ENHANCING A KINEMATICALLY-DERIVED AXIS OF THE KNEE FOR USE IN NAVIGATED TKA

Introduction: Correct component position is critical to the performance and longevity of total knee arthroplasties; for example, setting the femoral component rotation parallel to the transepicondylar axis (TEA) optimizes tibio-femoral and patello-femoral articulations.1 2 Because of this and based on the findings by Asano et al. and Churchill et al. that the knee flexion/extension axis corresponds with the TEA, we have pursued the study of using the flexion/extension axis (or average helical axis (HA)) in place of the TEA for component alignment when using a knee navigation system.3 4 As part of a larger study of the reliability of computing a kinematically-derived helical axis of knee motion using a knee navigation system, this paper will focus on whether this helical axis can or should be broken down further into more appropriate knee parameters for aligning bone cuts. The larger study found that computing the helical axis between 10° and 90° is much less variable than digitizing the TEA from bony landmarks. The hypothesis of this further study is that the helical axis computed within smaller segments of the arc of motion will yield consistent and different results from the full flexion arc. Specifically, we hypothesize that the helical axis between 10°-30° of knee flexion in the varus/valgus plane will be approximately 5° of valgus to the plane perpendicular to the average femoral mechanical axis (or 85° to the mechanical axis) while the helical axis computed between 60°-90° of knee flexion in the femoral internal/external rotation plane will correlate exactly with the average TEA and that these values may be different from those calculated for the full 10°-90° range of motion.

Methods: Twelve unpaired knees from fresh, frozen cadavers were used to calculate the helical axis of the knees using a knee navigation system and custom navigation software (Stryker Corporation, Kalamazoo, MI). Four surgeons were asked to flex and extend the knee repeatedly; however only the computed axis data for one surgeon will be presented here. From the range-of-motion trials, the helical axis was computed for the 10-90° arc of motion as well as 10-30° and 60-90° in both the varus/valgus plane and the femoral internal/external rotation plane. Each surgeon also digitized bony landmarks to define the TEA and femoral mechanical axes several times; averages of these digitized axes were used as reference axes. Each helical axis was calculated as an angle difference of its projection onto a plane with the projection of either the TEA or mechanical axis onto the same plane (see Figure 1).

Results: The helical axis between 10° and 30° of knee flexion projected onto the varus/valgus plane was found to lie within a 95% confidence interval of -5.92° to -1.88° (see Figure 2) compared to -3.95° to 0.09° for the full 10°-90° arc of motion (a matched pairs t-test revealed a significant difference between the means, P<0.05). The helical axis between 60° and 90° of knee flexion projected onto the internal/external rotation plane was within the 95% confidence interval of -2.18° to 1.40° (see Figure 3) compared to -1.39° to 1.34° for the full 10°-90° arc of motion. Negative values are valgus or internally rotated in their respective planes.

Discussion: Regardless of the location, the helical axis measurement with greater reproducibility would be the best choice for surgical navigation. Because the variation is smaller with the full arc-of-motion in the internal/external plane, that helical axis would be preferable in aligning the component in that plane. Since the variation appears to be equivalent for the full and segmented arc-of-motion in the varus/valgus plane yet the orientations are statistically different, this may be worth further study.

Acknowledgement: This research was supported by Stryker Corporation.

References:

Figure 1: Antero-lateral view of the left distal femur. θ is the angle between the projections of the transepicondylar axis (TEA) and the helical axis (HA) onto the plane of femoral internal/external rotation (defined as the plane perpendicular to the average mechanical axis).

Figure 2: Angle differences of the helical axes between 10°-30° with respect to the average mechanical axis in the varus/valgus plane. Each is expected to be an average of 5 degrees of valgus different from the mechanical axis (minus 90°) in the varus/valgus plane.

Figure 3: Angle differences of the helical axes for between 60°-90° with respect to the average TEA in the internal/external plane. Each is expected to be an average of 0 degrees different from the TEA in the internal/external plane.

53rd Annual Meeting of the Orthopaedic Research Society

Paper No: 0192