Tibial AP Translation during Gait Correlates with Intraoperative Medial Mid-flexion Laxity in Total Knee Arthroplasty Using a Robotic Ligament Tensioner

Takayuki Koya, Alexander Dickerson Orsi, Christopher Knowlton[1], Christopher Plaskos[2], Vasili Karas[3], Markus Wimmer[1]
[1]Rush University Medical Center, [2]Corin, [3]Midwest Orthopaedics at Rush

INTRODUCTION: Knee joint instability leads to poor outcome after total knee arthroplasty (TKA). A better understanding of how intraoperative ligament tensioning affects postoperative gait kinematics and kinetics, may lead to better decisions in the operating room. This study investigates the relationship between intraoperative joint laxity measured with a robotic ligament tensioner and AP translation measured postoperatively during over-ground gait in the motion analysis lab.

METHODS: For this IRB-approved study, twenty robotic-assisted TKA patients (BMI<35), who received PCL retained, inverse kinematically aligned TKAs, were recruited from a single surgeon's clinic. In all surgeries, laxity was recorded using a robotic ligament tensioner (Figure 1). In particular, medial and lateral laxity were recorded throughout the entire flexion range, as the knee moved from flexion to full extension during final trialing. Laxity was defined as the tibial insert's thickness subtracted from the gap between the resected tibia and the femoral component. Eight to 14 months after surgery, patients were invited to participate in a gait assessment in the motion analysis lab. The point cluster marker set (PCT) was used to obtain knee joint kinematics and kinetics from this group, which were then compared with those of a healthy, elderly control group from our data repository. Passive reflective markers were placed on the skin and tracked with a multi-camera system. Simultaneously, ground reaction forces were collected during level and downhill walking. Subjects were instructed to walk at their usual pace. Level walking trials were completed over a horizontal surface with embedded force plates. Downhill walking trials were performed on a ramp with a 12.5% slope and an embedded force plate, and five trials were recorded for each activity. Knee kinematics and external moments were calculated and normalized to %bodyweight x height using inverse dynamics. Medial and lateral mid-flexion laxities were computed as the mean laxity between 40-50° for each patient. AP translation during gait was defined as the relative distance between the center of the epicondylar axis and the center of the tibia. For both level and downhill walking, statistical parametric mapping of the AP waveforms was performed. Pearson's correlations were then obtained between laxity and AP translation for both the medial and lateral sides.

RESULTS: The final demographics of the robotic TKA group comprised of 3/17 male/females, 66.3 ± 7.7 years, 27.3 ± 3.2 BMI, and 13/7 right/left knees and compared with 7/13 male/female, 57.1 ± 8.6 years, 25.6 ± 4.1 BMI, 9/11 right/left in the healthy group. The robotic group showed statistically lower AP translation during the swing phase compared to the healthy group in both level and downhill conditions (p= 0.001, Figure 2). AP translation during swing was associated with medial mid-flexion laxity for both level (p=0.024) and downhill (p=0.013) walking (Figure 3).

DISCUSSION AND CONCLUSION: This observational study is one of the first to investigate the correlation between intraoperative mid-flexion laxity and tibial AP translation during level and downhill walking. Our results suggests that AP translation might be "normalized" in the operating room by adjusting joint laxity.

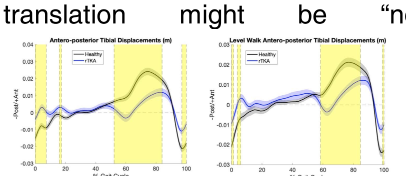

Figure 2: Antero-posterior tibial displacement relative to the center of the epicondylar axis of the femur during downhill and level walking. Yellowish shaded regions indicate significant differences between the robotic TKA group and an elderly healthy control group. Differences can be found during early swing phase when the knee flexes.

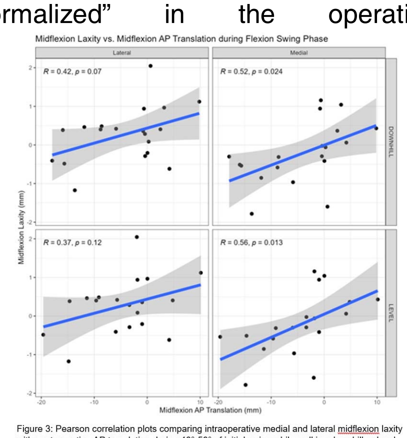

Figure 3: Pearson correlation plots comparing intraoperative medial and lateral midflexion laxity with postoperative AP translation during 40°-50° of initial swing while walking downhill or level ground.

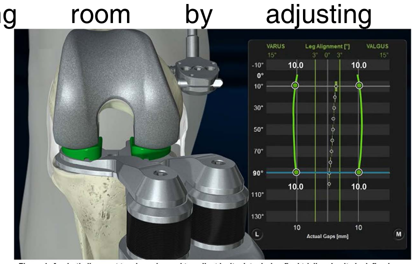

Figure 1: A robotic ligament tensioner is used to collect laxity data during final trialing. Laxity is defined as the tibial insert thickness subtracted from the gap between the resected tibia and the femoral component.