

Editorial

From My Perspective... Medial or Lateral? The Native Knee Pivot Controversy and Its Implant Consequences

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The author shares his thoughts on this topic.

Medial pivot or lateral pivot? Pick up a corporate brochure and the answer is settled. Pick up the primary literature — the journal articles — and it is not. The disagreement is real, but most of it dissolves when you ask the right question. The question is how much each femoral condyle translates anteriorly and posteriorly (AP) through the flexion arc you actually care about — the differential between the two determines the pivot location.

Freeman and Pinskerova gave us that framework two decades ago. The field has largely ignored it. Once applied, three things fall into place: the medial-pivot and lateral-pivot studies stop contradicting each other, the implant question becomes sharper, and the patient is better served.

THE RIGHT MEASUREMENT

The medial pivot is not a statement about a center of rotation. It is a statement about AP translation. On static MRI of the passive knee through the active functional arc from roughly 20° to 120° of flexion — the arc that covers chair-rise, stairs, lunging, squatting, walking past heel-strike, running, and hiking — the medial femoral condyle translates no more than ±2 mm anteriorly or posteriorly, while the lateral femoral condyle translates approximately 15 mm posteriorly (Freeman and Pinskerova 2005). Under weight-

bearing motion the medial side translates somewhat more, but the asymmetry persists. The medial condyle behaves like a somewhat-constrained ball-in-socket. The lateral condyle behaves like the wheel of a sidecar on ice — it rolls and slides. The result is about 30° of tibial internal rotation around a medial axis.

That is the medial pivot. Small medial AP excursion. Large lateral AP excursion. The greater the differential, the more pronounced the pivot.

IN THE ARC THAT MATTERS, THE EVIDENCE IS NOT CLOSE

Every modern in vivo study of the active functional arc in the normal knee returns the same answer — a medial pivot, albeit with more medial AP translation than during passive motion. Mobile biplane X-ray tracking of an entire walking stride — including the swing-phase peak flexion around 70° — found 15 mm of lateral contact displacement and 10 mm of medial contact displacement, with the tibia pivoting about the medial compartment (Gray et al. 2019). The same Melbourne group extended biplane imaging across six daily activities — level walking, downhill walking, stair ascent, stair descent, standing, and open-chain flexion — and reported a medial-pivot pattern in all six (Thomeer et al.

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2022). Dual fluoroscopy of twenty healthy knees through a weight-bearing lunge from 0° to 120° documented the same dominant medial-side stability with lateral excursion (Rao et al. 2020). Single-plane fluoroscopy of kinematically aligned TKA against the contralateral native knee showed that the medial contact stays centered and the lateral contact moves posteriorly with flexion in both — the implant reproduced the native pattern (Nicolet-Petersen et al. 2020).

For the flexion arc that TKA implants must serve, the medial pivot is not a hypothesis. It is what imaging of the native knee shows.

WHERE THE LATERAL-PIVOT RESULT ACTUALLY COMES FROM

Most of the literature cited in support of a lateral pivot does not describe a native knee at all. The cohorts had ACL injury, ACL reconstruction, or established osteoarthritis. These are altered joints, and their kinematics reflect the alteration (Isberg et al. 2011; Matsuki et al. 2017). They should be set aside in any discussion of native knee motion.

Once they are set aside, three native-knee studies remain. Two are methodologically unreliable. One is uncorroborated.

A skin-marker analysis of 46 healthy knees during gait placed the center of rotation in the lateral compartment for the entire stance phase (Koo and Andriacchi 2008). That rudimentary technique yields root-mean-square errors of up to 24° for bone motion at the knee — larger than the entire medial-versus-lateral rotation under debate (Gray et al. 2019). When measurement noise exceeds the signal, the result cannot be trusted.

High-speed stereo radiography of 53 adults revealed a lateral pivot during gait at < 10° of flexion (Hamilton et al. 2023). Although the imaging modality is accurate, the pivot location was derived using a closest-distance (“low-point” or “nearest-point”) method, which is sensitive to the curvature of the articular surfaces. That method underestimates internal tibial rotation in native knees by approximately 6.5° compared with the true geometric lowest point — large enough to wash out the screw-home signal and convert a medial pivot into an apparent lateral one (Simileysky and Hull 2024). Hamilton’s lateral-pivot finding is most likely an artifact of the method.

That leaves Kozanek et al (Kozanek et al. 2009). Dual fluoroscopy of eight healthy knees during the stance phase of treadmill gait found greater AP excursion of the medial condyle than the lateral — 17.4 ± 2.0 mm vs 7.4 ± 6.1 mm, $p < 0.01$. The methodology is sound. The result, however, is uncorroborated and is actively contradicted by multiple other in vivo gait studies of the native knee using equally accurate or more accurate imaging: single-plane fluoroscopy through deep knee bend and gait (Komistek et al. 2003), mobile biplane X-ray through complete walking strides (Gray et al. 2019), and moving-fluoroscope analysis of complete gait cycles (Postolka et al. 2020) all report a predominantly medial or central pivot. A single dissenting

study, however well conducted, does not overturn a finding repeated across multiple independent cohorts.

