matching was less successful due to the non-Gaussian distribution ($P = 0.28$ [Wilcoxon Signed Rank test]). There was a wide variation in the measured distance between knees with respect to the manufacturers ($P < 0.00001$), showing systematic differences between the radiographs. A new standardised measure (stDist) was found by subtracting the mean distance from each manufacturer.

Mode 1 was significantly correlated with Hip-knee angle (HKA), manufacturer. Differences in the system correlation for the unstandardised distance (mm) was also significantly correlated with mode 1 ($P < 0.0001$, $R = -0.6$). Despite this, no significant systematic difference was evident in mode 1. The scatterplot of mode 1 against the distance between the knees highlights the systematic differences between the imaging equipment (Fig. 1a). However, this is ameliorated when the distance is standardised (Fig. 1b). The correlation between mode 1 and stDist ($P < 0.00001$, $r = -0.6$) was stronger than that for the unstandardised distance. Investigation of apparent outliers in figure 1b identified individuals with strong asymmetry between the left and right knees in HKA and/or JSW.

Conclusions: This study shows that the AAM model of bilateral knee radiographs can model gross anatomical differences associated with OA, independently of imaging resolution. This result shows its potential as a robust model for investigating radiographic OA from a variety of image sources.

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PATIENTS WITH EARLY OSTEOARTHRITIS: RADIOGRAPHIC FINDINGS OF PATIENTS WITH EARLY TO SEVERE OSTEOARTHRITIS


Introduction: In order to design early treatment and prevention programs for the onset of osteoarthritis, factors associated with early osteoarthritis need to be defined. The purpose of this study was to describe factors associated with osteoarthritis in a large patient population.

Methods: A prospective database was queried. A group of 1722 patients has complete radiographic, demographic, and subjective data. For this study, patients with a Kellgren-Lawrence (KL) grade of 2 were defined as early osteoarthritis. This was compared to patient age, gender, alignment, and WOMAC score. The average age of the population was 56 years (range 18 to 90). There was 719 females (48%) and 781 males (52%), 504 (29%) patients had KL grade 1, 512 (30%) had KL grade 2, 399 (23%) had KL grade 3, and 304 (18%) had KL grade 4. Grade 3 and 4 were combined as one group (moderate/severe OA). ANOVA with Bonferroni post-hoc correction was used to compare groups.

Results: Grade 1 patients’ average age was 49 years (95% CI: 48 to 50 years); grade 2 was 56 years (95% CI: 55 to 57 years), and grade 3/4 was 60 years (95% CI: 59 to 61 years). Patients with KL grade 2 were significantly older than patients with KL grade 1 and significantly younger than patients with KL grade 3 and 4 ($P < 0.0001$). The distribution of gender was not significantly different between KL grade 1 and grade 2 ($P = 0.23$). There was a significant association between gender and KL grade II and grade 3/4. KL grade 2 had 38% males while grade 3/4 had 61% males (0.009). The average WOMAC score for KL grade 1 was 49 (95% CI: 48 to 50), grade 2 was 56 (95% CI: 55 to 57), and grade 3/4 was 61 (95% CI: 59 to 61) ($P < 0.001$). Alignment outside of neutral was seen in 34% of KL grade 1, 42% of grade 2, and 66% of grade 3/4. The average shift from neutral in grade 1 was 20 (95% CI: 18 to 24), grade 2 was 28 (95% CI: 24 to 31) and grade 3/4 was 45 (95% CI: 42 to 48).

Conclusion: In this patient population, patients with mild osteoarthritis were younger than those with moderate/severe osteoarthritis and more likely to be male. The WOMAC score showed improvement in the mild OA group. The mild OA group also had a lower prevalence of malalignment, and if they did have malalignment, it was within 30% of neutral.

