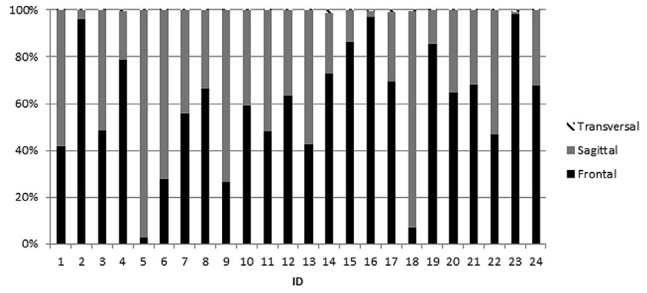

Figure 2. Bar chart of percentage distribution of the contributors to the Knee Index.

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ASYMPTOMATIC OBESE SUBJECTS WITH MR-BASED INDICATIONS OF KNEE OA HAVE ALTERED GAIT KINETICS

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Purpose: Obesity is an established risk for knee osteoarthritis (OA), yet the association between obesity and OA remains unclear. Previous studies that compared gait mechanics of young asymptomatic, older asymptomatic, moderate OA, and severe OA subjects established that specific features of gait mechanics (reduced first peak extension moment) were present in older healthy individuals and was more reduced with increased OA severity, suggesting that a reduced extension moment preceded clinical symptoms of OA in an aging population. Similarly it is known that the peak knee flexion moment is decreased in the presence of OA-related knee pain. Given the risk for developing obesity-associated OA it would be important to test if similar gait related changes in the flexion/extension moments precede clinical OA symptoms. A population of asymptomatic obese subjects with magnetic resonance imaging (MRI) signs of OA (Asymp-OA) were available for testing the following hypotheses: H1) a peak flexion moment no different than that of a matched (age, height weight, gender) healthy Control group and H2) a smaller first peak knee extension moment as compared with the Control group.
Methods: As part of a larger IRB-approved study on gait in obese individuals, bilateral knee MRI scans (3D SPGR) were taken of subjects who self-reported no chronic pain or injury to the lower extremities or back. These scans revealed that a subgroup ($n = 12$, 3 M) had early signs of osteoarthritis, specifically cartilage defects in either the patellofemoral or tibiofemoral joint, with or without meniscal degeneration. The demographics of this subgroup were: 1.7 ± 0.1 m (mean ± SD), 93.2 ± 11.2 kg, BMI 34 ± 4, and 51 ± 7 years old. From the same larger study population, age-, gender-, height-, and weight-matched individuals were used as a control group for comparison ($n = 20$, 8 M). An optoelectronic motion capture system and embedded forceplate were used to analyze knee mechanics while subjects performed walking trials at a self-selected normal walking speed. The study limb was selected randomly for the Control subjects and the more affected limb, based on MRI, was analyzed for the Asymp-OA subjects. Knee kinetics were calculated using a standard method (BioMove, Stanford). First peak extension moment and peak flexion moment (positive %BW*Ht) were compared between the Asymp-OA and Control groups using one- and two-tailed unpaired Student's t-tests, respectively (Fig 1). A Bonferroni adjusted (2 tests) p-value threshold of $p = 0.03$ was used.
Results: The first peak extension moment was significantly less in the Asymp-OA versus the Control group (2.2 ± 0.8 vs 2.8 ± 0.8 %BWxHt, $p = 0.02$, Fig 2). There were no group differences in peak flexion moment (2.2 ± 1.1 vs 2.4 ± 0.9 %BWxHt, $p = 0.6$), walking speed, stance duration, or ground reaction forces.
Conclusions: The results indicate that there are specific gait characteristic that appear in obese subjects with structural cartilage degeneration that are not present in obese subjects with healthy cartilage. Specifically these results suggest a reduced first peak extension moment as a potential gait marker for the very early stages of OA in the obese, which occurs before the onset of symptoms. The finding that there was no group difference in the peak flexion moment was consistent with the patients reporting no pain, as this flexion moment has been reported as one of the most sensitive gait metrics for pain. This finding suggests that the gait feature (reduced extension moment) of the Asymp-OA group was not an adaptation to pain but may be attributable to muscular, neuromuscular, or soft tissue alterations. The characteristic of the extension moment near heel strike could have implications for interventions if these gait changes are found to provoke the onset of disease.

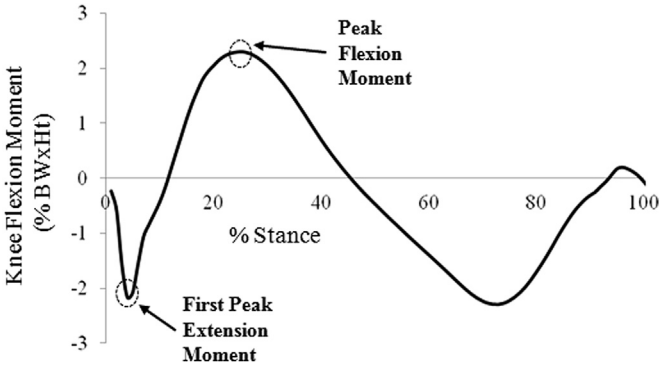

Figure 1. First peak extension and peak flexion moment definitions.

