

171 A PRELIMINARY STUDY OF CONTRALATERAL KNEE STRUCTURE AND FUNCTION ASSOCIATIONS IN PERSONS WITH UNILATERAL KNEE OSTEOARTHRITIS

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Purpose: Persons with unilateral knee osteoarthritis (OA) are at risk for developing bilateral OA. Because of joint pain and dysfunction, some individuals will adopt compensatory gait mechanisms that shift the load distribution from the affected to the healthy contralateral limb during weight-bearing activities. The resultant change in load history is speculated to contribute to bilateral disease onset. The purpose of this preliminary study was to evaluate structure-function associations in persons with unilateral knee OA in order to identify risk factors for contralateral OA onset. We hypothesized that gross morphological and microstructural OA indicators are associated with greater contralateral limb loading during stair descent.

Methods: **Subjects:** Four radiographically-diagnosed unilateral OA (age=56.2±11.7), and four sex- and age-matched healthy controls (age=57.5±11.3) were recruited. The “affected” limb of controls was assigned based on the side of the injured knee of their matching OA subject. **Tibiofemoral gross morphology:** Bilateral 3T knee magnetic resonance (MR) images were obtained using fast-spin echo and steady state free precession image sequences (GE, USA). Two musculoskeletal radiologists, who were blinded as to the treatment group, graded knee morphology using the established MOAKS grading construct. Contralateral tibiofemoral bone marrow lesion (BML) and cartilage lesion size subscale scores were summed and used to quantify morphological differences between OA and control knees, as these measures were hypothesized to be sensitive to load changes. **Microstructural OA indicators:** T2 relaxometry sequences were captured using a multislice Carr-Purcell Meiboom-Gill sequence. For each medial and lateral tibiofemoral compartment, a single mid-compartment sagittal MR image was selected, and the tibiofemoral cartilages were segmented manually. For each mid-compartment slice, cartilage T2 relaxation was calculated on a pixel-by-pixel basis, and the T2 relaxation variance of all identified cartilage pixels determined. T2 variance was chosen as a microstructural OA indicator as this measure has been previously associated with OA-like changes in high-risk populations enrolled in the Osteoarthritis Initiative study. **Loading asymmetry:** A custom-built staircase was instrumented with a force plate (Kistler Instruments, CH), and vertical ground reaction force data (vGRF) were collected at 1200Hz as subjects stepped down onto and over the plate three times for each limb. Force data were low-pass filtered at a cut-off frequency of 5Hz, and mean peak vGRF calculated for affected and contralateral limbs. All force data were normalized to body weight (%BW). **Statistics:** Significant between-group differences in contralateral knee measures were tested using a Mann-Whitney test (gross morphology), or one-tailed t-tests (contralateral limb loading). Associations between contralateral limb vGRF and cartilage T2 relaxation variance were tested using Pearson correlation tests.

Results: Affected tibiofemoral MOAKS BML and cartilage lesion size grades were consistent with OA, whereas only minor abnormalities were noted in healthy control knees. Summed contralateral tibiofemoral scores were greater in OA subjects (4.5±4) than controls (0.25±0.5), but did not reach significance (p=0.06). Contralateral limb vGRF was not greater than affected limb vGRF in OA (-1.2±17.6 %BW) or control (9.2±8.2 %BW) subjects, nor was there a between-group effect (p=0.22). Tibiofemoral cartilage T2 relaxation variance was not associated with increased contralateral limb vGRF forces (r²=-0.4-0.7; p=0.07-0.8). Medial femoral condyle T2 relaxation variance and contralateral vGRF approached significance only because the contralateral limb was loaded less compared to the “affected” limb in the control group.

Conclusions: The preliminary study results do not support the hypothesis; however, work is ongoing to increase sample size, and to map cartilage T2 relaxation variance across multiple MR image slices. Inclusion of additional MOAKS construct subscales may increase the sensitivity to detect significant contralateral differences between OA and control groups by capturing more joint damage features. Additional knowledge of relative tibiofemoral surface interactions and joint moments in this patient

population may reveal biomechanical factors that contribute to OA pathogenesis not reflected by the current outcome measures. Identifying and quantifying risk factors for bilateral OA onset are central to implementing effective intervention strategies early on in the disease trajectory.

172 BIOMECHANICAL AND MORPHOLOGICAL CHANGES OF SUBCHONDRAL BONE IN ANTERIOR CRUCIATE LIGAMENT TRANSECTION – INDUCED RAT MODEL OF KNEE OSTEOARTHRITIS

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Purpose: To observe the biomechanical and morphological changes of subchondral bone in aratmodelof knee osteoarthritis (OA).

Methods: Sprague-Dawley (SD) rats (6 weeks old, n=30) were selected to establish OA model using Anterior Cruciate Ligament Transection (ACL) method in the right knee joint. After six weeks, the knee joints were dissected and scanned by micro-computed tomography (μCT) to measure morphological parameters of bone mineral content (BMC). In Micview software, subchondral bone (including epiphysis and trabecular bone) was divided into medial and lateral regions of interest (ROI) by tibial tuberosity. The three-dimensional micro-finite element model of knee OA was established through Mimics software. The model was then imported into Hypermesh and ABAQUS to analyses mechanical properties of medial and lateral ROI quantitatively, including Von Mises (VM) and displacement (DIS). In this process, the compressive load of 5 N from femur, equal to the weight of rat, was applied. The stiffness of subchondral bone was calculated as VM/DIS. Statistical analyses were performed within-animal, between left and right knee, then between medial and lateral ROI.

Results: Compared with the left healthy knee, BMC was lower (6.035±0.688 vs 6.675±0.492, p=0.037), while stiffness of subchondral bone higher (11206.73±3434.75 vs 7365.45±1060.55, p=0.034) significantly in the right OA knee. Medial BMC was lower in medial compartment than in lateral compartment (6.035±0.688 vs 7.065±1.135, p=0.33). Subchondral bone stiffness in medial compartment was also higher than that in lateral compartment (7872.565±2467.827 vs 11206.726±3434.751, p=0.031).

Conclusions: While subchondral BMC is lower, subchondral bone stiffness is higher in osteoarthritic than in healthy joints, and in medial than lateral compartment, suggesting that biomechanical and morphological changes of subchondral bone may play roles in knee OA development.

173 DEVELOPMENT OF ASIAN HIP STEM 2 – COMPUTATIONAL ANALYSIS USING 3D FINITE ELEMENT METHOD

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Purpose: Finite element analysis (FEA) is a useful tool for preclinical testing of newly designed implants and can be used to predict early and medium term results. FEA helps the researcher to produce better designs before the fabrication stage by enhancing their understanding the stress distribution and micromotion that occurs within the medullary canal.

Methods: The implant model was designed using computer aided design (CAD) software. As the ultimate goal was to achieve optimal fit and fill, the stem was designed according to a prior anthropometric. The stem was then imported to finite element software in geometric data file format (.igs) to convert the triangle node mesh into the tetrahedral node mesh and to produce better mesh by repairing the edges. The model input file (.inp) was then converted into stereo lithographic (.stl) format. The osteotomy level was set to 20 mm above the center of the lesser trochanter. A perfect contact fit between stem and medullary canal was assumed by creating a ‘virtual surgery femur’ from the surface mesh of the correct position of the cementless stem during the surgery in a manner similar to Boolean operation in MAGICS. An average of 13 200 elements with 4200 nodes was found to be optimal for the cementless femoral stem, and the ‘virtual surgery femora’ consisted of 7900 nodes and 41 900 elements. The finite element model was completely restrained distally. Two static physiological loads were simulated; normal walking and stair climbing. The micromotion algorithm