DEFINE THE SCREW-HOME — THE CAUSE

The screw-home is multifactorial, but its contributors are not equally influential. The cruciate ligaments — primarily the ACL — are the necessary and irreplaceable mechanism. As the knee approaches full extension, the ACL tightens from impingement on the intercondylar roof, limiting anterior tibial translation and driving the coupled external rotation, while the taut PCL guiding bundle adds an obliquity torque (Fuss 1992; Moglo and Shirazi-Adl 2005). Finite element transection of the ACL substantially alters the screw-home (Fuss 1992; Moglo and Shirazi-Adl 2005), and direct 4DCT measurement in ACL-deficient knees shows significantly reduced terminal tibial external rotation in the 0–15° flexion range compared with the contralateral intact knee (Morishige et al. 2022). The remaining contributors modulate but do not, on their own, reconstitute the native screw-home. The longer articular arc of the medial femoral condyle (Monk et al. 2014), the concave upslope of the anterior medial tibial plateau versus the flatter lateral plateau (Rajendran 1985), and the intercondylar eminence deflecting the medial condyle (Fuss 1992) all contribute geometrically — but in the ACL-deficient knee, where the dominant driver is gone, these factors are insufficient. Consistent with this, in vivo fluoroscopy of a ball-in-socket medial, flat lateral, PCL-retaining design implanted with kinematic alignment found the terminal screw-home attenuated relative to the native knee — most plausibly because the ACL is absent (Elorza et al. 2023).

All factors operate only in the terminal arc. Walking past heel-strike, stair use, chair-rise, squatting, lunging, and running all operate in deeper flexion than this arc, where the medial pivot is well established. After the methodologically unreliable studies and the single uncorroborated dissenter are set aside, no native-knee evidence contradicts the medial pivot within the 20°–120° arc that an implant must serve.

TRANSLATING NATIVE KINEMATICS INTO A TKA

Most TKA implants require ACL removal, which prevents the physiological recreation of the screw-home mechanism since the main driver is missing; simply changing the implant’s surfaces isn’t enough. Replacing the ligament surgically often doesn’t reliably restore this motion—ACL reconstruction frequently fails to bring back terminal-extension rotation during demanding activities (Stergiou et al. 2007). Therefore, an implant can’t be expected to do so. Moreover, it is not necessary: ACL-deficient knees often function well without the screw-home, demonstrating that this motion isn’t essential. Designing a lateral pivot without an intact ACL is challenging and conflicts with native knee kinematics and ligament laxity patterns.

TKA implants must function across the active functional arc — walking, sitting, standing, climbing, descending, squatting, lunging. In that arc the medial pivot is dominant, yet most implants on the market today are designed for a knee whose medial and lateral compartments are treated as symmetric — a geometry that does not exist in vivo.

Two articular features follow directly from the anatomy. First, the lateral tibial articular surface should be flat, or close to it. The native lateral femoral condyle rolls and slides 15 mm posteriorly through flexion — the wheel of a sidecar on ice. A constraint-free, low-conformity lateral surface permits that excursion without imposing a non-native pivot, and prevents paradoxical anterior translation of the medial femoral condyle initiated by a posterolateral insert rim that obstructs lateral excursion.

A flat lateral surface leaves the lateral compartment free to rotate. When native laxity is restored, as in kinematic alignment, the knee's own soft tissues preserve the magnitude of tibial rotation through the active arc — but the terminal screw-home, which the ACL drove, is attenuated. In vivo fluoroscopy of exactly this design — ball-in-socket medial, flat lateral, PCL-retained, implanted with kinematic alignment — reproduced native tibial rotation at maximum flexion (12–13°, indistinguishable from the native knee) yet showed the rotation arriving progressively rather than concentrated in terminal extension, the screw-home being less evident because the ACL is gone (Elorza et al. 2023). Function was nonetheless high (Forgotten Joint Score 69, flexion 127°), which is the point: the design reproduces the rotation it can and forgoes the screw-home it cannot, without cost to the patient. The medial-pivot implant design neither blocks terminal rotation nor forces it. What it does not do — because no implant can — is recreate the ACL-driven screw-home solely by shape. This is the point that the dual-pivot literature leaves unaddressed: those studies correlate an observed intraoperative pattern with satisfaction, but do not show that implant geometry produces the terminal pivot. The opposite is documented — even bicruciate-retaining TKA, which preserves both cruciates, loses the screw-home (Nabeki et al. 2023), and tibial rotation after TKA is “not necessarily dictated by implant design” (Beach et al. 2019).

