using STATA 13.1. Descriptive statistics for continuous variables are expressed as mean (standard deviation) and categorical variables as frequency (percentage). Differences in continuous variables between men and women were assessed using Student's *t*-tests and in categorical variables using Pearson's X^2 test or Fisher's exact test, as appropriate. Linear regression was used to examine the associations between the presence of JSN and HRpQCT bone parameters. Participants were then grouped into those with no bony changes, osteophytes alone, and both osteophytes and sclerosis. Linear regression was used to assess for differences in HRpQCT bone parameters between each of these three groups separately. All regression analyses were undertaken with and without adjustment for the a priori covariates of age and BMI.

Results

Characteristics of study participants

The mean (SD) age of participants was 76.1 (2.5) and 76.4 (2.6) years in men and women, respectively (Table I). Rates of smoking were higher in men than women ($P < 0.001$); 58.2% of men ($n = 99$) and 37.8% of women ($n = 56$) were current or ex-smokers. Alcohol consumption was also greater in men ($P < 0.001$). Prevalence of radiographic hip OA (Croft score $\geq$3), sclerosis and JSN did not differ significantly by sex whereas osteophytes were more common in men than women ($n = 119$ (70.0%) vs $n = 84$ (56.8%); $P = 0.014$).

Bone geometry, volumetric BMD and microarchitecture

Tb.vBMD and Tb.Th both tended to be higher in men with bony changes. However, these differences only reached statistical significance for osteophytes alone with Tb.vBMD in the distal radius and Tb.Th in both the distal radius and tibia ($P < 0.05$ in each case) (Tables II and III; Fig. 1). These relationships were maintained after adjustment for age and BMI.