INTRODUCTION: Previous in vivo studies have not documented if ethnicity or gender influence knee kinematics for the healthy knee joint. Other measurements, such as hip-knee-ankle alignment have been previously shown to be significantly different between females and males, as well as Japanese and Caucasian populations in the young healthy knee [1]. Differences in knee kinematics in high flexion positions may relate to both etiology of osteoarthritis and success in knee replacement designs. Although differences in knee anatomy have been identified, their significance in knee function has not yet been clarified. Therefore, the objective of this study was to determine the 3D, in vivo normal knee kinematics for various subjects from different gender and ethnic backgrounds, and to identify significant differences, if any, between populations.

METHODS: The 3D, in vivo, weight bearing normal knee kinematics was determined for 79 healthy subjects, including 48 Caucasians, 24 Japanese, 42 males, and 37 females - during a deep knee bend involving a standing (full extension) to squatting to a lunge motion, until maximum knee flexion was reached. The study was approved by the Institutional Review Board and informed consent form was obtained from all subjects. The 3D bone models, created by segmentation from MR images, were used to recreate the 3D knee kinematics using the previously described fluoroscopic and 3D-to-2D registration techniques (Fig. 1) [2,3]. Tibiofemoral rotations were described using the ISB recommended Grood and Suntay convention [4,5]. Anterior-posterior translations of the centers of the posterior femoral condyles were normalized due to significantly different anthropometry in the subjects. Anterior cruciate ligament (ACL) laxity was also measured using a KT-1000 device for 72 of these subjects. Statistical analysis was performed using the Student’s t-test, set at the 95% confidence interval.

RESULTS: Most subjects achieved very high flexion positions (Fig.3), however substantial variability occurred in all groups. Range of motion (ROM) varied from 17° to 177°, while average external rotation was 31°± 9.9° for all subjects. Japanese and female subjects achieved greater ROM than Caucasian (p=0.048) and male (p=0.014) subjects (Fig. 2).

DISCUSSION: High variability and ROM in knee kinematics were similar to those seen in previous studies of healthy subjects during a deep knee bending activity [6]. Subjects in this study achieved much greater axial rotation and ROM than previously analyzed TKA patients. A relationship was found between greater axial rotation and increased ROM, and may be related in part to increased ACL laxity in the knee. Significant differences in ROM and laxity were identified between genders and ethnic groups. Also the medial condyle remaining significantly more anterior for females than for males in deep flexion may explain higher external rotation and consequently higher flexion experienced by women. However, understanding the causes for variability within each group may be the key to improved implant design.


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