KNEE OSTEOARTHRITIS IS ASSOCIATED WITH DIFFERENCES IN KNEE JOINT SHAPE

D. Haverkamp, D. Schiphof, S.M. Bierma-Zeinstra, H. Weinans,
J.H. Waarsing
Erasmus MC, Rotterdam, Netherlands

Purpose: An important topic in current OA research is the quest for new biomarkers that sensitively monitor the disease progress and/or that are predictive for development or progression of the disease. Previously we have shown, using Statistical Shape Models (SSM) that the shape of the hip is different in subjects before developing radiologic hip OA which appears promising for novel imaging biomarkers to predict progression.

In the current study we investigated the knee to see if the shape of the joint is different in subjects who have OA of the knee, in an open population of middle aged women.

Methods: A Statistical Shape Model was created of the shape of the distal femur, patella and proximal tibia on AP radiographs of both knees in 609 women of the Rotterdam Study (age 45-65). The method results in a set of independent modes that together quantitatively describe the total shape, while each mode separately describes a specific pattern in the shape as present in the population. Using Generalized Estimating Equations (GEE) analysis, we tested which modes were different between subjects with radiological OA and subjects without. For the modes that associated with OA, we further tested the relation with more specific radiological scores (JSN, osteophytosis, sclerosis) and the presence of cartilage damage scored from MRI images that were made of the same knees.

Results: In this relatively young population, 74 knees showed clear signs of radiological OA (KL≥2). Interestingly, 11% of the knees without radiological OA showed cartilage damage on MRI, while in 30% of the knees with clear signs of radiological OA, no cartilage damage on MRI could be observed. Of the 24 shape modes, 3 showed a significant association with radiological OA, after correction for BMI and age (p<0.001). These modes show that subjects with radiological OA have relatively broad knees (mode2), stand with extended knees (mode4) and have an upward shaped lateral edge of the tibial plateau (mode15). All of these modes associated significantly with the separate scores of JSN, osteophytosis and sclerosis, except mode4, which did not associate with JSN.

Mode 2 values were different between subjects with MRI cartilage damage and subjects without, irrespective of KL grade, indicating that MRI cartilage damage corresponded to broader knees (p<0.001).

Conclusions: We found a few distinct aspects of shape of the knee joints that were different between subjects with and subjects without radiological OA. Since this is a cross-sectional analysis, we cannot make definite statements about whether these aspects of shape are a cause or a consequence of OA. However, mode2 and mode4 showed a clear dose response relation with KL grade, while mode15 does not, which might indicate that broader knees and a more extended standing position are a consequence of OA, while an upward shaped lateral edge of the tibia plateau might be a causing factor.

Of special interest here is mode2, indicating that knees might become broader with progression of the disease. Since this broadening can already be seen in knees with cartilage damage, before any signs of radiological OA (KL=0) can be detected, this shape feature could be a useful marker to monitor early OA.

This study shows that the shape of the knee plays a definite role in the OA process which can lead to novel imaging biomarkers to monitor knee OA.

DO PREDEFINED GEOMETRY MEASURES AND STATISTICAL SHAPE MODELS DESCRIBE THE SAME ASPECTS OF HIP SHAPE?

M.C. Castano Betancourt, J. Van Meurs, S. Bierma-Zeinstra, F. Rivadeneira, A. Hofman, A. Uitterlinden, H. Weinans, E. Waarsing
Erasmus MC, Rotterdam, Netherlands

Purpose: Variation in hip morphology has been associated to prevalent and incident osteoarthritis and risk of hip fractures. Hip geometry is commonly quantified through predefined measures, typically lengths and angles using radiographs. Alternatively, Statistical Shape Models (SSM) can be used to quantify the existing patterns of variation in hip shape present in a population. This result in a number of quantitative measures (modes) of which each describes a distinct pattern of geometry variation. While predefined geometry parameters provide quantifiable measures of specific parts of the hip geometry, the SSM method, by taking the entire shape of the hip joint and pelvis into account, incorporates these geometric differences in its assessment of the modes of variation. Our aim is to compare both methods to determine whether they describe the same aspects of hip morphometry.

Methods: This study is part of the Rotterdam study, a large prospective population-based cohort study among men and women ≥55 years of age. Baseline weight-bearing antero-posterior pelvic radiographs were obtained. Using the freely available ASM toolkit (Manchester University, Manchester, UK), we constructed a SSM of left and right side for 469 hips using a set of 67 points that delineated proximal femur, pelvis contour and acetabulum. Using these points, we automatically calculated 11 geometry parameters (GP) expressed as angles, ratios or distances. Additionally, pelvis rotation/inclination was measured using the Foramen obturator index from Tonnis (FOI). Statistical analysis were done using Principal component analysis (PCA), Linear mixed models and linear regressions.

Results: The resultant SSM contained 29 modes that explained 95% of variation in hip/pelvis shape in our population. GPs related to lengths: pelvic width (PW), isquioipubic index (IPI), hip axis length (HAL), offset, narrow neck (NN), head radius and neck length (NL), while well explained by the 29 modes (Figure 1, R² between 0.8-0.94). The percentage of variation in angles (Wiberg angle (WA), neck shaft angle (NSA), spherical sector (SS)) and ratios (head/neck (H/N), triangular index (TI)) was lower (Figure 1, R² between 0.37-0.65). On the other hand, 8 representative GPs selected after PCA of all GPs (WA, HAL, TI, H/N, NSA, IPI, NL and FOI) were used to analyze all 29 modes. The GPs could explain between 54-59% of variation for the first 3 modes, and the proportion explained decreased from 46 till 1% for the last modes.

Figure 1. Percentage of variation in geometry parameters explained by modes.

