

ZBEdge Catalogue of Supporting Evidence

February 2026

ZBEdge[®]

by  ZIMMER BIOMET



Document Overview



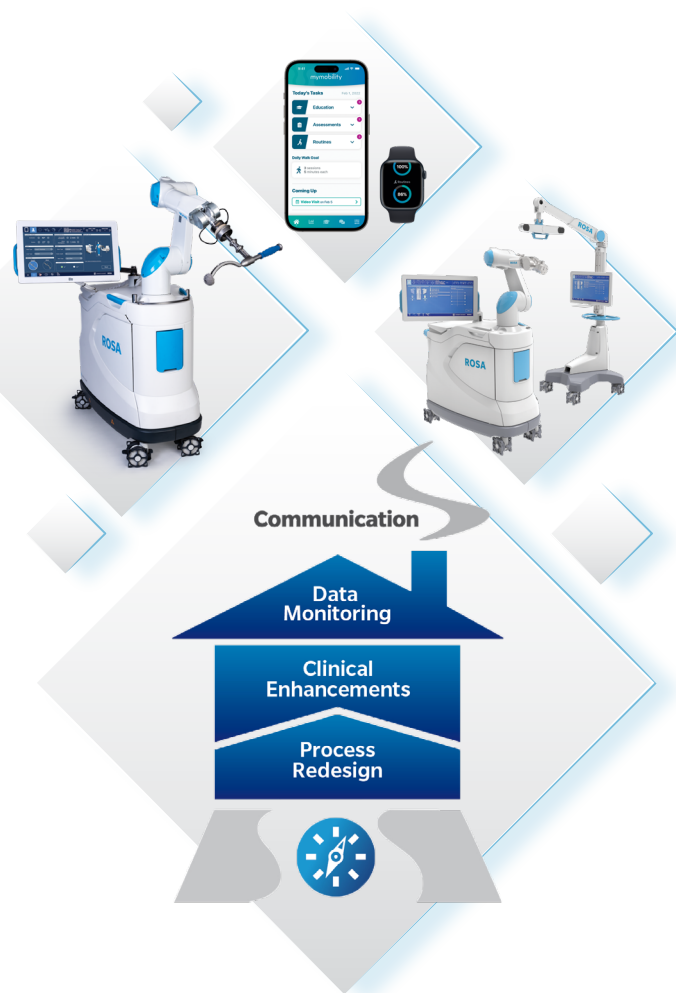
ZBEdge[®] is Dynamic Intelligence[™] with the power to elevate and unlock the full potential of Zimmer Biomet's cutting-edge digital technologies, robotics and implant solutions, built to unlock data-powered insights across the entire episode of care.

Zimmer Biomet is committed to demonstrating the value of our technology with clinical supporting evidence. Explore the enclosed summary documents and discover data that can challenge assumptions.

The evidence in this catalogue is organised by technology and discussion topic.

Contents include one-page summaries of peer-reviewed, published studies.

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Performance Benchmarks Drive Operating Room Efficiency Increasing Case Volume

Reference:

Kashanian K, Juric M, Ramsay T, Fallavollita P, Beaulé PE*. **Optimizing Operating Room Efficiency for Primary Hip and Knee Arthroplasty Using Performance Benchmarks.** Arthroplast Today. 2024;31:101590. Published 2024 Dec 24. doi:10.1016/j.artd.2024.101590

<https://www.ncbi.nlm.nih.gov/pubmed/39811774>

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01 Study Design

A retrospective, observational study analyzing operating room efficiency in primary total hip and knee arthroplasty.

The study reviewed 59 Operating Room (OR) days and assessed the impact of predefined time benchmarks on OR efficiency in outpatient joint replacement procedures.

OR efficiency was evaluated using Al-Zoubi et al. benchmarks for completing 4 surgeries in an 8-hour OR day:

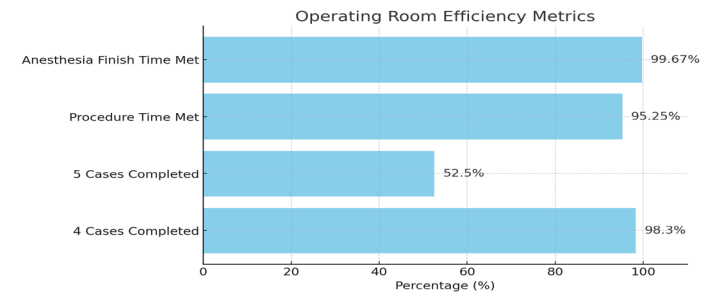
- APT <11 min
- Procedure <72 min
- AFT <21 min
- Turnover <22 min

Study outcomes were assessed against these benchmarks to measure surgical throughput and OR utilization.

- N= 295 patients (160 females, 135 males)
- Studied outpatient surgeries:
 - 161 total knee arthroplasties (TKA)
 - 134 total hip arthroplasties (THA)

02 Key Findings

- 98.3% of OR days (58/59) successfully completed 4 joint arthroplasties within 8 hours, and 52.5% (31/59) completed 5 cases, demonstrating the ability to maximize case volume without increasing resource needs.
- 95.25% of procedures met the target surgical time, and 99.67% met anesthesia finish time, supporting efficient OR utilization.
- Mean procedure time was 55 minutes, turnover time 19 minutes and anesthesia preparation time 11 minutes, highlighting improved operating room efficiency.
- Implementing benchmarks facilitated an optimal volume of surgeries within standard OR hours without additional resource strain.



03 Clinical Significance

Implementing time benchmarks optimized OR utilization, enabling consistent surgical throughput within standard hours. Adherence to these benchmarks facilitated efficient case progression without extending resources.

Driving Precision and Performance in the Operating Room

Reference:

Cholewa, J,* Kaneriya, A, Anderson, MB* (2024). **Data Driven Insights to Operating Room Inefficiencies: What's Next? Part 2.** Journal of Orthopaedic Experience & Innovation.

<https://doi.org/10.60118/001c.117197>

*Zimmer Biomet employee

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01 Study Design

This two-part analysis explores operating room (OR) inefficiencies using a data-driven approach. It identifies key inefficiency drivers, their impact on surgical workflows, and solutions to optimize resources.

Key methodologies include leveraging data captured in real-time, predictive analytics and process optimization strategies.

02 Key Findings

- **Scheduling Variability:** Unpredictable case durations and inconsistent start times lead to delays and resource underutilization.
- **Prolonged Turnover Times:** Delays in preparing ORs between cases reduce daily capacity and increase staff fatigue.
- **Staffing Misalignment:** Mismatched staffing levels contribute to resource waste, errors and team stress.
- **Communication Breakdowns:** Poor communication among surgical teams causes delays, errors and reduced cohesion.

03 Clinical Significance

Data-driven insights enable targeted interventions, streamlining workflows and optimizing resource use. By addressing inefficiencies effectively, healthcare organizations can streamline workflows, foster consistent processes, and empower surgical teams to deliver optimal patient care.

Standardized Pathway Can Deliver Outpatient Arthroplasty Success

Reference:

Zimmer Biomet. **Outpatient Arthroplasty with Rapid Recovery™**. 2021. Document No. 3706.1-EMEA-en.3706.1-EMEA-en Rapid Recovery Outpatient Arthroplasty White Paper (v1.0)

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01 Study Design

This white paper presents clinical outcomes and implementation insights from centers using the Zimmer Biomet Rapid Recovery™ Program to support outpatient total joint arthroplasty (TJA). It compiles peer-reviewed literature, case studies, and expert consensus across multiple countries and healthcare settings.

Data presented include real-world outcomes from hospitals performing same-day total hip, knee and partial knee arthroplasty using standardized, multidisciplinary protocols developed within the Rapid Recovery framework.

02 Key Findings

- Same-day discharge was found to be feasible and safe for selected THA, TKA and UKA patients using Rapid Recovery protocols.
- Reported outcomes show low readmission and complication rates, comparable to inpatient procedures.
- Outpatient pathways yielded high patient satisfaction and functional recovery, with complication and readmission rates comparable to inpatient care.
- Use of standardized care protocols supports predictable and efficient discharge planning.
- Multidisciplinary alignment and staff engagement are critical to successful outpatient implementation.
- Outpatient THA, TKA, and UKA procedures are associated with lower overall costs compared to inpatient procedures, with no increase in complications or readmissions, and may offer financial advantages when resources are efficiently reallocated.

03 Clinical Significance

Rapid Recovery protocols help to enable safe and effective outpatient total joint arthroplasty by standardizing care and aligning multidisciplinary teams. This approach supports same-day discharge without compromising patient safety, satisfaction, or outcomes.

Efficiency Gains in Robotic Knee Arthroplasty

Reference:

Anderson MB, Martens R, Cholewa J. **Evaluating an Approach to Improve Operating Theatre Efficiency with the Use of a Robotic Assistant in Total Knee Arthroplasty.** Zimmer Biomet; 2024. 4818.1-EMEA-en.

[ROSA_EC_Whitepaper_2024_0517_Final.pdf](#)

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01 Study Design

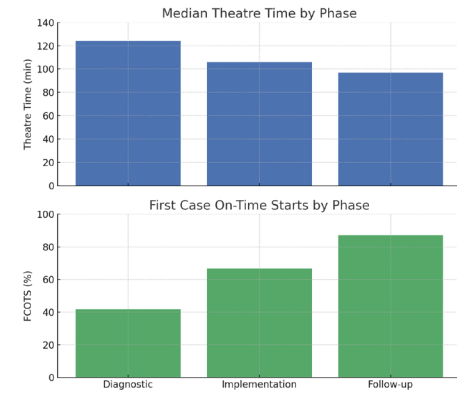
This single-center, retrospective analysis evaluated the impact of the ROSA® Efficient Care program on operating theatre efficiency during robotic-assisted total knee arthroplasty (TKA).

Three phases were analyzed. Diagnostic (n=334): Cases performed prior to implementation of the ROSA® Efficient Care Program. Implementation (n=46): Cases performed immediately after team training and workflow optimization workshops. Follow-up (n=96): Cases performed ~4 months post-implementation to assess sustainability of changes.

Time metrics and first-case-on-time starts (FCOTS) were compared using the Wilcoxon Rank Sum Test, Hommel’s Procedure for multiple comparisons, and Fisher’s Exact Test. A Shapiro-Wilk test confirmed non-normal distribution of the data.

02 Key Findings

- The ROSA Efficient Care Program improved operating theatre times and reduced overall wheels-in to wheels-out time from a median of 124 (IQR 111 – 143) in the diagnostic phase to 97 (IQR 86 – 114) minutes at final follow-up.
- Reduction in total OR time increased the number of raTKA cases able to be performed each day from a median of 2 (1 – 3) cases/day to 3 (2 – 4).
- First case on time starts increased from 41.7% in the diagnostic phase to 87.1% in the follow-up phase.



03 Clinical Significance

By targeting workflow inefficiencies, the ROSA® Efficient Care program demonstrated that significant reductions in theatre time can be achieved in robotic-assisted TKA. These findings address a key concern surrounding the operational impact of robotics and support its practical integration into high-volume clinical settings.”

The ROSA® Knee System: Shows Good Accuracy Without Increasing Operative Times

Reference:

Bolam SM, Tay ML, Zaidi F, et al. Introduction of rosa robotic-arm system for total knee arthroplasty is associated with a minimal learning curve for operative time. *Journal of Experimental Orthopaedics*. 2022;9(1) doi:10.1186/s40634-022-00524-5

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01 Study Design

A single center study by three high-volume orthopedic surgeons to evaluate the impact of integrating the ROSA Knee System into the surgical workflow.

