TIBIOFEMORAL GAPS OF HUMAN CADAVERIC KNEES BEFORE AND AFTER SACRIFICING BOTH CRUCIATE LIGAMENTS

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Introduction

Implant alignment and the resulting knee stability are crucial factors that affect short- and long-term outcomes of total knee arthroplasty (TKA) [1]. While the goal of gap balancing is to create equal and symmetric flexion and extension gaps to obtain correct soft tissue balance, it was shown that gaps in the native knee are neither equal nor symmetric through the arc of flexion [2]. However, tibiofemoral gaps of native knees are so far measured after tibial-cut and resection of the anterior cruciate ligament (ACL), while the "true" native gaps are mostly unknown. Therefore, the objective of this study was to quantify the tibiofemoral gaps of native knees at different flexion angles prior to tibia and ACL resection and to investigate changes after sacrificing both cruciate ligaments.

Methods

Eleven fresh-frozen human cadaveric knees were tested on a six degrees of freedom joint motion simulator (Advanced Mechanical Technologies Inc., Watertown, USA) by applying 100 N distraction force for 25 s at different flexion angles (0°, 30°, 45°, 60° and 90°) and different stages of resection (native knee and after resection of the cruciate ligaments) with all other forces/moments maintained at 0 N/Nm. Before testing, femur and tibia of each specimen underwent a complex 3D fitting process (ARAMIS 12M, GOM Metrology GmbH, Braunschweig, Germany) using segmented CT scans containing landmark based femoral and tibial coordinate systems. During testing, the relative position of femoral and tibial coordinate systems was tracked by the joint motion simulator. This allowed subsequent positioning of the segmented CT scans relative to each other to measure the tibiofemoral gaps medially and laterally along the mechanical axis of the tibia.

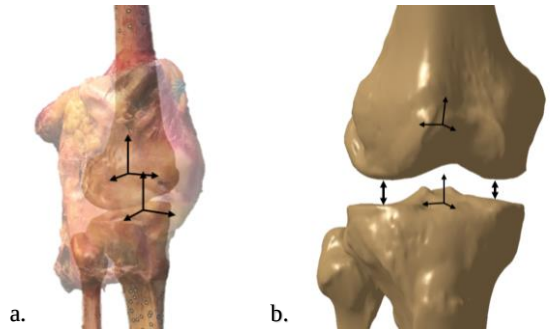

Figure 1: a. Specimen with 3D fitted segmented CT scans. b. Exemplary gap measurement within the positioned CT scans.

Measured gaps were normalized to the native medial gaps at 0° flexion to enable comparison of the specimens. Mean standardized gaps and standard deviations were calculated across the eleven specimens.

Results

Native medial and lateral gaps were tightest in extension, increased mostly until 30° flexion, then only showed a small increase until 60° and a slight decrease again at 90°. The lateral native gap was larger than the medial gap throughout the complete range of flexion. After resection of the cruciate ligaments, the gaps increased on both, the medial and lateral sides. In contrast to the native knees, the gaps continued increasing until 90° flexion.

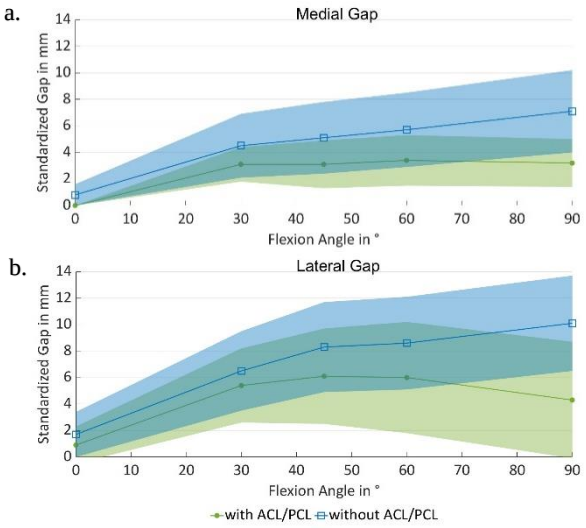

Figure 2: Mean standardized medial (a) and lateral (b) gaps (n = 11) and standard deviations throughout the range of flexion (0° to 90°) in the native (green) and cruciate sacrificed (ACL & PCL, blue) knees.

Discussion

It was shown that the tibiofemoral gaps in native knees, prior to tibia-cut and ACL resection, are neither equal nor symmetric with a markable increase until 30° flexion. This may affect knee stability in mid-flexion after gap balanced TKA. Furthermore, sacrificing both cruciate ligaments resulted in a greater flexion-extension mismatch than in native knees.

References

1. Dennis et al., Clin Orthop Relat Res, 468:102–107, 2010.
2. Shalhoub et al., J Arthroplasty, 33(9):3043-3048, 2018.