Can Cadaver Testing Replicate In Vivo Kinematics of Total Knee Arthroplasty?

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INTRODUCTION: Whether the kinematics of cadaveric knees recreate those of the patient's knees after total knee arthroplasty remains unknown. This study compared in vivo and in vitro kinematics of knees after total knee arthroplasty while deep knee bending (DKB) using the same local coordinate system.

METHODS: Patients who had undergone cruciate-retaining and cruciate-substituting total knee arthroplasty (CR-TKA and CS-TKA) (N=21) were examined in in vivo study. On the other hand, fresh-frozen human cadaveric knees were examined in in vitro study (N=10). To simulate a DKB of cadaveric knees, the knees were mounted on a dynamic, quadriceps-driven, closed-kinetic chain simulator based on the Oxford knee rig design. Under fluoroscopy, the patients performed squatting motions. To estimate the spatial position and knee orientation, a 2-dimensional or 3-dimensional registration technique was used. The axial rotation angle and anteroposterior translation of medial and lateral contact points of the femoral component relative to the tibial component were evaluated in each flexion angle.

RESULTS SECTION: No significant differences of the axial rotation angles were found between in vivo and in vitro studies in both CR-TKA and CS-TKA (p=0.07 and p=0.56). In early-flexion, the medial and lateral contacts point of in vitro study was located more posterior than that of in vivo study in CR-TKA (p=0.02 and p=0.04). From early-flexion to high-flexion, the medial and lateral contact points of in vitro study were located more posterior than that of in vivo study in CS-TKA (p=0.02 and p=0.04) (Figure 1 and Figure 2).

DISCUSSION: With regard to axial rotation angle, no significant differences were found between in vivo study and in vitro study. This finding suggests that the rotational kinematics of cadaveric knees during DKB, investigated using the Oxford knee rig, could recreate the kinematics of the patient's knees after TKA. However, with regard to AP translation and kinematic pathway, some differences exist between in vivo study and in vitro study contrary to the hypothesis. In other words, the medial and lateral contact points of in vitro study were located more posterior than those of in vivo study. Li et al. demonstrated that a quadriceps force affects the femoral posterior translation and a hamstring force affects the femoral anterior translation [1]. This suggests that the quadriceps load relative to the hamstring of cadaveric knees might be larger than that of the patient's knees. In this study, the difference of AP location between in vivo study and in vitro study was more remarkable in CS-TKA. In CS-TKA, posterior cruciate ligament (PCL) was sacrificed. The PCL removal may decrease the posterior stability. Moreover, this in vitro study did not add the hamstring load. This posterior instability and hamstring weakness may affect the posterior location of bilateral contact points of in vitro study.

SIGNIFICANCE/CLINICAL RELEVANCE: The axial rotation angle of cadaveric knees after total knee arthroplasty may recreate that of patient's knees after total knee arthroplasty. Conversely, the anteroposterior location of cadaveric knees after total knee arthroplasty may be more posterior than that of the patient's knees after total knee arthroplasty.

REFERENCES:

1. Li G et al: The importance of quadriceps and hamstring muscle loading on knee kinematics and in-situ forces in the ACL. J Biomech. 1999;32(4):395-400.

IMAGES AND TABLES:

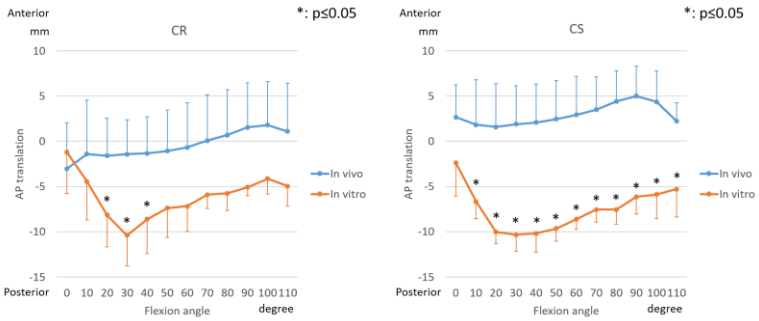

Figure 1. Anteroposterior translation of the medial contact point

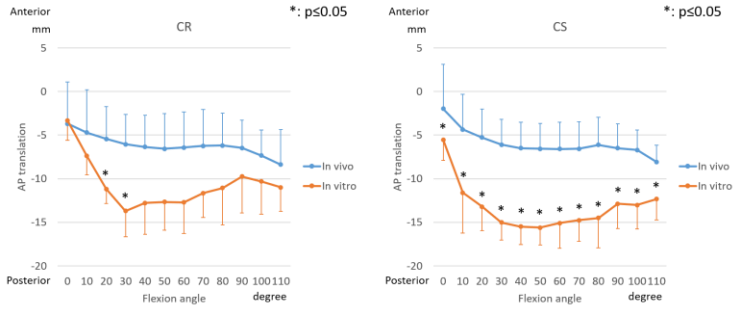

Figure 2. Anteroposterior translation of the lateral contact point