- Prospective cohort
- 83 Conventional Jig-based TKAs vs. 53 Robotic Surgical Assistant (ROSA) system TKAs
- Cumulative Summation (CUSUM) for learning curves in operative times
- Outcomes Reviewed: Peri-operative and delayed complications (infection, periprosthetic fracture, thromboembolism, wound healing issues), and surgical revisions

02 Key Findings

- Proficiency using the ROSA Knee System was achieved after **8.7 cases on average** (range: 5-15 cases)
- **No significant differences in operating time** (skin-to-skin) between the learning phase or proficiency phase of the ROSA Knee System nor the conventional TKA procedure
 - Learning phase (114+17 minutes)
 - Proficiency phase (110+20 min)
 - Conventional TKA (110+20 min)
- **Component planning and implantation accuracy did not have a learning curve**
- There were **no adverse events, complications, or revisions** with the ROSA Knee System

03 Clinical Significance

“The learning curve associated with introducing the ROSA Knee System ... was relatively **short and did not lead to increases in operative time or any additional complications or adverse events** for case performed during the learning phase.”

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The ROSA® Knee System: Improved Outcomes Compared to Imageless Navigation

Reference:

Mancino F, Rossi SM, Sangaletti R, Lucenti L, Terragnoli F, Benazzo F. A new robotically assisted technique can improve outcomes of total knee arthroplasty comparing to an imageless navigation system. Archives of Orthopaedic and Trauma Surgery. 2022;143(5):2701-2711. doi:10.1007/s00402-022-04560-9

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01 Study Design

Retrospective analysis of prospectively collected data comparing 1-year clinical outcomes of robotic-assisted total knee arthroplasty (rTKA) with an imageless navigated procedure (nTKA)

- n=50 rTKA
- n=47 nTKA
- 1-year follow-up

02 Key Findings

- Robotic-assisted, imageless TKA had better range of motion (ROM) (119.4° vs. 107.1°; $p < 0.001$)
- Significantly better ROM gains (23.02° v. 11.36°, $p < 0.001$)
- Significantly better KOOS pain scores ($p = 0.028$)
 - ROSA Knee: 85 ± 11.4 (44–100)
 - iAssist® Knee: 79.1 ± 14.7 (33–100)
- Significantly better KSS Knee and Function scores ($p < 0.001$)
- Cautionary Note: “the overall number of postoperative outliers was higher in the rTKA group (30.00% vs. 17.02%; $p = 0.1570$)”
 - This is based on $\pm 3^\circ$ of neutral mechanical alignment. However, the ROSA Knee with Personalized Alignment technique aimed for 2° varus

03 Clinical Significance

“Imageless rTKA was associated with longer surgical time, **better pain perception and improved ROM at 12-month follow-up** compared with nTKA. No significant differences were reported on other PROMs, complication rates and radiographic outcomes.”

The ROSA® Knee System: Less Pain with Improved Satisfaction and Patient Reported Outcomes at Six Months

Reference:

Kenanidis E, Paparoidamis G, Milonakis N, Potoupnis M, Tsiridis E. Comparative outcomes between a new robotically assisted and a manual technique for total knee arthroplasty in patients with osteoarthritis: A prospective matched comparative cohort study. *European Journal of Orthopaedic Surgery & Traumatology*. 2022;33(4):1231-1236. doi:10.1007/s00590-022-03274-3

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01 Study Design

A single center, prospective comparative cohort study to evaluate the clinical outcomes between manual (mTKA) and robotic-assisted total knee arthroplasty (raTKA) using the ROSA Knee System

- n=30 raTKAs
- n=30 mTKAs
- Unilateral TKAs using the same prosthesis

02 Key Findings

- No difference in complications between groups
- More raTKA patients would have the operation again compared to mTKA patients (100% vs. 86.7%)
- Significantly better pain levels, Oxford® Knee Score, and Forgotten Joint Scores six months post-operative in the raTKA group

03 Clinical Significance

The “results indicate that raTKA may help enhance the early functional recovery of TKA patients and promote a better satisfaction level in the early post-operative period.”

The ROSA® Knee System: High Accuracy of Cutting Angles and Implant Placement

Reference:

Hasegawa M, Tone S, Naito Y, Sudo A. Two- and three-dimensional measurements following robotic-assisted total Knee Arthroplasty. The International Journal of Medical Robotics and Computer Assisted Surgery. 2022;18(6). doi:10.1002/rcs.2455

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01 Study Design

Single center study comparing radiographic (2D) and computed tomography (3D) measurements in robotic-assisted TKA. Discrepancies calculated between 2D and 3D measures of component alignments by comparing the intended angles, the actual cutting angles, and the confirmed implantation angles.

- n=38 patients undergoing TKA

02 Key Findings

- **The ROSA Knee System showed high accuracy** for the validated cutting angle compared to post-operative 2D radiographs
 - Zero outliers for the femoral or tibial coronal and sagittal angles with all cutting errors less than 0.8°
- **The ROSA Knee System showed high accuracy** for the validated cutting angle compared to post-operative 3D CT scans :
 - 1 outlier out of 38 cases
 - Femoral coronal and sagittal cutting errors of 0.9 and 1.7°, respectively
 - Tibial coronal and sagittal cutting errors of 1.2 and 1.0°, respectively
- **Interpretive note:** Although 3D CT scans are more reliable, 2D radiographs are more commonly performed clinically to evaluate post-operative component implantation but are more dependent on patient and X-ray positioning, which may introduce error
 - Regardless, the authors found **no difference in final implant positioning between 2D and 3D imaging**

03 Clinical Significance

“...this new robotic system demonstrated high accuracy [for resection angle and implant placement] in 2D and 3D measurements...”

The ROSA® Knee System: High Reproducibility of Bony Landmarks and Tissue Laxity Among Robotic -Assisted TKA for Experienced and Novice Surgeons

Reference:

Charette RS, Sarpong NO, Weiner TR, Shah RP*, Cooper HJ*. Registration of bony landmarks and soft tissue laxity during robotic total knee arthroplasty is highly reproducible. Surgical Technology Online. Published online 2022. doi:10.52198/22.sti.41.os1633

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01 Study Design

A cadaveric study* to evaluate the inter- and intra-rater reliability in robotic registration with the ROSA® Knee System.

- Two unpaired cadaveric knee specimens
- Three separate evaluators
- Repeated anatomic registration, soft tissue laxity assessment, and measurements of coronal/sagittal alignment, femoral size, and compartment openings in flexion/extension
- Intraclass Correlation Coefficient (ICC) for intra- and inter-rater reliability in robotic registration

02 Key Findings

- Excellent intra-rater reliability for both robotic-assisted total knee arthroplasty (rTKA) with experienced (ICC=0.952) and inexperienced (ICC=0.925) surgeons.
- Excellent inter-rater reliability between rTKA with experienced and inexperienced surgeons for both imageless and image-based.
 - Imageless landmark registration (ICC=0.89); Tissue laxity (ICC=0.985)
 - Image-based landmark registration (ICC=0.977); Tissue laxity (ICC=0.998)
- Significance: excellent reliabilities for soft tissue laxities suggest that inherent differences in tension applied by physicians during the dynamic stress evaluation will not affect the ROSA Knee System gap analysis.

03 Clinical Significance

“[The] results show a high repeatability of registration of anatomic landmarks and gap assessment among observers using this robotic system for both image-based and [imageless] software.”

The ROSA® Knee System: Similar Component Positioning Accuracy to Mako®

Reference:

Rajgor H, Mayne A, Munasinghe C, Pagkalos J, Agrawal Y, Davis E, Sharma A. Mako versus ROSA: Comparing Surgical Accuracy in Robotic Total Knee Arthroplasty. *Journal of Robotic Surgery*, 2024; 18(33):1-5. doi:110.1007/s11701-023-01786-6

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01 Study Design

A single center retrospective evaluation of accuracy between the ROSA Knee System and Mako robotic arm-assisted surgery.

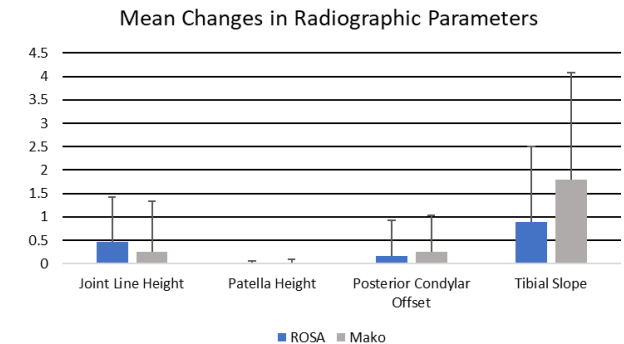
- ROSA Knee: n=50
- Mako Knee: n=50

Accuracy was measured as the pre- to post-operative restoration of radiographic parameters:

- Joint line height
- Patella height
- Tibial slope
- Posterior condylar offset

02 Key Findings

- There were no significant differences between ROSA Knee and Mako for joint line height (0.47 vs. 0.26 mm), patella height (0.01 vs. 0.03 Insal-Salvati ratio), tibial slope (0.9° vs. 1.8°) or posterior condylar offset (0.16 vs. 0.26 mm)
- No pin-site fractures occurred in either ROSA Knee or Mako groups



03 Clinical Significance

Robotic-assisted total knee arthroplasty with the ROSA Knee System is highly accurate and provides comparable component positioning to the Mako knee system in both sagittal and transverse planes.

The ROSA® Knee System: Addressing Flawed Research Methods and Measurement Validity

Reference:

Shin C, Crovetto C, Huo E, Lionberger D. Unsatisfactory accuracy of recent robotic assisting system Rosa for total knee arthroplasty. *Journal of Experimental Orthopaedics*. 2022;9(1). doi:10.1186/s40634-022-00522-7

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01 Study Design

A single center comparative study to evaluate the accuracy of the ROSA Knee System for Total Knee Arthroplasty (TKA)

- n=37 patients
- TKA performed using ROSA Knee by the same surgical team over 3 months
- Intra-operative mechanical axis (alpha, beta, gamma, delta angles, hip-knee-ankle angle) calculated by ROSA Knee
- Mechanical implant angles from post-op films, comparing with ROSA Knee's intra-operative plan for accuracy within 2° and 3°

02 Key Findings

- **Exceptional accuracy** between ROSA Knee's intra-operative planned axes and "post-operative mechanical angles" for the coronal, but not sagittal angles
- **Substantial measurement error and bias concerns** have been raised over the **sagittal measurements** (Gamma and Delta angles)
 - The measurement methods used by the authors **do not match the methods used by the robotics system**
 - The post-operative interrater reliability was moderate and **faulty sagittal images were included in the analysis**
 - **Measurement and subject selection biases** are evident in the study
- Despite the inflammatory title and above errors, the authors reported individual mean errors of ≤ 2.04 degrees with standard deviations ≤ 1.55 degrees for all four angles assessed, indicative of **accurate and precise resections**.
 - Alpha: 0.88 ± 0.71
 - Beta: 1.24 ± 1.06
 - Gamma: 1.93 ± 1.03
 - Delta: 2.04 ± 1.55

03 Clinical Significance

The ROSA Knee System is accurate and precise in both the coronal and sagittal planes according to the raw values reported.