Second, with the lateral side left free, the medial articulation does the stabilizing work. A tightly conforming, ball-in-socket-like medial geometry holds the medial femoral condyle to roughly ± 2 mm of AP excursion; the two compartments are coupled exactly as in the native knee. The medial socket has an additional role specific to the ACL-deficient state of the TKA knee: a tall posteromedial insert rim mechanically substitutes for the ACL's AP-stabilizing function, restoring the constraint against anterior tibial translation that the ACL would otherwise provide.

WHERE I STAND

Two financial relationships are fully disclosed in the ICMJE form on file with the journal. First, I developed kinematic

alignment and run its educational platform; however, KA is a surgical target, usable with any implant, so it does not influence the main question of pivot location. Second, and more directly relevant, I receive royalties and consulting fees from a manufacturer of a medial-pivot, ball-in-socket implant. The literature makes the medial pivot argument, which is the lesson worth carrying from this debate.

THE BOTTOM LINE

Sort the studies by flexion arc, set aside the pathologic-knee cohorts and the methodologically unreliable analyses, and the medial-versus-lateral pivot controversy mostly disappears. The active-arc medial pivot is what the native knee does, and a TKA can reproduce it: flat laterally, conforming medially with a tall posteromedial rim that mechanically substitutes for the ACL's AP-stabilizing function. What an implant cannot do — and need not try — is engineer a substitute for the ACL-driven screw-home.

The medial pivot is not a marketing slogan. It is what the bones do in the arc that matters. Implants should be designed for that knee — the one the patient actually brings to the operating room, ACL-less and all.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the author used Claude (Anthropic, San Francisco, CA, USA) to improve the language, readability, and clarity of the manuscript. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the publication's content.

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CONFLICTS OF INTEREST

The author's financial relationships are disclosed in full in the ICMJE form on file with the journal, including royalties and consulting fees related to a medial-pivot, ball-in-socket implant. These relationships do not affect the author's judgement here; the science drives the conclusion, which the author would defend with no financial interest in any implant.

