INTRODUCTION: Optimal femoral rotational alignment in total knee arthroplasty (TKA) is essential for restoring proper patellofemoral and tibiofemoral kinematics. Recent biomechanical analyses reveal that the surgical transepicondylar axis (surgical TEA) and the posterior condylar angle (PCA) changes with variations in the transection plane. To this end, we simulated variations in the transection plane by reslicing the 3D MR image sets of healthy knees, which allowed us to study the sensitivity of the PCA to the angulation in the transection plane.

METHODS: Five male and five female healthy volunteers (ten right knees) were evaluated. All of the subjects were imaged in a supine position at full knee extension with relaxed muscles using a 1.5-T GE CX MRI imager. A 3D fast-gradient recalled echo sequence was used (the in-plane resolution was 0.625mm). The 3D MR image sets were reformatted using MIPAV (Medical Image Processing, Analysis, & Visualization, NIH, Bethesda, MD, USA) computer program in order to create a consistent osteo-based analysis coordinate system (ACS) for each knee (Figure 1). MIPAV is a platform-independent, n-dimensional, general-purpose, extensible image processing and visualization program.

Three dextral, mutually orthogonal unit vectors (Ax, Ay, Az) defined the orientation of the ACS relative to a fixed imager coordinate system (ICS). Ay was parallel to the femoral shaft axis in the sagittal plane, with a positive vector indicating the superior direction. Az was mutually perpendicular to the surgical TEA and to Ay. A positive Az vector indicated the anterior direction. Ax was mutually perpendicular to both Az and Ay. Mathematically, Ax was defined as the cross product of Ay and Az. A positive Ax indicated the medial directions for the right leg, respectively. The origin of the ACS coordinate system was defined as the geometric center of the surgical TEA.

RESULTS: The mean (± SD) TEA angle and PCA in the ARP were 4.1° (± 0.9) and 4.0° (± 1.6°), respectively (Figure 3). Over the 10° change in image plane orientation TEA angle varied 0.39° (min-max) and PCA varied 3.1° (min-max), a ten-fold increase.

DISCUSSION: In this study, we determined that the PCA was variable across subjects and varied as a function of image plane orientation. In contrast, the TEA angle varied little across subjects and was independent of image plane orientation. Surgically, this translates directly into variations in femoral prosthesis alignment with variations in transection angle, if the PCA and not the surgical TEA is used as the reference axis. Thus, if the PCA were to remain as a surgical reference line, we would recommend carefully imaging the joint pre-operatively in order to measure the PCA based on a fixed coordinate system that can be easily transported to the surgical theater.

After establishing the ACS coordinate system 11 images were created from the 3D image set of each knee. The first image was the axial reference plane (ARP), containing the center of the TEA and perpendicular to the Ay direction. The remaining 10 images (altered axial planes - AAP) were created to mimic alterations in the surgical transection plane (Figure 2). The 10 AAPs were oblique axial images. All contained the center of the TEA and were rotated from -5° to +5° in 1° increments about an axis in the Az direction that crossed the geometric center of the TEA. In each of the 11 images the angle between surgical TEA and clinical TEA (the line connecting the most prominent points of the medial and lateral femoral epicondyles in the ARP) (TEA angle) and the PCA were measured.

3A: Angle between Clinical & Surgical TEA
3B: The posterior Condylar Angle