The ROSA® Knee System: Less Physician Stress and Strain with ROSA Total Knee Arthroplasty

Reference:

Haffar A, Krueger CA, Goh GS, Lonner JH. Total Knee Arthroplasty with robotic surgical assistance results in less physician stress and strain than conventional methods. *The Journal of Arthroplasty*. 2022;37(6). doi:10.1016/j.arth.2021.11.021

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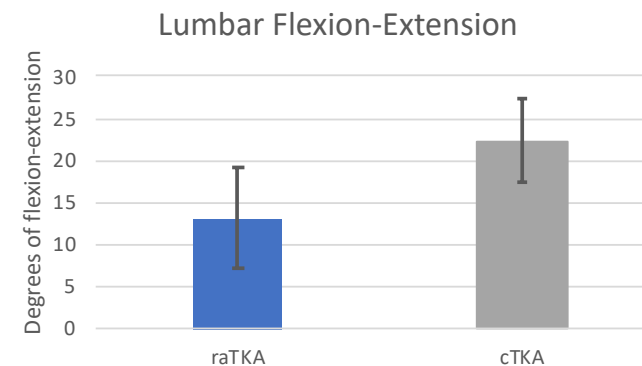
01 Study Design

A single center, single-surgeon study to evaluate surgeon stress and strain during robotic-assisted Total Knee Arthroplasty (rTKA) and conventional Total Knee Arthroplasty (cTKA)

- 40 consecutive unilateral TKAs (20 rTKAs, 20 cTKAs)
- The study utilized heart rate, heart rate variability, respiratory rate, minute ventilation, and energy expenditure as indicators of physiological stress. For assessing intraoperative ergonomics, measurements included cervical, lumbar, and shoulder movements

02 Key Findings

- Energy expenditure rate was lower in rTKA than cTKA
- Average heart rate was lower in rTKA
- rTKA resulted in less lumbar flexion and a reduction in the time spent in demanding lumbar flexion
- Neck rotation was significantly reduced by rTKA



03 Clinical Significance

Robotic-assisted TKA with the ROSA Knee System may improve the surgeon's operative experience by reducing the physiologic and ergonomic strain associated with total knee arthroplasty, however more studies are needed to support this.

The ROSA® Knee System: An Initial Learning Curve of 6-11 Cases

Reference:

Vanlommel L, Neven E, Anderson MB, Bruckers L, Truijen J. The initial learning curve for the ROSA® knee system can be achieved in 6-11 cases for operative time and has similar 90-day complication rates with improved implant alignment compared to manual instrumentation in total knee arthroplasty. *Journal of Experimental Orthopaedics*. 2021;8(1). doi:10.1186/s40634-021-00438-8

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01 Study Design

A retrospective study to determine the learning curve for the ROSA Knee System in Total Knee Arthroplasty (TKA)

- n=180 patients
- Three high-volume orthopaedic surgeons (over 200 cases/year)
 - 90 underwent robotic-assisted TKA (raTKA) using the ROSA Total Knee System
 - 90 underwent manual TKA (mTKA)
- Follow-up: minimum three months

02 Key Findings

- A change point of 6 to 11 cases for each of three surgeons for operative times suggests a rapid initial learning curve
 - Total surgical times continued to decrease with time
- The proportion of outliers for the final hip-knee-ankle angle compared to planned was 5.2% (3/58) for the mastered raTKA compared to 24.1% (19/79) for mTKA ($p=0.003$)
- The absolute mean difference between the validated and planned resections for all angles evaluated was $<1^\circ$ for the mastered raTKA cases

03 Clinical Significance

The ROSA Knee System can be adopted rather quickly regarding the initial learning curve. This was measured as the initial cut point for reducing surgical time back to the mean surgical time. Improvements in accuracy compared to manual TKA were seen in the mastered robotic-assisted TKA cases.

The ROSA[®] Knee System: Faster Recovery of Range of Motion Compared to Manual Total Knee Replacement

Reference:

Fary C, Cholewa J*, Ren AN*, Abshagen S*, Anderson MB*, Tripuraneni K. Multicenter, prospective cohort study: Immediate postoperative gains in active range of motion following robotic-assisted total knee replacement compared to a propensity-matched control using manual instrumentation. *Arthroplasty*. 2023;5(1). doi:10.1186/s42836-023-00216-0

Study funded by Zimmer Biomet.
*Zimmer Biomet employee

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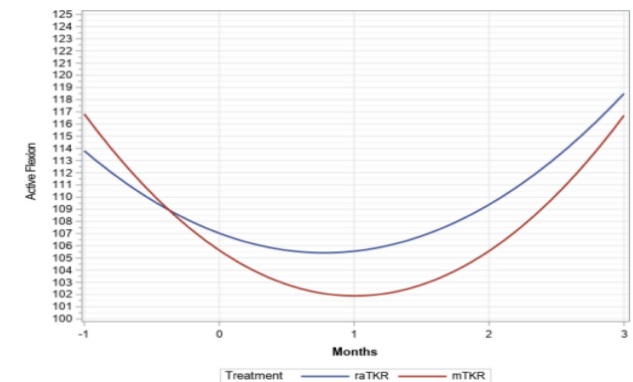
01 Study Design

A multicenter, propensity-matched, prospective study evaluating active range of motion (aROM) changes following total knee replacement (TKR) between robotic-assisted Total Knee Replacement (raTKR) and manual Total Knee Replacement (mTKR)

- aROM measured pre-operative and at one- and three-months post-operative
- raTKR: n=216
- mTKR: n=216

02 Key Findings

- aROM increased by 6.9° and 4.9° more in raTKR compared to mTKR at one- and three-months post-operative, respectively
- raTKR had 2.15 higher odds of achieving 90° of active flexion at one-month compared to mTKR
- Opioid use was significantly less (31.2% vs. 42.6%) in raTKR compared to mTKR



03 Clinical Significance

raTKR is associated with a lower loss of aROM in the immediate post-operative period and higher odds of achieving 90° of flexion within one-month. Unlike mTKR patients, raTKR patients also exceeded their pre-operative aROM by three-months post-operative.

The ROSA[®] Knee System: Superior Precision In Vivo Compared to Conventional Instrumentation

Reference:

Schrednitzki D, Horn CE, Lampe UA, Halder AM. Imageless robotic-assisted total knee arthroplasty is accurate in vivo: A retrospective study to measure the postoperative bone resection and alignment. Archives of Orthopaedic and Trauma Surgery. 2022;143(6):3471-3479. doi:10.1007/s00402-022-04648-2

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01 Study Design

Single center, retrospective study evaluating the precision of the ROSA Knee System for total knee arthroplasty (TKA) and its effectiveness in reducing outliers compared to conventional instruments

- n=71 robotic-assisted TKAs
- n=308 conventional TKAs
- Comparative analysis of bone sections intraoperatively planned vs. radiographically measured
- Analysis of post-operative alignment

02 Key Findings

- Significantly lower rate of the hip-knee-ankle angle outliers ($\pm 3^\circ$) in ROSA Knee compared to conventional TKA
 - Zero outliers in ROSA Knee cases compared to 75 (24.3%) in conventional TKA cases
 - Average deviation from the planned angle was significantly less with ROSA Knee compared to conventional TKA (1.01 vs. 2.05°, respectively)
- All ROSA Knee-assisted bone resections showed a high degree of precision
 - Average bony resection accuracies were within 0.4 mm for all six cuts
 - No resections in any cases were greater than 2 mm from the planned cut

03 Clinical Significance

“The [ROSA Knee System] is accurate in terms of the coronal alignment and bone resections. [This study] ... shows that the accuracy previously reported only in cadavers can also be achieved in patients.”

The ROSA® Knee System: Improved Precision and Outcomes Compared to Conventional Total Knee Arthroplasty

Reference:

Winger AE, Lambert BS, Sullivan TC, Brown TS, Incavo SJ, Park KJ. Robotic-assisted total knee arthroplasty can increase frequency of achieving target limb alignment in primary total knee arthroplasty for preoperative valgus deformity. *Arthroplasty Today*. 2023;23:101196. doi:10.1016/j.artd.2023.101196

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01 Study Design

Single center, retrospective cohort study evaluating the precision of robotic-assisted Total Knee Arthroplasty (rTKA) to manual Total Knee Arthroplasty (mTKA)

- Intervention:
 - Surgeon A:
 - 103 cases using rTKA with the ROSA Knee System
 - Target limb alignment: 0° for all cases
 - Surgeon B:
 - 103 cases using only mTKA
 - Target limb alignment: 2° varus for varus knees, 0° for valgus knees
- Accuracy Target: Within ±2 degrees of predefined target alignment

02 Key Findings

- Resection angles were more precise with the ROSA Knee System compared to conventional instrumentation in pre-operatively aligned valgus knees
 - The percentage of valgus cases within 2° of the target angle were significantly higher with ROSA Knee compared to conventional instrumentation (71.4 vs. 44.1%)
 - The difference between target and measured angles were significantly less with ROSA Knee compared to conventional instrumentation (1.64° vs. 2.65°)
- Greater 3- and 6-month increases in Patient-Reported Outcomes Measurement Information System Physical Component were reported for ROSA Knee compared to conventional instrumentation

03 Clinical Significance

The ROSA Knee System improved reproducibility of post-operative alignment in valgus deformities and improved tibial component positioning compared to conventional TKA, suggesting that the ROSA Knee System may be more effective in challenging cases requiring precise alignment and component positioning.

The ROSA® Knee System: An Initial Learning Curve in as Little as Three Cases

Reference:

Dragosloveanu S, Petre M-A, Capitanu BS, Dragosloveanu CD, Cergan R, Scheau C. Initial learning curve for robot-assisted total Knee Arthroplasty in a dedicated Orthopedics Center. Journal of Clinical Medicine. 2023;12(21):6950. doi: 10.3390/jcm12216950

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01 Study Design

Single center, retrospective cohort study evaluating the learning curve, operative times, and complications of the ROSA Knee System

- Robotic-Assisted Total Knee Arthroplasty (raTKA): n=39
- Manual Total Knee Arthroplasty (mTKA): n=45
- Twelve surgeons performed the 39 raTKA

02 Key Findings

- Only 3 of the 12 surgeons reached the proficiency phase
- Proficiency stage was reached in 3-6 cases for those 3 surgeons
- There were no significant differences in proficiency operative times compared to manual TKA (86.43+19.09 vs. 80.56+17.03)
- No complications were recorded

03 Clinical Significance

Experienced surgeons may easily adopt the ROSA Knee System and quickly adapt without significant complications.

The ROSA® Knee System: No Differences in Complications in an Ambulatory Surgical Center

Reference:

Eason T, Mihalko W, Toy PC. Robotic-assisted total Knee Arthroplasty is safe in the ambulatory surgery center setting. Orthopedic Clinics of North America. 2023;54(2):153-159. doi:10.1016/j.oacl.2022.11.001

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01 Study Design

Retrospective review evaluating differences in complications between robotic-assisted Total Knee Arthroplasty (raTKA) and conventional Total Knee Arthroplasty (cTKA) by a single surgeon in an ambulatory surgical center

- 2-, 6-, and 12-week follow-up
- raTKA: n=86
- cTKA: n=86

02 Key Findings

- No difference in complications between groups, though there were 5 more manipulation under anesthesia (MUA) in raTKA
- No differences in PROMs (KOOS-JR or VAS pain) between groups
- Operating room (OR) time was longer in raTKA, but length of stay was shorter

03 Clinical Significance

“Robotic-assisted total knee arthroplasty [with the ROSA Knee System] may be safely performed in the ambulatory surgery center setting.”