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CT ARTHROGRAPHY OF THE KNEE TO MEASURE CARTILAGE QUALITY WITH LOW RADIATION EXPOSURE

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Purpose: Contrast-enhanced microCT ($\mu$CT) and in vivo $\mu$CT arthrography are imaging techniques which measure cartilage quality in terms of the sulphated glycosaminoglycan (sGAG) content of cartilage. Recently, we showed that CT arthrography ($\mu$TA) performed on a clinical CT system using human cadavers is also capable of measuring cartilage quality in terms of the sGAG content using a high radiation dose protocol. Before $\mu$TA can be used in a clinical setting, the radiation dose of the CT protocol must be decreased. Therefore, the aim of this study was to assess the effect of radiation dose reduction on the capability of $\mu$TA to measure overall and local cartilage quality.

Methods: Seven human cadaveric knee joints were scanned on a second generation dual source multidetector spiral CT scanner (Definition Flash, Siemens) after intra-articular injection of a negatively charged contrast agent (Hexabrix 320, Mallinckrodt). CT was performed with six different radiation exposures: 3140 (maximum dose), 1570 (50%), 1256 (40%), 942 (30%), 628 (20%) and 314 (10%) mAs with a constant tube voltage of 80kV. Mean X-ray attenuation of all scans was calculated in seven large anatomical multisection regions of interest (ROIs) of cartilage (weight-bearing (WB) and non weight-bearing (nWB) areas of the medial and lateral femoral condyles, WB medial and lateral tibial plateaus and the mid-portion of the patella). Next, all knee joints were dissected and femoral condyles, tibial plateaus and the patella were separated. After dissection, all ROIs were re-scanned with $\mu$CT, which served as reference standard because it accurately measures sGAG content and hence quality of cartilage. In all anatomical ROIs of the $\mu$CT the mean X-ray attenuation was calculated. Finally, all $\mu$CT and $\mu$TA data was registered to enable comparison of local cartilage quality on corresponding slices. Areas of good and bad cartilage quality were defined in the mid-portion slice of the $\mu$CT of the patella using visually selected attenuation thresholds. The visual agreement for good and bad areas of cartilage was determined and used to represent the capability of $\mu$TA to detect local cartilage quality. The correlation between mean X-ray attenuation values of the $\mu$TA and $\mu$CT per anatomical ROI was analyzed with linear regression. The visual agreement for defining good and bad cartilage quality per radiation dose were compared with $\mu$CT.
RESULTS: CTa acquired using the maximum dose correlated excellent with reference μCT values (R = 0.86; R² = 0.73; p < 0.0001). The CTa scans acquired using the lower radiation doses correlated well with the μCT values (R = 0.75–0.74; R² = 0.57–0.55; p < 0.0001) (Table 1).

The visual agreement between the CTa and the reference μCT showed that CTa acquired using the maximum radiation dose agreed most with μCT in locally determining good and bad cartilage quality. The agreement decreased with the decrease in radiation dose. CTa acquired using 10% can not distinguish between small regions of good and bad cartilage quality (Figure 1).

Conclusions: Despite a lower radiation dose and hence an increase in noise in the images, CTa acquired using a low radiation dose is capable of detecting overall cartilage quality in large anatomical ROIs. The results also suggest that CTa may be capable of determining local good and bad cartilage quality when acquired using enough radiation. In conclusion, low radiation dose CTa may be a potential clinical application to measure overall cartilage quality in humans.

420 OSTEOPOROTIC CHANGES OF SUBCHONDRAL TRABECULAR BONE IN OSTEOARTHRITIS OF THE KNEE: A 3-T MRI STUDY

Purpose: To investigate structural features of subchondral trabecular bone of knee osteoarthritis (OA).

Methods: Sixty knees with KL grade 0–4 (all female) were examined. Fast imaging employing steady-state acquisition-cycled phases (FIESTA-c) and FatSat Spoiled gradient recalled acquisition in the steady state (SPGR) images were acquired by 3-T MRI. At four sites (the medial femur, medial tibia, lateral femur, and lateral tibia), subchondral trabecular bone structure was analyzed by FIESTA-c imaging, cartilage area was measured by SPGR imaging, and subchondral trabecular bone structure in each group was compared.

