

Functional Knee Positioning Restores Native Kinematic Patterns in Total Knee Arthroplasty

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INTRODUCTION: Functional Knee Positioning (FKP) aims to personalize implant placement according to 3D CT-based implant planning, dynamic joint balancing, and robotic-execution of surgical plans [1]. While this individualized planning aims to restore patient anatomy and soft tissue balance, the impact of this technique on kinematic pattern is not well understood. Recent studies have reported medial pivot kinematics in normal knees [2] and have associated medial pivot kinematics in total knee patients with improved functional outcomes [3]. The objective of this study was to characterize intra-operative kinematic patterns of osteoarthritic patients in their native intact condition and with final implanted components following FKP and quantify the restoration of native kinematic pattern.

METHODS: A total of 269 patients undergoing single-radius, cruciate-retaining, functionally-positioned RATKA by a single surgeon were retrospectively analyzed. Intra-operative dynamic stability assessments were performed by passively moving the knee through a full range of motion (deep flexion >120° to near extension <10°) during the native intact condition (prior to bone cuts or soft tissue releases) and with final implant components. A proprietary script computed femoral low point kinematics with respect to the tibial bone to estimate tibiofemoral medial and lateral contact positions during the dynamic assessments. Kinematic patterns were classified into three categories using the anterior-posterior translation of the medial and lateral contact points: medial pivot (lateral:medial ratio ≥1.5), symmetrical rollback (lateral:medial ratio between 0.66 and 1.5), or lateral pivot (lateral:medial ratio <0.66) (Figure 1). Medial contact position and kinematic pattern were compared between the native and implanted conditions.

RESULTS: Native kinematics demonstrated a medial pivot in 70.2% (189/269), symmetrical rollback in 28.3% (76/269), and lateral pivot in 1.5% (4/269) of cases (Table 1). Final implanted kinematics following FKP showed a medial pivot in 66.2% (178/269), symmetrical rollback in 30.5% (82/269), and lateral pivot in 3.3% (9/269) of cases. The native kinematic pattern was preserved in 77.7% (209/269) of cases with 82.5% (156/189) of native medial pivot knees remaining medial pivot with final implants, 67.1% (51/76) of native symmetric knees remaining symmetric pivot, and 50% (2/4) of native lateral pivot knees remaining lateral pivot. Native kinematics were restored or corrected to a more medial pivoting pattern in 86.6% (233/269) of patients.

CONCLUSION: While the majority of patients presented a medial pivot kinematic pattern in their native arthritic condition, there was variation in native kinematic patterns. Functionally-positioned RATKA using a cruciate-retaining implant resulted in a medial pivot pattern in the majority of cases and restored native kinematics in most knees, particularly for knees that were initially medially pivoting. While intra-operative kinematic patterns changed in a subset of patients, these changes may be intentional by the surgeon to correct pathology. Further research is ongoing to determine the impact of restoring native kinematic patterns on functional outcomes.

SIGNIFICANCE/CLINICAL RELEVANCE: Functional Knee Positioning (FKP) restored native kinematic pattern in 77.7% of cruciate-retained cases, particularly for medially pivoting knees (82.5%), which demonstrates that the surgical technique may be effective in restoring native kinematic patterns

REFERENCES: [1] Scholl, Laura Y., et al. J Knee Surgery 37.08 (2024): 607-611. [2] Hamilton, et al. Journal of biomechanics 149 (2023): 111487. [3] Warth, Lucian C., et al. J Arthrop 32.8 (2017): 2411-2416.

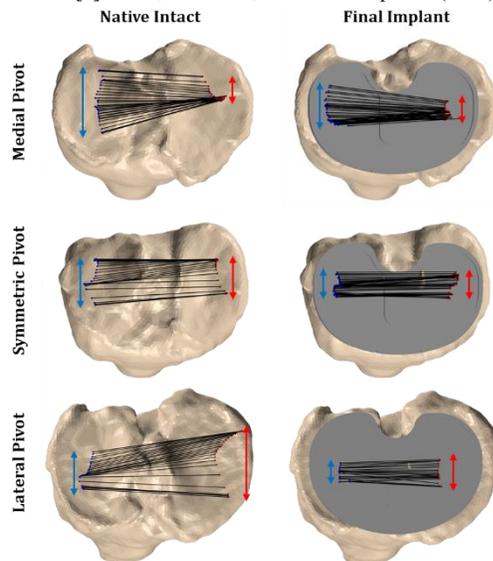


Figure 1: Representative patients with medial pivot (lateral:medial AP ratio>1.5), symmetric pivot (0.66<lateral:medial AP ratio<1.5), and lateral pivot (lateral:medial AP ratio<0.66) kinematic patterns in their native intact and final implant conditions

Table 1: Total number and percentage of patients for medial, symmetric and lateral pivot kinematic classifications in the native intact and final implant conditions. Percentages are reported relative to the total native kinematic classification. Green boxes indicate patients who restored their native kinematic pattern.

		Final Implant			Total
		Medial Pivot	Symmetric Pivot	Lateral Pivot	
Native Intact	Medial Pivot	156 (82.5%)	29 (15.3%)	4 (2.1%)	189
	Symmetric Pivot	22 (28.9%)	51 (67.1%)	3 (3.9%)	76
	Lateral Pivot	0 (0%)	2 (50%)	2 (50%)	4