The ROSA® Partial Knee System: Greater Precision and Reproducibility Compared to Conventional Instrumentation

Reference:

Lonner JH, Seidenstein AD, Charters MA, et al. Improved accuracy and reproducibility of a novel CT-free robotic surgical assistant for medial unicompartmental knee arthroplasty compared to conventional instrumentation: A Cadaveric study. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2021;30(8):2759-2767. doi:10.1007/s00167-021-06626-4

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01 Study Design

A pair-matched cadaveric study* investigating the accuracy and reliability of ROSA Knee in unicompartmental knee arthroplasty (UKA)

- 15 surgeons
- 60 knee specimens
 - conventional UKA (cUKA): n=30
 - Robotic-assisted (raUKA): n=30
- Optical navigation used to measure resection angles

02 Key Findings

- raUKA was significantly more accurate in all 5 resection angles (Tibia A/P, V/V, I/E and Femur V/V, F/E)
- Percentage of >2-degree outliers were significantly less in raUKA for Tibia V/V, I/E and Femur V/V, F/E
- Tibia resection depth (but not femur depth) was significantly more accurate with raUKA

03 Clinical Significance

The ROSA Partial Knee System is associated with more precise and reproducible femoral and tibial resection angles in the coronal, sagittal, and axial planes. The ROSA Partial Knee also was associated with fewer recuts and more accurate tibial resection depths.

The ROSA® Knee System: No Differences in Component Noise Compared to Conventional Total Knee Arthroplasty

Reference:

Cozzarelli NF, Khan IA, Imam N, et al. Robotic-assisted total knee arthroplasty has similar rates of prosthetic noise generation as conventional total knee arthroplasty. *Arthroplasty Today*. 2023;23:101216. doi:10.1016/j.artd.2023.101216

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01 Study Design

A retrospective analysis by a single institution to compare the rates of patient-reported prosthetic noise generation and functional outcomes between robotic-assisted Total Knee Arthroplasty (raTKA) and conventional Total Knee Arthroplasty (cTKA)

- Minimum of one-year follow-up
- raTKA: n=162
- cTKA: n=320
- Four surgeons

02 Key Findings

- No difference between raTKA and cTKA for hearing or feeling ringing, popping, clicking, or clunking
- No difference in KOOS-JR or Forgotten Joint Score (FJS) between groups
- Patients who felt or heard noise reported lower FJS and KOOS-JR than patients who did not report noise

03 Clinical Significance

There were no differences in noise generation between raTKA and cTKA, but patients who experience noise have lower functional scores.

The ROSA® Knee System: Greater Precision and Reproducibility Compared to Navigated Technology

Reference:

Mancino F, Rossi SM, Sangaletti R, Caredda M, Terragnoli F, Benazzo F. Increased accuracy in component positioning using an image-less robotic arm system in primary total knee arthroplasty: A retrospective study. Archives of Orthopaedic and Trauma Surgery. Published online 2023. doi:10.1007/s00402-023-05062-y

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01 Study Design

A retrospective analysis comparing the accuracy and reproducibility of robotic-assisted Total Knee Arthroplasty (raTKA) to navigated Total Knee Arthroplasty (nTKA) by a three surgeons at a single institution

- raTKA: n=86
- nTKA: n=86
- Comparison of plan to 3-month post-operative radiographs
- Hip-knee-ankle (HKA) axis, femoral coronal alignment, femoral sagittal alignment, tibial coronal alignment, and tibial slope assessed

02 Key Findings

- There were fewer outliers ($>1^\circ$) for HKA in raTKA (47.7%) compared to nTKA (81.4%). The mean deviation was also less in raTKA (1.3° vs. 1.9°)
- Mean deviation from femoral sagittal target was less in raTKA (0.9° vs. 1.9°)
- Mean deviation from tibial coronal target was less in raTKA (0.8° vs. 1.5°)
- Mean tibial slope deviation was also less in raTKA (0.9° vs. 1.7°)
- There were no differences in femoral coronal angle deviations between groups

03 Clinical Significance

The ROSA Knee System produces more accurate and reproducible component position angles in the sagittal plane for both femoral and tibial components, and the coronal plane for the tibial component compared to navigated TKA.

The ROSA® Knee System: No Differences in Operative Time Compared to Conventional Total Knee Arthroplasty After 70 Cases

Reference:

Kenanidis E, Boutos P, Sitsiani O, Tsiridis E. The Learning Curve to Rosa: Cases needed to match the surgery time between a robotic-assisted and a manual primary total knee arthroplasty. *European Journal of Orthopaedic Surgery & Traumatology*. 2023;33(8):3357-3363. doi:10.1007/s00590-023-03554-6

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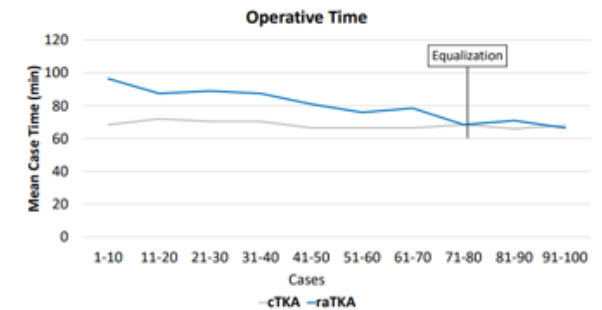
01 Study Design

A retrospective comparative cohort study between robotic-assisted (raTKA) and conventional (cTKA) total knee arthroplasty cases

- Single high-volume surgeon
- First 100 raTKA cases compared to 100 cTKA cases
- Operative time defined as first incision to wound closure
- Cases were grouped by ten and compared between techniques

02 Key Findings

- Average operative times were significantly less with cTKA after 71-80 cases
- Time neutrality with cTKA occurred between 63-72 cases
- No pin site or other raTKA specific complications were observed



03 Clinical Significance

Achieving a time neutral robotic procedure, compared to conventional TKA, is feasible and has been shown to require approximately 70 cases in this study for a senior surgeon.

The ROSA® Knee System: Greater Precision and Reproducibility Compared to Conventional Instrumentation

Reference:

Seidenstein A, Birmingham M, Foran J, Ogden S. Better accuracy and reproducibility of a new robotically-assisted system for total knee arthroplasty compared to conventional instrumentation: A Cadaveric study. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2020;29(3):859-866. doi:10.1007/s00167-020-06038-w

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01 Study Design

A cadaveric study* comparing the accuracy of robotic vs. conventional Total Knee Arthroplasty (TKA)

- 14 robotically assisted (ROSA Knee System) vs. 20 conventional TKAs
- Performed by four high-volume, board-certified arthroplasty surgeons (only one with prior robotics experience) using three different implant systems
- Accuracy in angle/level of bone resections evaluated via optical navigation/caliper vs. plan

02 Key Findings

- Resection angles were more precise with the ROSA Knee System compared to conventional instruments for all four measured angles
 - The mean difference between the planned and executed angles was between 0.5 and 1.3° ROSA Knee compared to 1.1 to 2.4° with conventional instrumentation
- Two of three measured resection levels were more precise with ROSA Knee compared to conventional instrumentation
 - Mean differences between planned and executed levels was 0.6 to 0.7 mm for ROSA Knee compared to 1.0 to 2.4 mm for conventional

03 Clinical Significance

The ROSA Knee System produces more accurate and reproducible bone resection angles and levels compared to conventional instrumentation.

The ROSA® Knee System: Demonstrates High Precision In Vivo

Reference:

Rossi SM, Sangaletti R, Perticarini L, Terragnoli F, Benazzo F. High accuracy of a new robotically assisted technique for total knee arthroplasty: An in vivo study. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2022;31(3):1153-1161. doi:10.1007/s00167-021-06800-8

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01 Study Design

A single center, prospective study conducted to evaluate the accuracy of the ROSA Knee System for Total Knee Arthroplasty (TKA)

- n=75 patients
- Differences were evaluated between the planned and X-ray measured cuts

02 Key Findings

- No significant differences were found between planned resection levels and post-operative measures in any of the six cuts
 - The four mean femoral difference was less than 1 mm and the two mean tibial differences were less than 2 mm
- No significant differences between any of the four planned resection angles and post-operative measured angles
 - The difference in all angles was less than 1°
- No significant difference between planned and three-month post-operative hip-knee-ankle angle

03 Clinical Significance

The ROSA Knee System produces high precision and reproducibility of resection levels, angles, and post-operative limb angles in vivo.

The ROSA® Knee System: Demonstrates High Precision In Vitro

Reference:

Parratte S, Price AJ, Jeys LM, Jackson WF, Clarke HD. Accuracy of a new robotically assisted technique for total knee arthroplasty: A Cadaveric Study. The Journal of Arthroplasty. 2019;34(11):2799-2803. doi:10.1016/j.arth.2019.06.040

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01 Study Design

A cadaveric study* evaluating the accuracy of the ROSA Knee System for Total Knee Arthroplasty (TKA)

- Eight trained, board-certified orthopedic surgeons
- Target angles from intra-operative planning vs. actual bone cuts by robotic system, measured with a validated computer-assisted navigation system

02 Key Findings

- No significant difference between the planned and measured resection angles for five of the six angles
 - The femoral sagittal angle was significantly different, but the mean difference was only 0.95°
 - All other differences in angles were 0.03 to 0.20°
- No significant difference between the planned and measured resection level for four of the six cuts
 - The femoral medial distal and tibial medial plateau were different, but the mean difference was less than 0.7 mm
 - All other differences in resection levels were 0.06 to 0.23 mm

03 Clinical Significance

The ROSA Knee System produces high precision and reproducibility of resection levels, angles, and post-operative limb angles in vitro.

The ROSA[®] Knee System: Faster Post-Operative Improvements in Pain and Function

Reference:

Khan IA, Vaile JR, DeSimone CA, et al. Image-free robotic-assisted total knee arthroplasty results in quicker recovery but equivalent one-year outcomes compared to conventional total knee arthroplasty. *The Journal of Arthroplasty*. 2023;38(6). doi:10.1016/j.arth.2023.02.023

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01 Study Design

A multicenter, propensity score-matched, retrospective study evaluating the functional outcomes of robotic-assisted Total Knee Arthroplasty (raTKA) compared to conventional Total Knee Arthroplasty (cTKA)

- Participants: 254 raTKA and 762 cTKA patients
- Follow-up: 14 months average (12-20 months range)
- Criteria: Patients with primary unilateral TKA, pre/post-operative KOOS-JR data
- Outcomes: Minimal Clinical Important Difference (MCID) and PASS for KOOS-JR

02 Key Findings

- The ROSA Knee group had significantly higher KOOS-JR than the conventional group at 4-6 weeks post-operative (61.3 vs. 59.0)
 - The change in KOOS-JR scores between pre-operative and 4-6 weeks post-operative were also significantly greater in the ROSA Knee group (19.9 vs. 14.0)
- The ROSA Knee group had significantly higher KOOS-JR than the conventional group at one-year post-operative (77.8 vs. 74.3)
 - However, there were no differences between groups in the number of patients who achieved a minimal clinical important difference in KOOS-JR scores (84.0 vs. 80.9%)

03 Clinical Significance

“[Imageless] robotic-assisted TKA with ROSA Knee reduces pain and improves early functional recovery compared to conventional TKA at 4-6 weeks, but functional outcomes at one year are equivalent based on the MCID for KOOS-JR.”

The ROSA® Knee System: The First Publication on Robotic Sequential Bilateral Total Knee Arthroplasty

Reference:

Batailler C, Anderson MB, Flecher X, Ollivier M, Parratte S. Is sequential bilateral robotic total knee Arthroplasty a safe procedure? A matched comparative pilot study. Archives of Orthopaedic and Trauma Surgery. 2022;143(3):1599-1609. doi:10.1007/s00402-022-04455-9

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01 Study Design

A single center, pair-matched retrospective analysis to evaluate peri-operative outcomes of ROSA Knee for sequential bilateral Total Knee Arthroplasty (TKA).