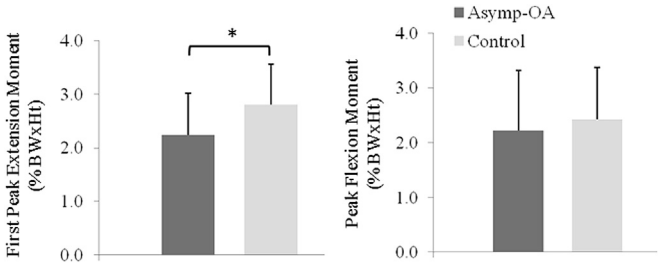

Figure 2. Mean first peak extension moment and peak flexion moment comparison. Errors bars depict standard deviations. *$p = 0.02$.

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CORRELATION BETWEEN 3D KNEE KINEMATICS AND TIBIO FEMORAL RADIOGRAPHIC OSTEOARTHRITIS GRADING SYSTEM

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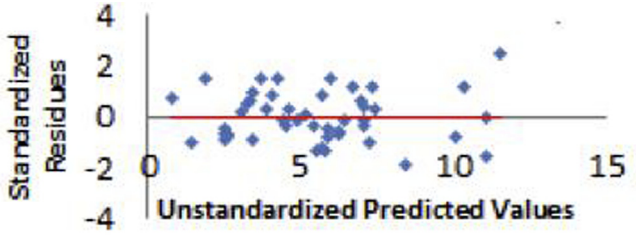
Purpose: Radiographic grading scheme have shown to be sensitive to the deterioration of osteoarthritic knees. However, previous studies have suggested that radiological assessment does not correlate well with clinical symptoms. Few analyses were done in order to link the radiographic scores to joint function (3D kinematics). The objective of this study is to assess if tibio femoral (TF) knee osteoarthritis (OA) grading scores are correlated with functional knee kinematics.
Methods: Forty-seven knees from 35 patients with a confirmed diagnosis of tibio femoral OA underwent a knee functional assessment (KneeKGTM, Laval, Canada) measuring, in clinic, 3D knee kinematic during treadmill gait. All patients also had a weight bearing x-ray of their knees that were graded using OAISYS radiographic scheme. This x-ray score is composed of 5 sub scores (FA_TA (femoral and tibial anatomical axis), JS (joint space), FO (femoral osteophytes), TE (tibial erosion) and SU (subluxation)) and one total score (TS). Those scores are applied on the most damaged knee compartment: medial or lateral. All the patients in this study had predominantly the medial compartment affected. Knee kinematic parameters were evaluated in all three planes of movement (sagittal, frontal and transverse) going from punctual knee angle value at specific times of the gait cycle (GC), to ranges of motion (ROM) and mean values for specific phases of the GC.
Using SPSS Statistics software, Pearson's Correlation Coefficient was first evaluated between TS and each kinematic parameter to find a preliminary result of the correlations. Kinematic parameters that showed significant correlation ($p < 0.05$) were further investigated. A multiple linear regression (MLR) was done for each of these parameters as dependent variable with the sub scores (FA_TA, JS, FO, TE, and SU) as independent variables.

Results: Table 1 presents the correlation coefficients between the radiographic grading sub scores and kinematic parameters. Correlations with the frontal plane kinematics showed to be the strongest, with R values going from 0.641 to 0.724. Furthermore, joint space demonstrated to be strongly correlated with frontal plane kinematics based on the high weight of this x-ray sub-score in the MLR. Results in the transverse and sagittal planes showed negative correlations ranging from -0.440 to -0.497. Results show that FO is the sub-score that is the most strongly correlated (in this case negative correlation) with kinematic parameters in the transverse plane.
A residues analysis was also conducted to confirm a random distribution of the residues around zero (figure 1). The absence of error patterns means that the choice of a linear regression fits well the relationship between the kinematic parameters and radiographic sub scores.
Conclusions: The frontal plane presented the strongest correlation between the x-ray grading scale and the knee kinematic parameters. This analysis showed that the higher the x-ray sub scores are, meaning a more advanced state of the disease, the higher the varus angle parameters during gait are. This strengthens the link between a dynamic varus alignment and medial TF compartment OA progression. Interestingly, joint space showed a strong influence on the correlations with kinematic parameters in frontal plane.
The transverse and sagittal plane both showed a negative correlation, meaning that the higher the x-ray sub scores are, the lower the kinematic parameters will be. In the sagittal plane this translate to a more fixed flexion adaptation strategy to protect the knee and in the transverse plan to a more internally rotated tibia. An offset towards internal rotation was previously linked to faster progression of OA which could also support the link with higher FO score.
Further investigations, with a larger and more homogeneous sample group should lead to stronger correlations and should better define the relationships between the knee 3D kinematic parameters and radiographic grading system. This study supports the involvement of dynamic biomechanical factors in the progression of the disease. Results give new insights to develop personalized treatment plan based on kinematic parameters and x-ray OA grading scales to potentially limit the progression of the disease.