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REFERENCES

- Beach, A., G. Regazzola, T. Neri, R. Verheul, and D. Parker. 2019. "The Effect of Knee Prosthesis Design on Tibiofemoral Biomechanics during Extension Tasks Following Total Knee Arthroplasty." *Knee* 26 (5): 1010–19. <https://doi.org/10.1016/j.knee.2019.07.008>.
- Elorza, S. P., E. O'Donnell, A. J. Nedopil, S. M. Howell, and M. L. Hull. 2023. "A New Tibial Insert Design with Ball-in-Socket Medial Conformity and Posterior Cruciate Ligament Retention Closely Restores Native Knee Tibial Rotation after Unrestricted Kinematic Alignment." *J Exp Orthop* 10 (1): 115. <https://doi.org/10.1186/s40634-023-00671-3>.
- Freeman, M. A., and V. Pinskerova. 2005. "The Movement of the Normal Tibio-Femoral Joint. Review." *Journal of Biomechanics* 38 (2): 197–208. <https://doi.org/10.1016/j.jbiomech.2004.02.006>.
- Fuss, F. K. 1992. "Principles and Mechanisms of Automatic Rotation during Terminal Extension in the Human Knee Joint." *Journal of Anatomy* 180 (Pt 2): 297.
- Gray, H. A., S. Guan, L. T. Thomeer, A. G. Schache, R. de Steiger, and M. G. Pandey. 2019. "Three-Dimensional Motion of the Knee-Joint Complex during Normal Walking Revealed by Mobile Biplane x-Ray Imaging." *J Orthop Res* 37 (3): 615–30. <https://doi.org/10.1002/jor.24226>.
- Hamilton, L. D., T. E. Andreassen, C. A. Myers, K. B. Shelburne, C. W. Clary, and P. J. Rullkoetter. 2023. "Knee Pivot Location in Asymptomatic Older Adults." *Journal of Biomechanics* 149 (March): 111487. <https://doi.org/10.1016/j.jbiomech.2023.111487>.
- Isberg, J., E. Faxén, G. Laxdal, B. I. Eriksson, J. Kärrholm, and J. Karlsson. 2011. "Will Early Reconstruction Prevent Abnormal Kinematics after ACL Injury? Two-Year Follow-up Using Dynamic Radiostereometry in 14 Patients Operated with Hamstring Autografts." *Knee Surgery, Sports Traumatology, Arthroscopy* 19 (10): 1634–42. <https://doi.org/10.1007/s00167-011-1399-y>.
- Komistek, R. D., D. A. Dennis, and M. Mahfouz. 2003. "In Vivo Fluoroscopic Analysis of the Normal Human Knee." *Clinical Orthopaedics and Related Research* 410: 69–81. <https://doi.org/10.1097/01.blo.0000062384.79828.3b>.
- Koo, S., and T. P. Andriacchi. 2008. "The Knee Joint Center of Rotation Is Predominantly on the Lateral Side during Normal Walking." *Journal of Biomechanics* 41 (6): 1269–73. <https://doi.org/10.1016/j.jbiomech.2008.01.013>.
- Kozanek, M., A. Hosseini, F. Liu, et al. 2009. "Tibiofemoral Kinematics and Condylar Motion during the Stance Phase of Gait." *Journal of Biomechanics* 42 (12): 1877–84. <https://doi.org/10.1016/j.jbiomech.2009.05.003>.
- Matsuki, K., K. O. Matsuki, T. Kenmoku, S. Yamaguchi, T. Sasho, and S. A. Banks. 2017. "In Vivo Kinematics of Early-Stage Osteoarthritic Knees during Pivot and Squat Activities." *Gait & Posture* 58: 214–19. <https://doi.org/10.1016/j.gaitpost.2017.07.116>.
- Moglo, K., and A. Shirazi-Adl. 2005. "Cruciate Coupling and Screw-Home Mechanism in Passive Knee Joint during Extension–Flexion." *Journal of Biomechanics* 38 (5): 1075–83. <https://doi.org/10.1016/j.jbiomech.2004.05.033>.
- Monk, A. P., K. Choji, J. J. O'Connor, J. W. Goodfellow, and D. W. Murray. 2014. "The Shape of the Distal Femur: A Geometrical Study Using MRI." *Bone Joint J* 96-B (12): 1623–30. <https://doi.org/10.1302/0301-620X.96B12.33964>.
- Morishige, Y., K. Harato, S. Oki, et al. 2022. "Four-Dimensional Computed Tomographic Analysis of Screw Home Movement in Patients with Anterior Cruciate Ligament Deficient Knee—a 3D-3D Registration Technique." *Skeletal Radiology* 51 (8): 1679–85. <https://doi.org/10.1007/s00256-021-03986-3>.
- Nabeki, S., Y. Okada, A. Teramoto, et al. 2023. "The Function of Cruciate Ligaments in Bi-Cruciate Retaining Total Knee Arthroplasty with Asymmetrical Design." *Clin Biomech (Bristol)* 107 (July): 106038. <https://doi.org/10.1016/j.clinbiomech.2023.106038>.
- Nicolet-Petersen, S., A. Saiz, T. Shelton, S. M. Howell, and M. L. Hull. 2020. "Small Differences in Tibial Contact Locations Following Kinetically Aligned TKA from the Native Contralateral Knee." *Knee Surg Sports Traumatol Arthrosc* 28 (9): 2893–904. <https://doi.org/10.1007/s00167-019-05658-1>.
- Postolka, B., P. Schütz, S. F. Fucentese, et al. 2020. "Tibio-Femoral Kinematics of the Healthy Knee Joint throughout Complete Cycles of Gait Activities." *Journal of Biomechanics* 110: 109915. <https://doi.org/10.1016/j.jbiomech.2020.109915>.
- Rajendran, K. 1985. "Mechanism of Locking at the Knee Joint." *Journal of Anatomy* 143: 189.
- Rao, Z., C. Zhou, W. A. Kernkamp, T. E. Foster, H. S. Bedair, and G. Li. 2020. "In Vivo Kinematics and Ligamentous Function of the Knee during Weight-Bearing Flexion: An Investigation on Mid-Range Flexion of the Knee." *Knee Surgery, Sports Traumatology, Arthroscopy* 28 (3): 797–805. <https://doi.org/10.1007/s00167-019-05499-y>.
- Simileysky, A., and M. L. Hull. 2024. "Tibial Contact Points Cannot Be Used to Determine Internal-External Axial Rotation of the Native Tibiofemoral Joint." *The Knee* 51: 145–52. <https://doi.org/10.1016/j.knee.2024.08.019>.

Stergiou, N., S. Ristanis, C. Moraiti, and A. D. Georgoulis. 2007. "Tibial Rotation in Anterior Cruciate Ligament (ACL)-Deficient and ACL-Reconstructed Knees: A Theoretical Proposition for the Development of Osteoarthritis." *Sports Medicine* 37 (7): 601–13. <https://doi.org/10.2165/00007256-200737070-00004>.

Thomeer, L. T., S. Guan, H. A. Gray, and M. G. Pandy. 2022. "Articular Contact Motion at the Knee during Daily Activities." *J Orthop Res* 40 (8): 1756–69. <https://doi.org/10.1002/jor.25222>.