- n=20 sequential bilateral robotic-assisted primary TKA (raTKA)
- n=20 sequential bilateral conventional technique
- Minimum 6-month follow-up

02 Key Findings

- Cases using robotic assistance had a longer operative time ($p<0.001$), 169 ± 17.7 vs. 140 ± 14.7 min
- There was no difference in length of stay, blood loss, immediate post-operative numeric pain rating scale, or adverse events
- There were **fewer post-operative radiographic outliers** for HKA in robotic vs. conventional TKA (5% vs. 30%, $p=0.003$)
- Robotic cases had **significantly better functional scores** (KSS) at 6 months, 93.3 ± 7.6 vs. 80.7 ± 8.7 ($p<0.001$)
- The KSS difference between groups exceeded the minimal detectable change

03 Clinical Significance

Sequential bilateral robotic-assisted TKA is a valid option for improving accuracy and early outcomes, without posing an additional risk of complications.

The ROSA® Knee System: X-Atlas® 2D to 3D Technology Improves Implant Size Predictions for Robotic Total Knee Arthroplasty

Reference:

Klag EA, Lizzio VA, Charters MA, et al. Increased accuracy in templating for total knee arthroplasty using 3D models generated from radiographs. The Journal of Knee Surgery. 2022;36(08):837-842. doi:10.1055/s-0042-1743496

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01 Study Design

Retrospective analysis comparing templating accuracy in Total Knee Arthroplasty (TKA) using 2D digital radiographs vs. a novel 3D modeling technology

- n=202 robotic-assisted primary TKA with Persona® Knee System
- Pre-operative 3D templating using a novel radiographic protocol and 2D digital templating from the same radiographs. Surgeons were blinded to final implant sizes

02 Key Findings

- “3D imaging technology predicted the exact tibial component size in 93.1% of cases and was significantly more accurate when compared with residents (40%, $p<0.01$) and attending surgeons (53%, $p<0.01$)”
- “Femoral components were predicted more accurately by the 3D imaging technology for 84% of the cases compared with both residents (58.4%) and attending surgeons (75.7%) ($p<0.01$)”
- 3D reliability was excellent for the tibial ($r=0.95$) and good for the femoral components ($r=0.87$)

03 Clinical Significance

“Overall, the increased accuracy of implant size predictions from this 3D templating technology has the potential to improve intra-operative efficiency and minimize costs and surgical time.”

The ROSA® Knee System: Optimizing Total Knee Arthroplasty

Reference:

Knapp P, Nett M, Scuderi G. Optimizing total knee arthroplasty with Rosa® Robotic Technology. Surgical Technology Online. Published online 2022. doi:10.52198/22.sti.40.os1522

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01 Study Design

Literature review and expert opinion on the application of the ROSA Knee System for Total Knee Arthroplasty (TKA).

02 Key Findings

- This article represents surgical techniques for optimizing total knee arthroplasty using the ROSA Knee System
 - Allows surgeon to use familiar conventional instrumentation with the precision of robotics
 - Allows for patient-specific total knee arthroplasty
 - Allows for accurate image-based 2D-3D planning or imageless intra-operative planning

03 Clinical Significance

“Early literature regarding this robotic system is promising as studies have shown precision of its bony resections, accuracy of overall limb alignment, and low early revision rates.”

The ROSA® Knee System: Improved Recovery with Anatomo-Functional Implant Positioning

Reference:

Parratte S, Van Overschelde P, Bandi M, Ozturk BY, Batailler C. An anatomo-functional implant positioning technique with robotic assistance for primary TKA allows the restoration of the native knee alignment and a natural functional ligament pattern, with a faster recovery at 6 months compared to an adjusted mechanical technique. *Knee Surgery, Sports Traumatology, Arthroscopy.* 2022;31(4):1334-1346. doi:10.1007/s00167-022-06995-4

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01 Study Design

Retrospective case control series assessing clinical outcomes of anatomo-functional implant positioning (AFIP) technique with robotic-assisted Total Knee Arthroplasty (raTKA) compared to adjusted mechanical alignment (aMA) with conventional Total Knee Arthroplasty (cTKA) instrumentation in Total Knee Arthroplasty (TKA)

- n=40 (AFIP)
- n=40 (aMA)
- 12-month follow-up

02 Key Findings

- The lateral gap was significantly more lax in flexion and no soft tissue release were required with AFIP raTKA
- Native femoral anatomy was retained with AFIP raTKA, while the femoral component was implanted significantly more varus in aMA cTKA
- Improvement of Knee and Function KSS at six months was better in the raTKA AFIP group vs. cTKA aMA group, with no peri-operative complications
- KSS Function PASS scores were only achieved in raTKA AFIP

03 Clinical Significance

“The AFIP concept allowed the restoration of the native knee anatomy and alignment with a natural ligament pattern.”

“With a more physiological target for ligament balancing, [robotically assisted] AFIP technique had equivalent clinical outcomes at 12 months compared to aMA, with a faster recovery.”

Robotic-Assisted TKA is Not Associated With Decreased Odds of Early Revision

Reference:

Kirchner GJ, Stambough JB, Jimenez E, Nikkel LE. Robotic-assisted TKA is not associated with decreased odds of early revision: An analysis of the American Joint Replacement Registry. *Clinical Orthopaedics & Related Research*. 2023;482(2):303-310. doi: 10.1097/corr.0000000000002783

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01 Study Design

A retrospective analysis of the American Joint Replacement Registry (AJRR) of Medicare patients undergoing total knee arthroplasty (TKA) between 2017 and 2022 with at least two years of follow-up.

- (This limits the inclusion of ROSA® Knee System in the analysis)

The revision rate and indications for revision were compared between conventional (cTKA) and robotic-assisted (raTKA) TKA

- cTKA: n=128,334
- raTKA: n=14,126

All reasons for revision were included in the analysis, thus some patients were counted more than once as they may have had both pain and instability.

02 Key Findings

- The rate of revision was 1.2% in each technique and not different between cTKA and raTKA
- When controlling for other variables, the odds of revision were significantly greater in raTKA for:
 - Instability: Odds ratio 1.6 (95% Confidence Interval: 1.0 to 2.4)
 - Pain: Odds ratio 2.1 (95% Confidence Interval: 1.4 to 3.0)

Limitations of the analysis:

- There were 1578 cTKA and 172 raTKA revisions
- There were 1844 cTKA and 216 raTKA indications for revision
- The primary reason for revision was not isolated, meaning one patient could have several diagnoses evaluated
 - This essentially resulted in more raTKA patients counted multiple times in the analysis on reasons for revision

03 Clinical Significance

Based on data from the AJRR, there does not appear to be a difference in the risk of two-year revision between cTKA and raTKA.

The primary indication for revision was not isolated, the higher odds of revision due to instability and pain should be interpreted with caution as raTKA cases were more likely to be counted multiple times.

The ROSA® Knee System: Successful Joint Restoration and Early Outcomes in Severe Deformities

Reference:

Rossi SM, Sangaletti R, Andriollo L, Matascioli L, Benazzo F. The use of a modern robotic system for the treatment of severe knee deformity. *Technology and Healthcare*. January, 2024; published online ahead of print. doi:10.3233/THC-231261

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01 Study Design

A single center evaluation of clinical and radiological outcomes in patients with severe varus or valgus deformity treated with the ROSA Knee System.

- Valgus deformity ($>10^\circ$)
 - n=10
- Varus deformity ($>15^\circ$ fixed intra-articular deformity)
 - n=20
- PROMs assessed at minimum six-months follow-up
 - Mean follow-up was 18 (range: 6 to 30) months post-operative
- Radiographs assessed at 3 months post-operative for mechanical coronal alignment

02 Key Findings

- Significant ($p<0.0001$) improvements in range of motion, Knee Society (KSS), Hospital for Special Surgery (HSS), Oxford Knee Score (OKS), and Western Ontario and McMaster University Osteoarthritis Index (WOMAC) Scores
 - ROM increased by 19.5°
 - Improvements in KSS (+53.4), HSS (+35.2), OKS (+23), and WOMAC* pain (-16.7), stiffness (-4.3) and function (-39.4) all exceed the minimal clinical important differences
- Post-operative hip-knee-ankle angle was restored to $179.5\pm 2.1^\circ$ and all implants were determined to be in mechanical alignment
- There were no revisions through 30 months of follow-up

*Lower WOMAC scores represent better outcomes

03 Clinical Significance

Robotic-assisted total knee arthroplasty with the ROSA Knee System is successful in restoring a neutral alignment and improving clinical outcomes even in severely deformed knees.

The ROSA® Knee System: Improved Accuracy in Low-Volume Surgeons

Reference:

Byrne C, Durst C, Rezzadeh K, Rockov Z, Moon C, Rajae S. Robotic-assisted total knee arthroplasty reduces radiographic outliers for low-volume total knee arthroplasty surgeons. *Arthroplasty Today*. 2024;25:101303. doi: 10.1016/j.artd.2023.101303

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01 Study Design

A single, low-volume surgeon retrospective evaluation of early radiographic and clinical outcomes comparing robotic-assisted (raTKA) to conventional (cTKA) total knee arthroplasty (TKA).

- Surgeon averages 30 TKAs annually
- raTKA: n=19
- cTKA: n=41
- Radiographic analysis:
 - Tibial slope
 - Tibial coronal alignment
 - Presence of notching
- Patient-Reported Outcomes Measures Information System (PROMIS) assessed at one- and three-months post-operative

02 Key Findings

- Significantly less tibial slope outliers in raTKA compared to cTKA
 - (0% vs. 22%)
- Significantly less cases of notching in raTKA compared to cTKA
 - (0% vs. 20%)
- Length of stay was significantly less in raTKA by approximately 20 hours
- There were no differences in operative times between groups
- There were more manipulations under anesthesia (2 vs. 0) and revisions (2 vs. 5) with cTKA compared to raTKA
- There were no significant differences in PROMIS scores
 - Small sample size and high attrition resulted in low statistical power

03 Clinical Significance

Robotic-assisted TKA with the ROSA Knee System significantly decreases radiographic outliers and length of stay without affecting the rate of complications or early patient reported outcome measures in low-volume surgeons.

Robotic-Assisted TKA Does Not Increase The Risk of Infection

Reference:

LaValva SM, Chiu YF, Fowler MJ, Lyman S, Carli AV. Does Computer Navigation or Robotic Assistance Affect the Risk of Periprosthetic Joint Infection in Primary Total Knee Arthroplasty? A Propensity Score-Matched Cohort Analysis. J Arthroplasty, 2024, 39(1):96-102. Doi: 10.1016/j.arth.2023.08.007

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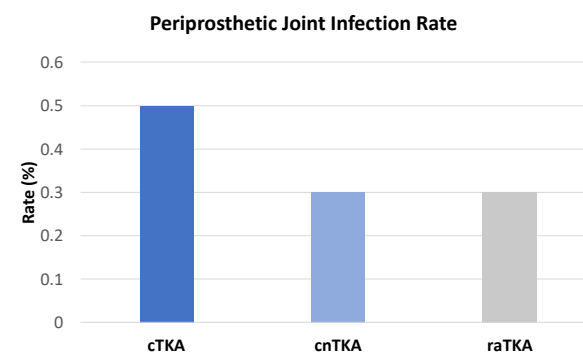
01 Study Design

A single center, propensity score-matched, retrospective study of conventional (cTKA), computer-navigated (cnTKA), and MAKO[®] robotic-assisted (raTKA) total knee arthroplasty cases.

- **Primary Outcome:** Periprosthetic joint infection (PJI) occurring within first 90-day post-operative
- **cTKA:** n=6,599
- **cnTKA:** n=5,673
- **raTKA:** n=743
- All raTKA cases were propensity matched 1:1 to cTKA cases
- Only 5174 cnTKA cases were able to propensity match on a 1:1 ratio to cTKA cases

02 Key Findings

- There were no significant differences in the rate of PJI between groups
- There were no pin-site complications through six-weeks follow-up in raTKA
- Surgical time was significantly longer with raTKA compared to cnTKA or cTKA (108 vs. 94 vs. 91 min)



03 Clinical Significance

Despite longer surgical times, robotic-assisted TKA does not increase the risk of periprosthetic joint infection compared to conventional or computer-navigated techniques within 90-days post-operative.

