Laxities of the Normal Knee at 0° and 90° Flexion: A Benchmark for Assessing Soft Tissue Balance in TKA

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INTRODUCTION

Soft tissue balancing is a critical step in total knee arthroplasty (TKA). Surgeons often assess balance at 0° and 90° flexion primarily considering varus-valgus[1-3] and distraction[4] laxity. However both anterior-posterior translation and internal-external rotation are also important degrees of freedom. Therefore it is important for surgeons to understand the laxity of the normal knee at 0° and 90° in all four of these degrees of freedom to determine whether the soft tissues are properly balanced. Accordingly, the objective of this study was to measure the laxities of the normal knee at 0° and 90° flexion in internal-external (I-E) and varus-valgus (V-V) rotation and in anterior-posterior (A-P) and compression-distraction (C-D) translation to provide a benchmark for soft tissue balancing in TKA.

METHODS

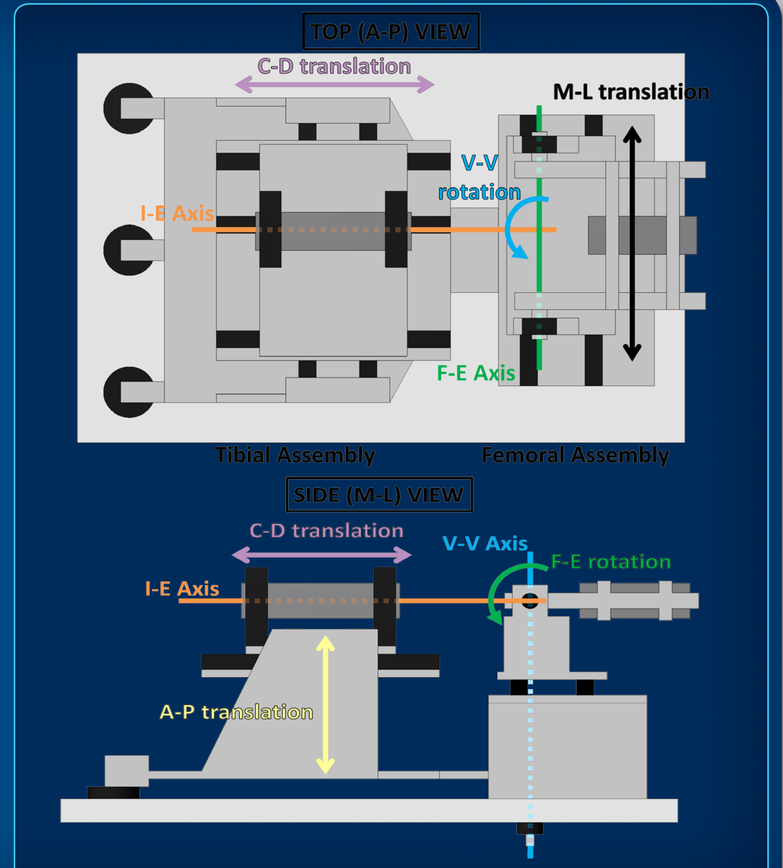
1. Seven fresh-frozen, cadaveric knees were included (average age: 69 years, range: 57 to 85 years). Specimens were free from degenerative joint disease, soft tissue damage, and evidence of previous surgery to the knee.

2. Following preconditioning, the laxity in I-E, V-V, A-P, and C-D were measured at 0° and 90° flexion using the load application system (**Figure 1**).

3. The applied loads used to define the laxity were ± 3 N-m for I-E rotation[5], ± 5 N-m for V-V rotation[6], ± 45 N for A-P translation[7], and ± 100 N for C-D translation[8]. Throughout testing, a 45 N compressive tare load was applied to the tibia to simulate the passive compression created by the soft tissues that were transected during dissection.

4. The laxity at 0° and 90° flexion in each degree of freedom was described by the mean and standard deviation of the seven knees at each flexion angle. Differences in the laxity for each degree of freedom between 0° and 90° flexion were analyzed using a paired t-test with a level of significance of $p<0.05$.

Figure 1. Functional schematic showing the six degrees of freedom of the load application system[2]. The A-P, M-L, and C-D translational degrees of freedom are allowed by linear bearings translating along linear rails. The F-E and I-E rotational degrees of freedom are allowed by rotation of radial ball bearings. V-V DOF is allowed by rotation of radial ball bearing and three air bearings.



RESULTS

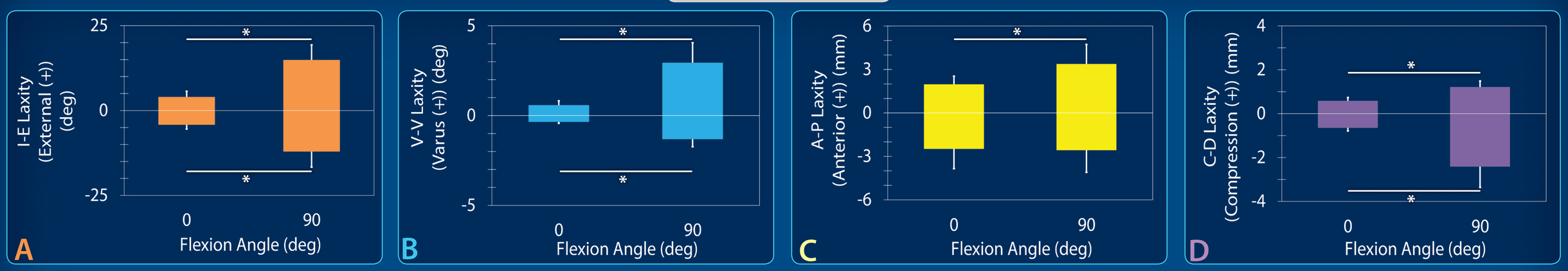


Figure 2. Four bar charts display the laxity in (A) I-E, (B) V-V, (C) A-P, and (D) C-D for the normal knee at 0° and 90° flexion. Error bars show one standard deviation. Each asterisk signifies that the laxity at 90° flexion was significantly greater than the laxity at 0° flexion. The laxity in all degrees of freedom and both directions increased significantly at 90° flexion ($p<0.05$) except in posterior translation.

CONCLUSION

Because the laxity of the normal knee increased in all degrees of freedom and both directions except in posterior translation, surgeons following the principle of gap balancing to balance the soft tissue in TKA should be aware that they may be over constraining the knee at 90° flexion, which may lead to stiffness, limited flexion, and abnormal contact kinematics.

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