Purpose: Patellofemoral (PF) osteoarthritis (OA) is known to considerably limit activities of daily living. To assess the severity and progression of PF OA, skyline view radiographs are typically used. Radiographic grading scales have been developed to quantify the degenerative changes. Functional outcome measures (i.e knee kinematics) are also recognized to be good indicators of knee OA impairments. Few studies have been done in order to evaluate a link between radiographic scores and joint function. The objective of this study is to assess if PF knee OA grading scores are correlated with functional knee kinematics parameters.
Methods: Twenty-three knees from 17 patients with a confirmed diagnosis of PF OA underwent a knee functional assessment (KneeKG, Laval, Canada) measuring, in clinic, 3D knee kinematic during treadmill gait. All patients had skyline view x-ray of their knees graded using OAISYS radiographic scheme. OAISYS scale is composed of 4 sub scores (JS (joint space), FO (femoral osteophytes), PE (patella erosion) and SU (subluxation)) and one total score (TS). These sub scores are applied to the most damaged knee compartment: medial or lateral. Knee kinematic parameters were evaluated in all three planes (sagittal, frontal, transverse,) going from punctual angle values at specific times of the gait cycle, ranges of motion (ROM), curve slopes and mean values for specific phases of the GC.
Using SPSS Statistics software, Pearson's Correlation Coefficient was first evaluated between TS and each kinematic parameter to find a preliminary result of the correlations. Secondly, kinematic parameters that showed correlation ($p < 0.05$) were further investigated. A multiple linear regression (MLR) was done for each of these parameters as dependant variables and the sub scores (JS, FO, PE and SU) as independent variables.
Results: Table 1 presents the correlation coefficients between the radiographic grading sub scores and kinematic parameters. Kinematic parameters in the frontal plane showed the strongest correlations; reaching for the lateral PF compartment ($R = 0.786$) and for the medial PF compartment ($R = -0.904$). Transverse plane did not show any significant correlation.
Interestingly, ranges of motion parameters in frontal and sagittal plane both showed strong inverse correlations with SU x-ray sub-score.
A residues analysis showed a random distribution of the residues around zero (figure 1), confirming that the choice of a linear regression fits well the relationship between the kinematic parameters and radiographic sub scores.
Conclusions: Radiographic grading sub scores JS and FO for the lateral PF compartment showed a correlation with frontal plane curve's slope after the loading phase. More specifically, an increase of lateral compartment JS and FO scores (i.e. a lesser joint space and more lateral femoral osteophytes) is associated with an increase in varus knee alignment after loading. Although we were expecting an increase in dynamic valgus alignment, similar results were previously reported in the literature. Since this kinematic parameter gives a slope rather than a punctual value, results cannot state if knees are in valgus or varus at the end of the loading phase. For the medial PF compartment, the higher FO and SU scores are, the lesser range of motion (ROM) is seen in the frontal plane during loading. Similar results were found when combining knees with medial or lateral PF compartment OA, a negative correlation was found between FO and SU score with ROM between the swing phase and the terminal stance phase, Both correlations characterize a stiffer knee during gait. Those results strengthen the involvement of dynamic biomechanical factors in the development of the disease. Results give insights to help

Plane	Kinematic Parameter	Radiographic Scorn (Estimate Coefficient)	R^2	R	*p*-value
Abduction Adduction (frontal)	Mean 0-10% of GC	FA_TA (-0.212) JS (1.608) FO (0.971) TE (2.139)	0.383	0.619	0.005
	Mean 10- 30% of GC	FA_TA (-0.357) JS (1.663) FO (0.808) TE (1.406)	0.412	0.641	0.002
	Mean 30- 50% of GC	FA_TA (-0.268) JS (1.808) FO (1.051) TE (0.865)	0.524	0.724	<0.001
	Mean 50- 60% of GC	FA_TA (-0.488) JS (2.596) FO (1.359)	0.478	0.691	<0.001
	Mean 0-60% of GC	FA_TA (-0.415) JS (2.921)	0.431	0.656	<0.001
Internal/External Rotation (transverse)	Initial Angle	FA_TA (0.370) FO (-2.087) TE (2.386) SU (-1.301)	0.247	-0.497	0.015
	Mean 0-20% of GC	FA_TA (0.235) FO (-2.262) TE (1.029)	0.230	-0.479	0.009
	Mean 0-60% of GC	FA_TA (0.208) FO (-1.825) TE (1.004)	0.194	-0.440	0.025
Flexion Extension (sagittal)	ROM loading – Initial angle	FO (-0.854) TE (-1.398) SU (-2.988)	0.219	-0.468	0.013

Note: The Estimate Coefficient indicates by its sign if the correlation is positive or negative.



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CORRELATION BETWEEN KNEE 3D KINEMATIC PARAMETERS DURING GAIT AND PATELLOFEMORAL OSTEOARTHRITIS RADIOGRAPHIC GRADING SCALE

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