The ROSA® Knee System: Successful One-Year Outcomes in Terms of Functional Results

Reference:

Selvanathan N, Ayena F, Sorial R. Incidence of soft tissue releases in robotic assisted cementless TKA with mechanical alignment and gap balancing. *Arthroplasty*, 2023, 5:8. doi:10.1186/s42836-023-00188-1

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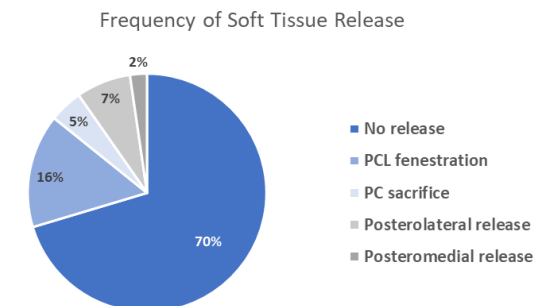
01 Study Design

A single center prospective and retrospective evaluation of the soft tissue releases required for ligament balance with the ROSA Knee System.

- n=175 robotic-assisted total knee arthroplasty patients
- Minimum follow-up of 6 months
- Medial releases were recorded for varus knees, posterolateral fenestrated release and retinacular release for valgus knees, and any posterior cruciate ligament (PCL) fenestration or sacrifice was documented

02 Key Findings

- 97.8% of initial bone resections were within 1.5 mm accuracy
- Soft tissue releases were performed in 29.7% of patients
- Only 9.7% of patients required a soft tissue release for coronal plane correction
- Valgus knees had a higher rate of soft tissue release than varus knees (53% vs. 29%)
- There were no revisions and only 2 patients (1.1%) required manipulation under anesthesia



03 Clinical Significance

Robotic-assisted total knee arthroplasty with the ROSA Knee System may reduce the need for unnecessary soft tissue releases to achieve coronal alignment to the mechanical axis in total knee arthroplasty.

The ROSA® Knee System: Has a Similar Accuracy of Implant Positioning as NAVIO® Robot System

Reference:

Hasegawa M, Tone S, Naito Y, Sudo A. Comparison of accuracy and early outcomes in robotic total knee arthroplasty using NAVIO and ROSA. Sci Rep. 2024 Feb 8;14(1):3192. doi:10.1038/s41598-024-53789-4

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01 Study Design

A retrospective analysis of patients who received robotic– assisted Total Knee Arthroplasty (rTKA) using the NAVIO or ROSA Knee System

- NAVIO Group: n= 40
- ROSA Group: n=48

Cutting error (planned vs. robot validated angles), implantation error (planned vs. radiograph measured angles), and one-year clinical outcomes were compared between groups

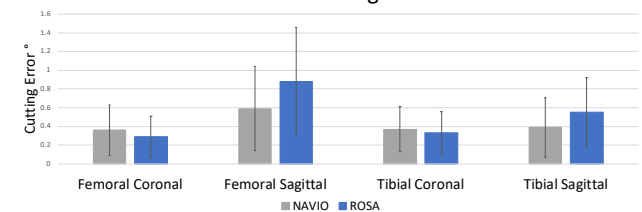
Potential Confounders:

- All surgeries were performed by one surgeon, though at a different institution per robot
- ROSA Knee patients received a medial congruent implant, while NAVIO patients received a bicruciate-substituting implant.
- The planned femoral flexion and posterior tibial slope angles were different between groups (ROSA Knee: 4°, NAVIO: 3°)

02 Key Findings

- Despite significant differences in femoral sagittal cutting error, all absolute cutting errors were less than 1°
- The ROSA Knee component was implanted significantly more extended in the ROSA group ($1.09 \pm 0.89^\circ$ vs. $0.20 \pm 1.20^\circ$), however, there were no differences between ROSA Knee and NAVIO in absolute error ($1.11 \pm 0.75^\circ$ vs. $0.90 \pm 0.80^\circ$, respectively)
- There were no significant differences between groups for femoral coronal, tibial coronal, or tibial sagittal implantation errors, and all absolute implantation errors were less than 1°
- One-year post-operative Knee Society Score (KSS) subscale for symptoms was superior in the ROSA Knee group (21.5 ± 3.8 vs. 19.9 ± 3.7)
- Overall KSS, KSS satisfaction, KSS functional activities, Forgotten Joint Score, and range of motion all improved equally between groups

Absolute Cutting Errors



03 Clinical Significance

The ROSA Knee System showed similar radiographic outcomes and improved symptoms at one-year follow-up when compared with the NAVIO robotic system

ZBEdge™: Integration of Pre-, Intra-, and Post-operative Data with the mymobility® Care Management Platform and the ROSA® Knee System

Reference:

Lonner JH**, Anderson MB*, Redfern RE*, Van Andel D*, Ballard JC**, Parratte S.** An orthopaedic intelligence application successfully integrates data from a smartphone-based care management platform and a robotic knee system using a commercial database. *International Orthopaedics*. 2022;47(2):485-494. doi:10.1007/s00264-022-05651-3

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01 Study Design

Secondary data analysis of 131 patients from a commercial database who underwent robotic-assisted total knee arthroplasty (raTKA).

There were three categories:

- Balanced
- Slightly imbalanced
- Imbalanced

Collection of pre-operative to six-week post-operative step counts and KOOS-JR scores, were analyzed alongside intra-operative laxity measures to assess if intra-operative variables are associated with post-operative outcomes.

02 Key Findings

- There were higher step counts at six-weeks post-operatively in knees with >2 mm laxity in both the lateral compartment in extension and medial compartment in flexion ($p < 0.05$)
- Knees balanced in flexion within <0.5 mm had higher KOOS-JR scores at six-weeks post-operative ($p = 0.034$) compared to slightly imbalanced knees (0.5 – 1.5 mm difference in laxity between compartments)
- Slightly imbalanced and imbalanced knees (> 1.5mm difference in laxity between compartments) in extension had significantly greater step counts at six-weeks compared to balanced knees

03 Clinical Significance

The study demonstrates the feasibility of data collection throughout the episode of care.

The ability of the mymobility® Care Management Platform to be integrated with intra-operative data from the ROSA® Knee System using an intelligence platform consisting of commercial data is feasible.

The ROSA® Knee System Robotic-Assisted Total Knee Arthroplasty Patients Report High Satisfaction

Reference:

Selvanathan, N., Ayeni, F.E. & Sorial, R. Is 80% satisfaction still the expectation in modern TKA mechanically aligned with robot assist? We think not. *J Robotic Surg* 18, 137 (2024). <https://doi.org/10.1007/s11701-024-01888-9>

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01 Study Design

A retrospective analysis of patients who underwent robotic-assisted total knee arthroplasty (raTKA) with the ROSA® Knee System by a single surgeon

- 175 patients underwent raTKA and 165 were available for follow-up at one-year post-operative
- Patients were asked if they were happy with the knee replacement and if they were happy with the outcomes of their knee replacement

02 Key Findings

- 95.2% of patients were happy with their knee replacement.
- 92.7% of patients were happy with the outcomes of their knee replacement.
- Patients requiring soft tissue release (approximately 29.7%) did not report any difference in happiness with the surgery or the outcomes compared to patients who did not require a soft tissue manipulation.
- Patients who received bilateral simultaneous raTKA were less happy with their surgery and the outcomes than patients who received either unilateral or staged bilateral raTKA.
 - However, the population of patients receiving bilateral simultaneous raTKA was low (4.8%) in comparison to the full cohort size.

03 Clinical Significance

Patients receiving raTKA with ROSA Knee appear to report higher levels of satisfaction compared to the general TKA population. These results should be interpreted with caution, as a conventional group was not used for control and the satisfaction survey was different from those typically used.

The ROSA® Knee System: Significantly Shorter Operative Time Compared to Mako®

Reference:

Zhou, G., Wang, X., Geng, X., Li, Z. and Tian, H. (2024), Comparison of Alignment Accuracy and Clinical Outcomes between a CT-Based, Saw Cutting Robotic System and a CT-Free, Jig-guided Robotic System for Total Knee Arthroplasty. Orthop Surg. <https://doi.org/10.1111/os.14055>

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01 Study Design

A retrospective analysis comparing accuracy and one-year clinical outcomes between the ROSA® Knee System and Mako, each performed by a single surgeon using mechanical alignment.

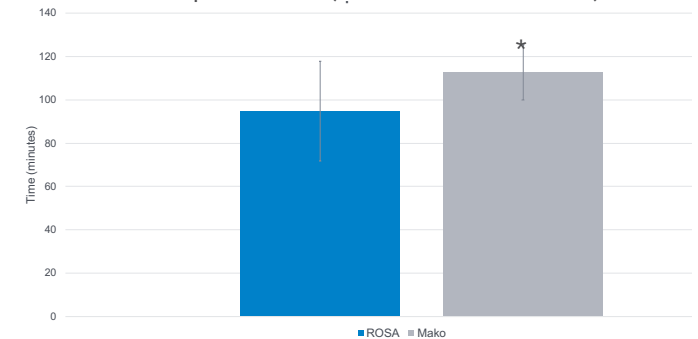
Accuracy was compared between the pre-operative plan and post-operative radiographs at three-months and one-year in the coronal tibial and femoral angles and sagittal tibial angle (tibial slope).

- ROSA Knee: n=20
- Mako Knee: n=20

02 Key Findings

- Operative time was significantly less in the ROSA Knee System compared to Mako by approximately 18 minutes.
- Both platforms produced similarly good accuracy for alignment and component position.
- Mean deviations for component positioning were all less than 2° for ROSA Knee and 2.5° for Mako at three-months and one-year post operative.
- There were no significant differences in patient-reported outcome measures or satisfaction at one-year post-operative.

Mean Operative Time (95% Confidence Intervals¹)



03 Clinical Significance

Robotic-assisted total knee arthroplasty with the ROSA Knee System provides comparable component positioning to the Mako knee system, but with significantly shorter operative times.

1. Confidence intervals 1.96 were calculated using the mean, standard deviation, and sample size: $\text{Mean} \pm Z \times (\text{standard deviation} / \sqrt{n})$, whereby Z denotes a confidence level of 1.96 corresponding to 95%.

The ROSA® Knee System: Critical Review of Nogalo et al.: Robotic-Assisted TKA is Not Associated with Improved Accuracy

Reference:

Nogalo C, Farinelli L, Meena A, di Maria F, Abermann E, Fink C. Robotic-assisted total knee arthroplasty is not associated with improved accuracy in implant position and alignment compared to conventional instrumentation in the execution of a preoperative digital plan. J Exp Orthop. 2024; 11:e12019. <https://doi.org/10.1002/jeo2.12019>

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01 Study Design

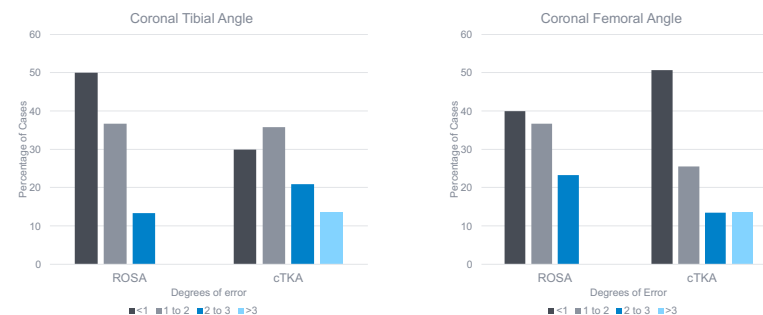
A single surgeon retrospective analysis comparing accuracy and clinical outcomes between the ROSA® Knee System and conventional total knee arthroplasty (cTKA) using constitutional alignment.

