Quantifying Manually-Performed Total Knee Arthroplasty Using Robot-Assisted Parameters: A Roadmap to Standardizing Future Studies

Charles Gusho, Henry Tsang[1], Khalid Waliullah, Emily Leary, Elie S Ghanem[2]
[1]Riverside University Health System, [2]University of Missouri at Columbia

INTRODUCTION:

Manually-performed total knee arthroplasty (TKA) introduces greater variability in alignment and joint gaps than does robot-assisted TKA with conflicting results comparing these two techniques. One major confounder is the inability of these studies to quantify manual TKAs and perform objective comparisons of their final alignment and gaps. Although robotic surgery improves the surgeon's precision in reproducing their desired alignment and gap philosophy with minimal outliers, our capacity to pair the different philosophies to various knee morphologies for achieving optimal outcome is rudimentary. This pilot study sought to quantify manual TKAs to bring objectivity and standardization when conducting future robotic versus manual TKA studies.

Aims:

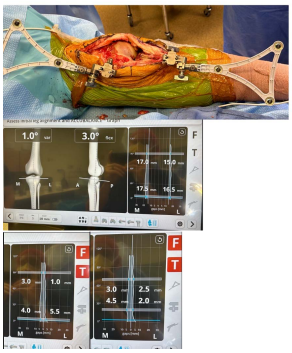
1) Describe the process of quantifying manually-performed TKA using robotic technology that utilizes line of site sensor arrays.

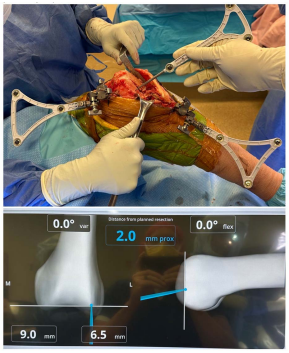
2) Compare expected robot-assisted parameters for bony resections and alignment variables to actual parameters obtained after quantifying manually performed TKAs based on a mechanical alignment philosophy.

METHODS: A total of 30 manually-performed TKAs in 30 patients with a mean (SD) patient age of 64.9 (7.3) years and body-mass-index of 35.7 (6) kg/m^2 were quantified intraoperatively using Velys^{TM} (DePuy, Raynham, MA) robot-assistance with goal of achieving mechanical alignment within 1^0 of varus. Femoral and tibial array pins were placed following standard medial parapatellar arthrotomy with appropriate joint exposure, after which bony registration points were acquired to obtain robotic measurements of hip-knee-angle (HKA) mechanical axes, tibial axes, and femoral axes (Figure 1). The extremity was then taken through initial alignment and balance testing to record planned HKAs, flexion/extension angles, posterior condylar axes, as well as medial/lateral gaps at 0, 20, 70, and 90^0 robotically (Figure 1). The femoral intramedullary guide was replaced, distal femur cuts performed manually with 5^0 valgus and 9mm resected from high side, cut surfaces and resection thicknesses checked with the Velys^{TM} probe (Figure 2), after which a proximal tibial cut was made with an extramedullary guide set to 3^0 slope, 1^0 varus, and a 9mm high side resection (Figure 3). Last, a 4-in-1 femur cut was made at 90^0 flexion after setting rotation based on gap balancing with lamina spreaders (Figure 4). We recorded the actual sagittal and coronal alignment measures and medial/lateral gaps at 0, 20, 70, and 90^0 with trials in place. Data analyses included descriptive statistics of continuous and categorical variables, and means comparisons of continuous variables using *t*-test with a $p>0.05$ indicating statistical significance.

RESULTS: There were no differences in mean (SD) expected robotic versus executed manual cuts of the distal medial (9.1 [1.2] *vs.* 8.9 [1.23] mm) or lateral (7.6 [2.0] *vs.* 7.6 [1.8] mm) femur, posterior medial (10.7 [1.3] *vs.* 10.5 [1.5] mm) or lateral (7.8 [1.2] *vs.* 7.6 [1.8] mm) femur, nor medial tibia (6.5 [2.0] *vs.* 7.3 [1.9] mm), respectively (all $p>0.05$), with high variability among manual cuts. The lateral manual tibial cut had a mean (SD) 9.7 (2.1) mm *vs.* a mean (SD) 8.8 (0.9) mm expected robotic cut (p=0.028). There were no differences in mean (SD) expected robotic versus manual proximal tibia angle (0.9^0 [0.3] varus *vs.* 1.1^0 [1.6] varus), mechanical HKA (0.9^0 [0.3] varus *vs.* 1.1^0 [3.1] varus), femoral rotation based on the manual *vs.* robot posterior-condylar axis (3^0 [3.5] external *vs.* 3.5^0 [2.8] external [1.43]), and large variance noted in the executed cuts. There was also noted variation between mean (SD) of expected vs. executed medial/lateral gaps overall in extension, mid-flexion, and flexion.

DISCUSSION AND CONCLUSION: The manually-performed TKAs quantified using our robotic platform exhibited large standard deviations compared to expected parameters if performed purely with robotic technology. Hence, when performing robotic-assisted versus manual TKA studies, it is imperative to not only include the philosophy that was targeted in the manual group but to quantify the actual execution of the TKA as there is great variance. Quantifying manual TKAs will standardize the analytical process to elucidate the possible benefits of robotic surgery.


1.0° var
3.0° flex
F
T
3.0
1.0
4.0
5.5
2.5
2.0
4.5


0.0° var
2.0 mm prox
0.0° flex
9.0 mm
6.5 mm


1.0° var
0.5 mm dist
3.0° post
8.5 mm
9.0 mm