Abstract

INTRODUCTION
In advanced knee osteoarthritis (OA), cartilage degeneration is severe in one or more compartments of the knee. Consequently, normal joint kinematics are altered, but the specifics of these changes remain unknown. Previous studies have reported on gait characteristics of patients with OA, or have examined flexion passively or actively [1-3]. No studies have reported on the in-vivo six-degree-of-freedom (6DOF) kinematics of the knee joint with advanced OA during weight-bearing activities. A quantitative understanding of OA kinematics may help to improve surgical technique during treatment procedures such as total knee arthroplasty. The objective of this study was to identify the 6DOF kinematics of the knee with advanced OA and compare them to that of the normal knee.

METHODS
Ten patients with advanced OA primarily in the medial compartment of the knee were recruited preoperatively. The study was IRB approved and all patients gave written consent to participate. First the osteoarthritic knee was MR scanned using a 3T MR imaging system. Patients were then asked to perform a quasi-static lunge activity from full extension to maximum flexion while images were taken using a dual fluoroscopic imaging system (DFIS) [4].

A virtual DFIS was created in solid modeling software that reproduced the location and orientation of the fluoroscopic system. Patient specific bone models constructed from the MR images were imported into the virtual system. Joint coordinate systems were established on the tibia and femur based on bony geometry and placed at the center of the knee. The models were matched to the fluoroscopic images to reproduce the in-vivo knee positions during flexion. From the matched knee positions the 6DOF tibiofemoral joint kinematics were determined from 0° to 120° of flexion at 30° intervals from 0° to 60°, followed by 15° intervals from 60° to 120° using the established coordinate systems. Data collected from a control group of 20 healthy subjects during weight bearing flexion has been used for comparison.

RESULTS
Posterior translation of the femur relative to the tibia in the OA knees was similar to the control group (Fig 1). However, OA knees had significantly reduced magnitude in posterior translation between 60° and 90° of flexion (p<0.05). Medial femoral translation was greater in OA knees than in the control group between 30° and 90° of flexion (p<0.05) (Fig 2). Between 30° and 90° medial translation ranged from 7.3 ± 3.0 mm and 8.0 ± 2.5 mm compared to normal knee values between 4.5 ±1.9 mm and 8.0 ± 2.5 mm compared to normal knee values between 4.5 ±1.9 mm and 8.0 ± 2.5 mm. No significant difference in  either posterior or medial translation was detected beyond 90°. No significant difference in tibial rotation was found at any flexion angle, however, OA knees demonstrated significantly greater internal rotation than normal between 30° and 90° of flexion (p<0.05) (Fig 3). Varus rotations varied between patients but were found to be significantly greater than in normal subjects at around 30° of flexion (p<0.05) (Fig 4). No significant difference in varus rotation was found at higher flexion angles.

DISCUSSION
This study was the first to examine the 6DOF kinematics in degenerative knees with primarily medial compartment OA. The OA knees had decreased posterior translation compared with normal knees between 60° and 90°, indicating that the severity of the disease and cartilage imbalance between the medial and lateral compartments may influence the typical roll/glide pattern seen in normal knees [3]. The increased medial translation seen between 30° and 90° of flexion is somewhat expected at full extension, given the severity of the medial compartment OA when compared to the lateral side. This increase during weight bearing flexion up to 90° may be due to contraction of the soft tissues on the medial side and overstretching on the lateral side. No differences were found in internal tibial rotation, which has been seen in a previous study when a decrease in tibial rotation was found with increasing OA severity [5]. Varus rotations did not show significant differences compared to normal knees beyond 30°. While few studies have investigated the kinematics within the knee joint, gait studies have determined that some differences seen in OA gait are due to a subject’s attempt to compensate for pain or weakness [1].

The advanced OA knee seemed to have no significant affect on knee kinematics beyond 90° of flexion, indicating that surgical treatments such as unicompartmental or total knee arthroplasty for advanced medial compartmental OA should restore knee kinematics in low flexion but should not necessarily affect the knee at high flexion. By identifying the differences between normal and OA knee kinematics, we may better understand the preoperative factors that affect patients and develop more appropriate surgical treatments for OA knees. Future studies will investigate OA knee kinematics with respect to the medial and lateral compartments in order to determine if the resulting kinematics are influenced by one side more than the other.

REFERENCES