Accuracy was compared between the pre-operative plan and post-operative radiographs.

- Differences between planned and measured (errors) were categorized as <1°, 1 to 2°, 2 to 3°, and > 3° for the hip-knee-ankle angle (HKA) and the coronal tibial and femoral angle
- ROSA Knee: n=30
- cTKA: n=67

02 Key Findings

- There were no differences in the percentage of cases within the specified categories between ROSA Knee and cTKA.
- There were zero coronal tibial or femoral cases with a cutting error greater than 3° for ROSA Knee compared to 13.4% and 10.4% of cases for cTKA, respectively.
- There were no differences in operative times between groups.
- The absolute mean errors between planned and measured angles were not reported for either group.



03 Clinical Significance

Improper statistical analyses limit the interpretation of these results. The study was underpowered to detect statistical significance with a 2x4 Chi Squared test. The absolute mean error was not reported nor statistically compared. There were no ROSA Knee cases with an error greater than 3° and it is unknown how large the error of the cTKA cases greater than 3° were.

Robotic-Assisted TKA isn't Associated with Increased Satisfaction: Study Limitations

Reference:

Hoveidaei AH, Esmaeili S, Ghaseminejad-Raeini A, Pirahesh K, Fallahi MS, Sandiford NA, Citak M. Robotic assisted Total Knee Arthroplasty (TKA) is not associated with increased patient satisfaction: a systematic review and meta-analysis. *Int Orthop.* 2024 May 6. doi: 10.1007/s00264-024-06206-4

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01 Study Design

A systematic review and meta-analysis of studies reporting satisfaction outcomes between robotic-assisted (rTKA) and conventional total knee arthroplasty (cTKA)

- Studies published prior to August 2023 were included
- There were 9 studies included that compared satisfaction outcomes between rTKA to cTKA
- 8 single cohort studies that involved only rTKA were also included
- Only one of the 17 studies used the ROSA® Knee System

1. Kahlenberg CA, Nwachukwu BU, McLawhorn AS, Cross MB, Cornell CN, Padgett DE. Patient Satisfaction After Total Knee Replacement: A Systematic Review. *Hss* j 14(2): 192, 2018

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02 Key Findings

- In the meta-analysis the rates of satisfaction were 95% and 91% for rTKA and cTKA, respectively, but the odds ratio for greater satisfaction with rTKA was not statistically significant.
- The study was limited by the following:
 - The authors excluded 6 studies from the meta-analysis without justification.
 - Satisfaction was statistically higher in 3 of the excluded studies.
 - Two of the excluded studies reported no statistical difference.
 - One study did not statistically analyze satisfaction.
 - Satisfaction was collected at different time points, and was not standardized in the meta-analysis.
 - Satisfaction may change from 6 months to 2 years.
- The rate of satisfaction following rTKA across 11 studies was 94% (95% Confidence Interval of 92% to 96%).

03 Clinical Significance

The systematic review found approximately 92% to 96% of patients are satisfied with their rTKA procedure, a value greater than the 80-90% reported in the literature for TKA.¹ Because 66% of the comparative studies were excluded from the meta-analysis, the finding that rTKA is not associated with increased patient satisfaction should be interpreted with caution.

ZBEdge
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Robotic-Assisted TKA: Similar Operative Times to Conventional TKA After 30 Cases

Reference:

Ejnisman L, Antonioli E, Cintra L, de Oliveira Souza PG, Costa LAV, Lenza M. Robot-assisted knee arthroplasty: Analyzing the learning curve and initial institutional experience. *Comput Struct Biotechnol J*. 2024 Apr 12;24:343-349. doi: 10.1016/j.csbj.2024.04.013.

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01 Study Design

A single center, retrospective review of robotic-assisted (rTKA) and conventional (cTKA) cases using either the ROSA® Knee System or Mako®.

- 617 cases of rTKA and cTKA were performed by 80 surgeons.
 - rTKA: n=321
 - cTKA: n=296
- Surgeons who had performed more than 10 rTKA cases were classified as “proficiency stage surgeons”.
- Surgeons with less than 10 rTKA cases were classified as “initial stage surgeons”.
- Operative time was defined as the time between initial skin incision to final wound closure.

02 Key Findings

- Significant differences in operative times were found between the first and last 10 rTKA cases (177.5 vs. 145 minutes) for five surgeons who had reached the proficiency stage.
- There were no differences in operative times between the surgeon’s last 10 rTKA and cTKA cases (145 vs. 150 minutes).
- 30 rTKA cases were required by proficiency-stage surgeons to reach an rTKA operative time less than that of cTKA.
- The number of cases necessary to reach the proficiency stage was highly variable, depending on the level of surgeon experience, ranging from 12 to 41 cases.
- There was no difference in clinical outcome measures between the groups pre- or 90 days post-operatively.

03 Clinical Significance

Robotic-assisted TKA is associated with a learning curve of 12 to 40 cases, depending on individual skill. Surgeons may expect their rTKA operative times to be equal to or less than their cTKA operative times after approximately 30 rTKA cases.

The ROSA® Knee System: Significantly Less Radiation Exposure Than Mako®

Reference:

Saad A, Mayne A, Pagkalos J, Ollivier M, Botchu R, Davis E, Sharma A. Comparative analysis of radiation exposure in robot-assisted total knee arthroplasty using popular robotic systems. *J Robot Surg.* 2024;18(1):120. doi: 10.1007/s11701-024-01896-9

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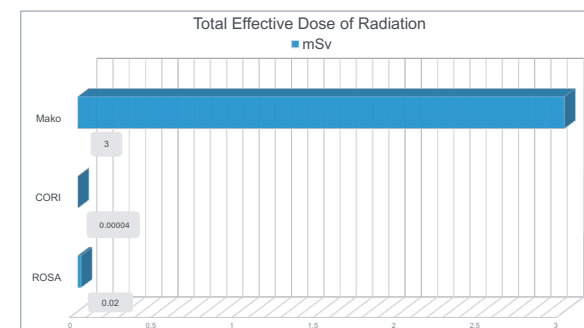
01 Study Design

A retrospective analysis comparing radiation exposure from three robotic-assisted total knee arthroplasty (raTKA) systems at a single institution. The systems used were Mako®, ROSA® Knee and CORI.

- Mako (n=43): Pre-operative CT image-based scanning of hip, knee, and ankle regions
- ROSA Knee (n=47): Antero-posterior long leg alignment radiographs
- CORI (n=50): standard antero-posterior, lateral, and skyline knee radiographs

02 Key Findings

- Significant differences in radiation were found between all three systems.
- Patients undergoing Mako raTKA were exposed to significantly more radiation compared to ROSA Knee raTKA.



03 Clinical Significance

Imageless raTKA with ROSA Knee System had significantly less radiation exposure than a CT-based system (Mako), though clinical safety limits were not exceeded by any group. This information may help surgeons inform the consenting process for patients.

The ROSA[®] Knee System: No Difference in Pin- Site Complications Compared to NAVIO[®] Surgical System

Reference:

Desai SS, Shah, RP*, Cooper HJ*. A comparison of pin site complications between large and small pin diameters in robotic-assisted total knee arthroplasty. J Exp Orthop. 2023 Mar 10;10(1):22. doi: 10.1186/s40634-023-00584-1

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01 Study Design

A single center retrospective analysis comparing overall and pin-site complications between small pin diameters with the ROSA[®] Knee System and large pin diameters with the NAVIO[®] Surgical System in robotic-assisted total knee arthroplasty (raTKA).

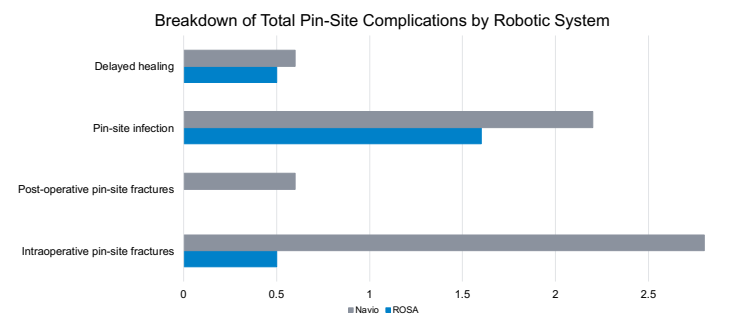
Small diameter pins (3.2 mm): n=190
Large diameter pins (4.5 mm): n=177

Three-month post-operative medical records were reviewed for:

- Pin-site infections, pin-site fracture, and delayed wound healing
- Non-pin-site complications
- Reoperations

02 Key Findings

- Total pin-site complications (2.6% vs. 5.6%), non-pin-site complications (7.4% vs. 10.2%), and reoperations (3.2% vs. 4.0%) were all lower with small compared to large diameter pins, however, the differences were not statistically significant.
- 86.7% of pin-site complications were on the tibia, most presented either intra-operatively or in the first-month post-operative, and there were zero pin or drill breakages.



03 Clinical Significance

Pin-site complications are uncommon following raTKA. Their occurrence seems to be less frequent when smaller diameter pins are used, highlighting a potentially lower risk of pin-site fractures with the ROSA Knee System.

The ROSA® Knee System: High in-vivo Accuracy Across the Workflow

Reference:

Zaidi F, Goplen CM, Fitz-Gerald C, Bolam SM, Hanlon M, Munro JT*, Monk AP*. High in-vivo accuracy of a novel robotic-arm-assisted system for total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc.* 2024 May 20. doi: 10.1002/ksa.12272.

Study funded by Zimmer Biomet.

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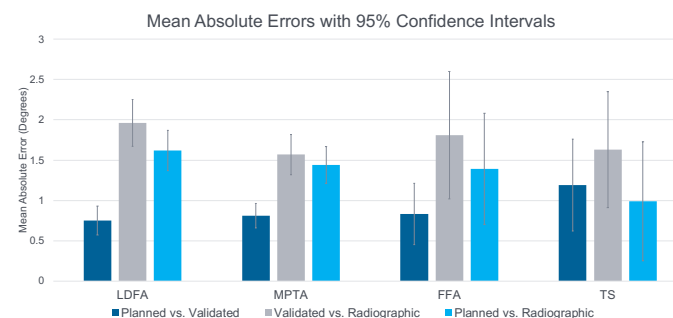
01 Study Design

A single center, multiple surgeon retrospective analysis of patients undergoing robotic-assisted total knee arthroplasty (raTKA) with The ROSA® Knee System.

- Three surgeons contributed a total of 74 cases.
- The pre-operative planned, robotic-validated, and three-month post-operative radiographically measured angles were compared for the:
 - Lateral distal femoral angle (LDFA)
 - Medial proximal tibial angle (MPTA)
 - Femoral flexion angle (FFA)
 - Tibial slope (TS)

02 Key Findings

- The mean absolute error between measures were all less than 2° for each angle investigated, without significant differences between planned, validated, and post-operative X-rays.
- High reliability was also reported, with the standard deviations of the errors all less than 1.5°.
- The proportion of cases with radiographically measured angles greater than 3° from the planned angle was 6.8%, 4.7%, 2.7%, and 5.4% for the LDFA, MPTA, FFA, and TS, respectively.



03 Clinical Significance

The ROSA Knee System supports high accuracy and reliability of executing the pre-operative plan in the coronal and sagittal planes across the surgical workflow.