Results: As cartilage area decreased in the medial joint, bone volume fraction and trabecular thickness in the medial tibia increased, and bone volume fraction, trabecular thickness, number, and connectivity in the lateral femur and lateral tibia decreased (r ≥ 0.4 or ≤ −0.4, p ≤ 0.001). Compared to medially, the changes laterally showed a higher correlation. When the medial-lateral ratio of trabecular thickness in the tibia was determined, it had the highest correlation coefficient (r = 0.7, p < 0.001). These changes were not significantly detected in the early stage.

Conclusions: To more sensitively detect OA changes in subchondral trabecular bone structure, a focus on osteoporotic changes in the lateral joint and the medial-lateral ratio would be useful. Detectability of early OA remains unknown, but based on a strong correlation with the degree of OA progression, trabecular structural analysis of subchondral bone may be a useful parameter to evaluate OA severity and evaluate treatment.

421 SIZE AND POSITION OF THE HEALTHY MENISCUS, AND ITS CORRELATION WITH SEX, HEIGHT, WEIGHT, BONE SIZE, AND AGE
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Purpose: Symptomatic knee osteoarthritis is known to be more common in women than in men. Also, it is suspected that meniscus extrusion increases the peak loads of the knee, which in turn increase the incidence of knee OA. Recently, an MR imaging-based method for quantitative analysis of meniscus size, shape and position (extrusion) has been introduced, which can be applied in vivo. Since men are, however, larger (and heavier) than women, a comparison of size-related morphometric meniscus measures between both sexes is not easily made.

Our goals were: (1) To test whether meniscus size, shape or position differ between healthy men and women, before the onset of knee OA; (2) To examine to what extent the size of the normal meniscus correlates with body height, weight, and bone size, in men and women. (3) To identify whether a relative measure of meniscus size can be derived for a direct comparison between sexes.

Methods: Knees of the healthy reference cohort of the Osteoarthritis Initiative (47 men; 70 women) without radiographic signs, symptoms or risk factors for osteoarthritis were studied. Three-dimensional multi-planar reconstructed coronal DESSwe MR images were used. Segmentation of the tibial plateaus and menisci was performed medically and laterally, and 3D measures of meniscal size and position were computed. Differences in these measures between men and women (non-paired t-test) and Pearson correlation coefficients with body height, weight, ipsi-compartmental, contra-compartmental, and total tibial plateau size were calculated. Finally, the ratio between total meniscus surface and the ipsi-compartmental tibial bone size was compared between men and women (non-paired t-test).

Results: The total medial and lateral tibial plateau area was 26% greater in men (22.8 cm²) than in women (18.0 cm²). The total medial meniscal surface area (17.8 cm² in men, 14.7 cm² in women; +18%; p < 0.001) and the total lateral meniscal surface area (18.5 cm² in men, 14.5 cm² in women; +22%; p < 0.001) were significantly different between both sexes.

Ipsi-compartmental tibial bone size was more strongly correlated with medial/lateral meniscus size in men (r = 0.71/0.67) and women (r = 0.63/0.68) than the contra-compartmental or total tibial bone size, body height or body weight. No significant correlation was observed with age.

The ratio between the total meniscus surface areas and the ipsi-compartmental tibial bone size was similar between men and women (medial meniscus: 1.52±0.16 in men and 1.55±0.16 in women; p = 0.37; lateral meniscus: 1.69±0.19 in men and 1.71±0.16 in women; p = 0.57). The within-sex, inter-subject variability for the above ratio was considerably smaller than that for total meniscus surface area without normalization (medial meniscus: CV 10.3% vs. 14.8% in men / 10.5% vs. 13.3% in women; lateral meniscus 11.1% vs. 14.0% in men and 9.5% vs. 12.0% in women).

Tibial coverage was similar in men and women (50% medially; 58% laterally). However, medial meniscal extrusion was significantly