Title: Altered Gait Mechanics in Younger Total Knee Arthroplasty Patients: Insights from Retrospective In Vivo Motion Analysis

Introduction: Total knee arthroplasty (TKA) is increasingly performed in younger, high-demand patients, yet no in vivo biomechanical data exist to inform return-to-sport decisions for individuals under 60. This study aimed to characterize gait kinematics and kinetics in young TKA patients (≤60 years) compared with older patients (>60 years) and healthy controls.

Methods: Eighty-eight knees from a motion analysis database were analyzed: older TKA (n=50), young TKA (n=21), and healthy controls (n=17) (Table 1). All TKAs were performed at a single institution by fellowship-trained surgeons. Gait assessment used a marker-based three-dimensional motion capture system with force plates. Primary outcomes included knee joint kinematics and kinetics. Statistical non-parametric mapping (SnPM) compared groups across the gait cycle, with post hoc pairwise SnPM t-tests using permutation inference and Bonferroni correction. Significance was set at $p<0.05$.

Results: Knee extension moments (%BW·ht) were substantially higher in young patients. At initial contact, young patients demonstrated 1.4 ± 1.4, which was roughly five times higher than older patients (0.2 ± 0.8) and four times higher than controls (0.3 ± 0.8, $p < 0.05$) (Fig. 1). During terminal stance, young patients showed 0.5 ± 0.6 compared with 0.2 ± 0.5 in older patients and 0.0 ± 0.3 in controls ($p < 0.05$). Young individuals also walked with greater varus alignment throughout the gait cycle ($3.2 \pm 7.8°$), while controls ($–7.0 \pm 4.3°$) and older patients ($–3.6 \pm 5.8°$) demonstrated valgus alignment. No additional significant differences in knee kinetics or kinematics were detected.

Conclusion: Younger total knee arthroplasty patients demonstrate elevated knee extension moments and persistent varus alignment, reflecting increased tibiofemoral loading during gait. These biomechanical patterns may impact implant longevity and are particularly relevant for return-to-sport in high-demand individuals. Targeted strategies to reduce excessive loading should be prioritized to optimize outcomes and durability.

Table 1: Patient Characteristics (Mean ± Standard deviation)

Characteristics	TKA Young (≤ 60 years)	TKA Old (> 60 years)	Healthy Controls
Number of Knees	21	50	17
Age During Testing (years)	55.3 (Range: 43-60)	68.3 (Range: 61-87)	55.9 (Range: 50-65)
Time After Surgery During Testing (months)	27.3 (Range: 11-93)	15.12 (Range: 7-119)	n/a
Sex (F/M)	11/10	33/17	15/2
BMI (kg/m^2)	34.03 ± 6.3	29.47 ± 8.1	25.7 ± 5.4
Laterality (L/R)	12/9	31/19	8/9
Number of Different Implant Types	Model A: 16 Model B: 4 Model C: 1	Model A: 17 Model B: 29 Model D: 2 Model E: 2	n/a

F = Females; M = Males; BMI = Body Mass Index; kg = Kilograms; m = Meters; L = Left; R = Right; n/a: Not Applicable. Model A-E: Implant brand information has been omitted per ESSKA abstract submission guidelines.