INTRODUCTION: Total Knee Arthroplasty (TKA) is a definitive treatment procedure for severe knee osteoarthritis. To achieve high functionality, it is important to restore the native knee biomechanics as much as possible. Robotic-assisted TKA holds promise in reliably ligamentous balancing through bony resection that may improve patient function, including during a more normal daily activity such as gait. This observational study aimed to capture functional parameters after robotic-assisted TKA and compare them with already recorded data of patients who had received a manually implanted TKA. In addition, we also used data from a healthy elderly subject group to see whether the gait of TKA patients with well-balanced ligaments had normalized.

METHODS: Three groups (n=13 each) were included. The rTKA (robotic single radius CR TKA) group consisted of 2/11 male/female, 68.4 ± 6.8 years, 27.6 ± 8.2 body mass index (BMI), 27.5 ± 8.9 right/left. All subjects were recruited from a single surgeon’s clinic for this ongoing IRB-approved study. For comparison, a data repository was assessed to obtain the mTKA (Manually implanted single radius CR TKA) comparison group which consisted of 1/12 male/female, 66.5 ± 6.8 years, 29.5 ± 6.8 BMI, 5/8 right/left. The third group was an elderly “Healthy” comparator group consisting of 4/9 male/female, 60.5 ± 6.1 years, 25.3 ± 4.0 BMI, 7/6 right/left. The point cluster marker set (PCT) was used to obtain knee joint kinematics and kinetics. Passive reflective markers were placed on the skin and tracked with a multi-camera system. Subjects were instructed to walk at their usual pace on level and downhill (Walkway with a 6° downhill slope was set at 2.8 m/s). The range of motion (ROM) during walking was similar in the rTKA and the Healthy in both conditions. In contrast, the mTKA displayed a smaller ROM than the Healthy in both level and downhill walking (p<.004, p=.001, respectively). Conversely, during the midstance phase of the gait cycle, the knee of rTKA stayed significantly more flexed (10.9°, SE=1.5) compared to the Healthy (3.4°, SE=1.5) and mTKA (5.3°, SE=1.5) in level walking (p<.001, p=0.044, respectively). A similar trend was also observed in downhill walking using SnPM. (Fig. 2A) The tibial anterior displacements of the rTKA were significantly smaller than the Healthy and mTKA in level (p=0.04, p=.002, respectively) and downhill (p=.011, p=.001, respectively) (Fig. 2B). The peak flexion moment, which occurs during the first half of the stance in the sagittal plane, was higher in the rTKA and the Healthy (p<.001, p=.017 in level walking, p=.001, p=.003 in downhill, respectively). The rTKA which normalizes the quadriceps moment during the second half of the stance, was significantly lower in the rTKA than the Healthy and mTKA (p<.001, p=.002 in level walking, p=.002, p=.003 in downhill, respectively) (Fig. 2C, D). In the frontal plane, there were no statistical differences among the 3 groups in adduction peaks in both level and downhill walking.

DISCUSSION: This study is one of the first to correctly compare manual and robotic ligament balancing techniques in TKA and report a difference in level walking as well as during a mid-flexion activity such as downhill walking. Some but not all of the gait parameters appear normalized after robotic surgery. The rTKA subjects demonstrated healthy quadriceps use during the stance phase under both conditions, suggesting that proper ligament tensioning may help the extensor mechanism, which is often compromised after TKA. On the other hand, the low extension moment during the swing phase suggests underutilization of the hamstrings, a feature that needs more study and could be related to implant design. One limitation of this study was that TKA implants for the manual and robotic groups were not the same. Future work will take this into account and identify the reason for the difference in kinetics.

SIGNIFICANCE/CLINICAL RELEVANCE: TKA with robotic-assisted ligament balancing suggests normalization of some, but not all, gait parameters and healthier quadriceps use during level and downhill walking when compared to manual TKA.

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Knee Kinematics and Kinetics During Level and Downhill Walking in Total Knee Arthroplasty Using a Robotic Ligament Tensioner
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