Varus-valgus Laxity Of The Normal Knee At 0° And 90° Flexion: Implications In Gap-balancing TKA

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Disclosures:
J.D. Roth: None. S.M. Howell: 1; Biomet Sports Medicine. 2; Biomet Sports Medicine. 3B; Biomet Sports Medicine. 7; Saunders/Mosby-Elsevier. M.L. Hull: 5; Stryker Orthopaedics, DePuy Orthopaedics. 6; Stryker Orthopaedics, DePuy Orthopaedics.

Introduction: The principle of gap-balancing total knee arthroplasty (TKA) is to create equal varus laxity and valgus laxity at 0° flexion, at 90° flexion, and between 0° and 90° flexion. Previous studies have pointed out the importance of understanding varus-valgus (V-V) laxity of the normal knee because it should serve as a standard for the assessment of V-V laxity during gap-balancing TKA [1-3]. However, an understanding of the laxity of the normal knee is only useful in gap-balancing TKA for the 36% of knees where ligament releases at 0° flexion are not required [4] because ligament releases change the V-V laxity from normal and may have different effects on the V-V laxity at 90° flexion depending on which structures were released [5, 6]. Therefore, this study will focus on the effects that the principle of gap-balancing TKA has on the 36% of knees for which the normal V-V laxity was retained at 0° flexion.

Some studies have reported that varus laxity is greater than valgus laxity at 0° flexion [1, 2] and 90° flexion [2, 3, 7, 8] and that both the varus laxity and valgus laxity are greater at 90° than 0° flexion [7-9]. Other studies have contradicted these findings reporting that valgus laxity is greater than varus laxity at 90° flexion [1, 9]. Also, many of these studies had a methodological limitation because coupled motions were constrained [1-3, 7]. Hence, a study that measures V-V laxity without constraining coupled motions is needed to provide a standard for the assessment of V-V laxity during TKA.

Accordingly the objectives of this study were to (1) measure the V-V laxity of the normal knee at both 0° and 90° flexion in vitro using a six degree-of-freedom (DOF) load application system (LAS) which does not constrain coupled motions, and (2) determine how frequently the principle of gap-balancing TKA would change the V-V laxity of the knee from normal which occurs when the varus laxity and valgus laxity are unequal at 0° flexion, at 90° flexion, or between 0° and 90° flexion.

Methods: Seven fresh-frozen, cadaveric knees were included in this study (average age: 72 years, range of ages: 57 to 91 years). Specimens were free from degenerative arthritis, chondrocalcinosis, osteophytes, meniscal tears, ligament tears, and evidence of previous surgery to the knee.

The following steps were used to measure V-V laxity of the knee at 0° and 90° flexion. First, each knee was aligned in a six DOF LAS so that the flexion-extension (F-E) and internal-external rotation axes of the LAS were coincident with the F-E and longitudinal rotation axes of the tibiofemoral joint[10]. Second, each knee was subjected to a preconditioning protocol consisting of five cycles between ±2.5 N-m in F-E and 5 cycles between ±5 N-m in V-V[7] at 0°, 60°, and 120° flexion; 0° flexion was defined as the position of the femur relative to the tibia under a 2.5 N-m extension moment [11]. Finally, the V-V laxity was measured at 0° and 90° under applied ±5 N-m relative to the neutral position of the unloaded knee.

The varus laxity and valgus laxity at 0° and 90° flexion were each described by the mean and standard deviation of the seven knees at each flexion angle. Differences between varus laxity and valgus laxity at 0° flexion, at 90° flexion, and between 0° and 90° were compared using a paired t-test. Laxities were considered unequal at 0° flexion, at 90° flexion, or between 0° and 90° flexion when the difference between varus laxity and valgus laxity was ≥ 1°.

Results: Varus laxity was 0.5° ± 0.1° at 0° flexion and 2.9° ± 0.9° at 90° flexion. Valgus laxity was -0.5° ± 0.1° at 0° flexion and -1.5° ± 0.4° at 90° flexion. Varus laxity and valgus laxity were unequal in 0% of the knees at 0° flexion, but were unequal in 71% of the knees at 90° flexion; varus laxity was 1.3° ± 0.5° greater than valgus laxity at 90° flexion (p < 0.001). Varus laxity was unequal between 0° and 90° flexion in 100% of knees; varus laxity was 2.4° ± 0.8° greater at 90° than 0° flexion (p < 0.001). Valgus laxity was unequal between 0° and 90° flexion in 43% of knees; valgus laxity was -1.1° ± 0.4° greater at 90° than 0° flexion (p < 0.001).

Discussion: The results of the present study confirm the findings of previous studies that, in the normal knee, varus laxity is greater than valgus laxity at 90° flexion [2, 3, 7, 8], and both varus laxity and valgus laxity are greater at 90° than 0° flexion [7-9]. These findings indicate that the principle of gap-balancing TKA frequently changes the V-V laxity from normal. First, when a surgeon cuts the gap at 90° flexion so that it is equal to the gap at 0° flexion, the gap at 90° flexion is frequently too small because both the varus laxity and the valgus laxity in the normal knee are greater at 90° than at 0° flexion. Second, when the gap at 90° flexion is rectangular so that the varus laxity and the valgus laxity are equal, the lateral gap is frequently too tight because varus laxity is frequently greater than valgus laxity at 90° flexion.

These changes to the V-V laxity from normal would have two important clinical implications. First, over-tightening the V-V laxity at 90° flexion, especially in the lateral gap due to greater over-tightening of varus laxity than valgus laxity, will externally rotate
the femoral component. External rotation of the femoral component will change both patellofemoral and tibiofemoral kinematics because the F-E axes of both the patellofemoral and tibiofemoral joints are parallel to the posterior femoral joint line [12, 13]. Second, over-tightening of the lateral gap of the knee at 90° flexion may lead to stiffness, limited flexion, and abnormal contact kinematics including either limited or reverse axial rotation (lateral pivot) coupled with knee flexion [14, 15]. These changes are problematic because patients often report them as a reason for dissatisfaction following TKA [16]. In conclusion, an understanding that both varus laxity and valgus laxity are greater at 90° than 0° flexion and that varus laxity is frequently greater than valgus laxity at 90° flexion allows surgeons to better restore normal knee kinematics following TKA.

**Significance:** The penalty of gap-balancing TKA is a frequent over-tightening of V-V laxity at 90° flexion from normal, which may lead to stiffness, limited flexion, and abnormal contact kinematics.

**Acknowledgments:**

**References:**

ORS 2014 Annual Meeting
Poster No: 0855