Figure 2. Percentage of variation in modes explained by predefined geometry parameters.

Conclusions: Although most of the information in GPs is captured by the SSM, angles and ratios seems to be less well represented by the modes. Only the first modes describe information contained in predefined GPs or explained by hip rotation. Predefined GPs represent gross variations in hip morphology and cannot capture more subtle variations that are contained
in latest modes from SSM. Further research is necessary to compare the contribution of both, SSM and GPs to identify the variations in hip morphology that precede hip pathology.

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THE RELATIONSHIP BETWEEN THE KNEE ADDUCTION MOMENT AND DISTRIBUTION OF CARTILAGE CONTACT AREA IN THE TIBIOFEMORAL JOINT IN HEALTHY, OLDER ADULTS AND SUBJECTS WITH MODERATE KNEE OSTEOARTHRITIS
C. Henderson, A. Kubinski, J. Higginson
Univ. of Delaware, Newark, DE

Purpose: The purpose of this study was to investigate the relationship between the peak external knee adduction moment during gait and the ratio of medial to lateral articular cartilage contact area in the tibiofemoral joint during full extension and weightbearing. It is hypothesized that the ratio of articular cartilage contact area may be representative of frontal plane joint alignment. Previous knee OA investigations have placed a high emphasis on frontal plane knee alignment. An increased medial to lateral articular cartilage contact area ratio would suggest a varus knee mal-alignment and an increased external knee adduction moment. It is hypothesized that healthy controls will demonstrate this relationship, while subjects with moderate knee OA will not.

Methods: Magnetic resonance imaging (MRI), gait data, and anterior-posterior radiographs were collected on 18 subjects. Subjects were required to be 30-85 years in age, have a body mass index less than 35, and able to walk on a treadmill at a self-selected speed for five minutes. Kellgren-Lawrence (KL) grading was determined by a radiologist through use of anterior-posterior radiographs of both knees. KL grading in the medial compartment of the more severe knee distinguished moderate OA subjects (KL = 2-3) from healthy controls (KL = 0-1) and subjects with laterally dominant OA or OA in any of the other lower limb joints were excluded. T1 fast spin echo sequence MRI data were collected in an open scanner with the maximum torque. Capsule, it was incised with a surgical knife after measuring the angle between the femur and tibia after total extra-articular myotomies were measured (n=8/group). We set limitation in range of motion and applied SAM to estimate elastic changes in the sound speed. Normal light microscopic images corresponding to the capsule after joint immobilization.

Results: All subjects (7 moderate OA, 11 healthy controls) exhibited a medial contact area that was greater than the lateral compartment. No significant differences were found between the groups in peak external knee adduction moment (p=0.11) or contact ratio (p=0.19); however ANCOVA found a significant difference (p=0.019) in the linear regression lines of the two groups.

Conclusions: Moderate OA subjects and healthy controls exhibited a significantly different relationship between medial to lateral articular cartilage contact area ratio and external knee adduction moment. Moderate OA subjects generally exhibited an increased peak external knee adduction moment with an increasing contact area ratio, while the healthy controls demonstrated a decreased contact ratio with an increasing knee adduction moment. The increasing contact area ratio may suggest that the OA subjects are able to better distribute the loads incurred from the increased peak external knee adduction moment during gait and decrease stress in the medial compartment which in turn may decrease the rate of disease progression.

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INCREASED CAPSULAR RESTRICTION AND STIFFNESS IN A RAT KNEE FLEXION CONTRACTURE MODEL
Y. Ono1, Y. Hagiwara2, E. Chimoto1, A. Ando1, H. Suda1, Y. Saijyo3, E. Itoi1

Purpose: A joint contracture is often seen in daily examinations, but its pathogenesis has been unsolved. Causes of joint contracture are classified into two types of components, arthrogenic (bone, cartilage, synovial membrane, capsule and ligaments) and myogenic ones (muscle, tendon, and fascia). Among the arthrogenic components, capsular stiffness might contribute more to joint contracture than the other ones. However, it is not known how the elasticity of the capsule is affected by joint immobilization. Acoustic microscopy for medicine and biology has been developed for more than twenty years at Tohoku University. Scanning acoustic microscopy (SAM) characterizes biological tissues by estimating the elastic parameters based on the sound speed, which strongly correlates with Young’s elastic modulus. The purpose of this study was to evaluate contribution of the capsule on limitation in range of motion and applied SAM to estimate elastic changes of the capsule after joint immobilization.

Methods: Animals: Adult male Sprague-Dawley rats’ knees were immobilized at 150° of flexion by rigid internal fixation with a plastic plate and metal screws for various periods (1, 2, 4, 6, 8, and 16 weeks). Sham operated rats had holes drilled in the femur and tibia with screws, but the plate was not inserted. The immobilized animals and the sham operated animals made up the immobilized group and the control group, respectively. Measurement of a joint angle: A special apparatus for taking lateral x-rays of the knees were made and the angle between the femur and tibia after total extra-articular myotomies were measured (n=8/group). We set three torques (450, 900, 1350 g-cm). To know the influence of the posterior capsule, it was incised with a surgical knife after measuring the angle at the maximum torque (Figure 1). After the release, the joint angle was measured again with the maximum torque.

Conclusions: Moderate OA subjects and healthy controls exhibited a significantly different relationship between medial to lateral articular cartilage contact area ratio and external knee adduction moment. Moderate OA subjects generally exhibited an increased peak external knee adduction moment with an increasing contact area ratio, while the healthy controls demonstrated a decreased contact ratio with an increasing knee adduction moment. The increasing contact area ratio may suggest that the OA subjects are able to better distribute the loads incurred from the increased peak external knee adduction moment during gait and decrease stress in the medial compartment which in turn may decrease the rate of disease progression.