The ROSA® Knee System: Planned femoral component size, rotation, and AP position are similar between manual stress and a ligament tensioner as measured by the ROSA Knee System

Reference:

Woelfle CA, Weiner TR, Sculco PK*, Sarpong NO, Shah RP*, Cooper HJ*. Surgeon-Applied Stress and a Ligament Tensor Instrument Provide a Similar Assessment of Preresection Flexion Laxity During Robotic Total Knee Arthroplasty. *Arthroplast Today*. 2024 Jul 3;28:101450. doi: 10.1016/j.artd.2024.101450.

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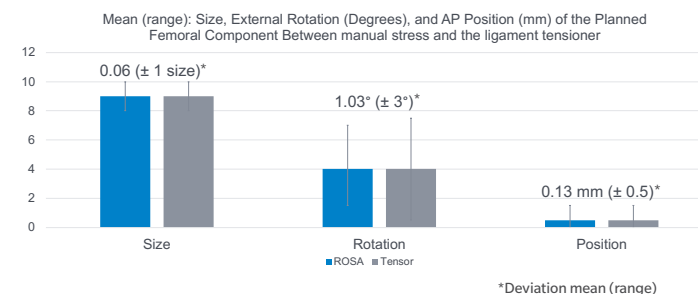
01 Study Design

A prospective comparison of planned flexion gap resections using manual stress versus a ligament tensioner device to evaluate flexion laxity.

- N=50 (primary TKA)
- Planning:
 - Manually applied, robotically measured Varus/Valgus laxity assessment in flexion using the ROSA Knee System
 - Instrument-applied, robotically recorded, Varus/Valgus laxity assessment in flexion using the Zimmer Biomet FuZion® Tensor
- The planned femoral component size, rotation (using the posterior condylar axis), and anteroposterior (AP) position were compared
 - AP position measured using the anterior flange

02 Key Findings

- There were no significant differences in the planned femoral component size ($p=0.569$), rotation ($p=0.741$), or AP position ($p=0.785$) between the manual stress and ligament tensioner assessments.
- Limitations:
 - Tensor assessment done with different methods before and after the cuts.
 - Regardless, similar planned flexion gap resections were reported.
 - Potential assessment order bias – manual stress performed first could have affected the tensioner plans.



03 Clinical Significance

Flexion laxity assessed with manual stress measured using the ROSA Knee System resulted in similar planned femoral component size, rotation, and AP positioning as flexion laxity assessed using a ligament tensioning device.

The ROSA[®] Knee System: High Accuracy With Less Outliers Compared to Conventional TKA

Reference:

Zaidi F, Goplen CM, Bolam SM, Monk AP*. Accuracy and Outcomes of a Novel Cut-Block Positioning Robotic-Arm Assisted System for Total Knee Arthroplasty: A Systematic Review and Meta-Analysis. Arthroplast Today. 2024;29:101451. Published 2024 Aug 4. doi:10.1016/j.artd.2024.101451

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Study was funded by Zimmer Biomet.

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01 Study Design

A systematic review and meta-analysis evaluating the accuracy, precision, functional outcomes and complications of the ROSA[®] Knee System.

- A total of 17 studies were evaluated.
- 9 studies included a control group of conventional TKA (cTKA).
- 10 studies evaluated accuracy and precision.
 - 3 compared the intra-operative plan to post-operative radiographs
 - 7 compared the intra-operative plan to intra-operative ROSA Knee validated measure
 - Accuracy was defined as the mean difference between planned and post-operative radiographical angles.
 - Precision was the standard deviations of the mean differences.

02 Key Findings

- 5 of the included studies reported the percentage of hip-knee-ankle angle (HKA) outliers (>3° of planned) between ROSA Knee and cTKA.
 - 3 studies reported a significant difference favoring ROSA Knee,
 - 1 study reported no statistical difference,
 - 1 study reported 0 of 14 outliers in ROSA Knee and 5 of 25 (25%) in cTKA but did not conduct a statistical analysis.
- There were no differences in complications between ROSA Knee and cTKA.
- 2 studies reported significantly greater changes in Knee Society Score function at 6-months and 1-year post-operative with ROSA Knee compared to cTKA.
- 2 studies reported a learning curve of 5-15 cases and one reported 70 cases to become time neutral.

Pooled Accuracy as measured by Precision of ROSA Knee

	Mean Absolute Difference	Standard Deviation
Lateral Distal Femoral Angle	0.61	0.97
Medial Proximal Tibial Angle	0.61	1.26
Tibial Slope	0.75	1.34
Femoral Flexion	1.87	1.11

03 Clinical Significance

The ROSA Knee System demonstrates high accuracy and precision across multiple studies in this meta-analysis. TKA with ROSA Knee is associated with less HKA outliers and greater improvements in post-operative function.

The ROSA[®] Knee System: Limitations Associated with Evaluating Outcomes in a Bilateral TKA Study

Reference:

Rajgopal A, Sundararajan SS, Aggarwal K, Kumar S, Singh G. Robotic Assisted TKA achieves adjusted mechanical alignment targets more consistently compared to manual TKA without improving outcomes. J Exp Orthop. 2024;11(3):e70008. Published 2024 Sep 2. doi:10.1002/jeo2.70008

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01 Study Design

A retrospective, single-blinded analysis of simultaneous bilateral total knee arthroplasties (TKA) comparing the ROSA[®] Knee System to conventional instrumentation.

- 135 patients participated
- Each knee was randomized to receive either robotic-assisted (raTKA: n=135) or conventional (cTKA: n=135) TKA
- Hip-knee-ankle angle (HKA) assessed at one-year
- Knee Society Score (KSS), Oxford Knee Score (OKS), and range of motion (ROM) assessed pre-operatively and at three-, six-, and twelve-months post-operative

02 Key Findings

- While there were no significant differences in the mean HKA between knees, there were five cTKA outliers compared to zero raTKA outliers.
- Mean operative time was significantly less with cTKA compared to raTKA (26.1 vs. 29.0 min).
- Blood loss was significantly less with raTKA (206.7 mL vs. 413.9 mL).
- There were no significant differences in OKS or KSS between knees.
- ROM was slightly greater (~3.3°) at six-months post-operative in the cTKA knee, but not significantly different at any other time point.
- The results of this study should be interpreted with caution due to the following limitations:
 - The study was likely underpowered to detect a statistical difference.
 - The authors reported a power of 50.5% (adequate power is usually 80%).
 - The authors did not describe how HKA outliers were defined, operative time was measured, blood loss was evaluated, nor which version of the OKS was used.
 - The authors did not adjust for multiplicity when assessing PROMs and ROM.
 - The six-month ROM difference was likely a false positive due to the statistical methods and is also not clinically relevant.

03 Clinical Significance

Total knee arthroplasty with ROSA Knee was associated with fewer HKA outliers and blood loss compared to conventional TKA in simultaneous bilateral TKA. There were no differences in PROMs or ROM up to one-year post-operative. Of importance, these findings should be interpreted with caution as there were significant weaknesses in this study.

The ROSA® Knee: Personalized Alignment Surgical Technique

Reference:

Massé V*, Cholewa J** and Shahin M (2023) **Personalized alignment™ for total knee arthroplasty using the ROSA® Knee and Persona® knee systems: Surgical technique.** Front. Surg. 9:1098504. doi: [10.3389fsurg.2022.1098504](https://doi.org/10.3389/fsurg.2022.1098504)

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01 Study Design

Dr. Vincent Massé describes how to perform a personalized technique with restricted kinematic alignment (rKA) using ROSA® Knee and the Persona® Knee systems.

This surgical technique paper covered the following topics:

- Differences between rKA and mechanical alignment.
- rKA boundaries.
- Image-based and imageless pre-operative planning.
- Anatomic landmarking.
- Intra-operative evaluation, planning and adjustment, and validation.
- Laxity assessments.
- Expected outcomes.

02 Key Findings

- The purpose of rKA is to recreate pre-arthritis anatomy by maintaining a patient's individual native soft tissue tensions.
- The boundaries for rKA are:
 - Arithmetic hip-knee-ankle angle: 0 ± 3
 - Distal femoral coronal angle: $0 \pm 5^\circ$
 - Proximal tibial coronal angle: $0 \pm 5^\circ$
- ROSA Knee allows the surgeon to perform valgus and varus stress tests at 10° and 90° to assess native ligament laxity and maximal deformity correction.
- Robotic validation is performed after the femoral and tibial resections, and allows the surgeon to adjust the pre-operative plan and obtain final information on the accuracy of the resections. The Personalized Alignment technique minimizes soft tissue release, however, anatomical corrections in excess of $2\text{-}3^\circ$ will often necessitate ligament releases.

03 Clinical Significance

The ROSA® Knee System allows for a personalized approach using a restricted kinematic alignment philosophy in primary total knee arthroplasty.

Six-month post-operative outcomes with a contemporary knee system challenges the 80% satisfaction rate

Reference:

Zhang E, Yeo W, Liu E, Chen J, Pang H, Yeo S, Liow L. (2025) **Does robotic surgical assistant (ROSA) functionally aligned TKA lead to higher satisfaction than conventional mechanically aligned TKA: A propensity-matched pair analysis**, Journal of Orthopaedics, 63: 93-97. [doi: 10.1016/j.jor.2024.10.039](https://doi.org/10.1016/j.jor.2024.10.039).

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01 Study Design

A retrospective, propensity-matched cohort study of patients who received the cemented Persona® The Personalized Knee® comparing the ROSA® Knee System total knee arthroplasty (rTKA) using functional alignment to a manual mechanically aligned technique (mTKA).

- Patient Reported Outcome Measures (PROMs) were measured pre-operatively and post-operatively at six months:
 - Knee Society Knee Score (KSS)
 - Knee Society Function Score (KSFS)
 - Oxford Knee Score
 - Short-Form 36 questionnaire (SF36)
 - Satisfaction
- Cohorts were matched for age and sex:
 - rTKA: n=46
 - mTKA: n=46

02 Key Findings

- At six-months follow-up, both groups demonstrated excellent clinical and satisfaction outcomes.
- There were no significant differences between rTKA and mTKA for post-operative KSS (80.9 vs. 85.1), KSFS (76.3 vs. 68.2), OKS (19.1 vs. 20.1) SF36-Physical Component (46.6 vs 46.3), or rate of satisfaction (100% vs. 98.1%).
- This study was limited by differences in physical function between the groups pre-operatively and a small sample size.
 - The rTKA group had significantly ($p=0.04$) higher SF36-general health and trended toward a higher SF36-Physical Component ($p=0.06$) and KSS ($p=0.07$) pre-operatively.
 - This data suggests the rTKA group had higher pre-operative function and thus, less potential room for improvements.
 - The sample size was too small to detect a difference in patient-reported outcomes.
 - A post-hoc power analysis revealed each cohort required 86 patients to be adequately powered.

03 Clinical Significance

rTKA patients had equivalent outcomes and satisfaction levels compared to mTKA patients when measured post-operatively. All patients were **highly satisfied** at six months post-operative (>98%), suggesting that contemporary knee replacements are challenging the 20% dissatisfaction rate often reported.

The ROSA® Knee System: Less deviations in post-operative gait compared to manual Total Knee Arthroplasty

Reference:

A. G. Salvi; P. Valpiana; B. Innocenti; S. Ghirardelli; M. Bernardi; G. Petralia; G. Aloisi; K. Zepeda; C. Schaller; P. F. Indelli. (2024). **The Restoration of the Prearthritic Joint Line Does Not Guarantee the Natural Knee Kinematics: A Gait Analysis Evaluation Following Primary Total Knee Arthroplasty.** Arthroplasty Today, 30:101586. doi: [10.1016/j.artd.2024.101586](https://doi.org/10.1016/j.artd.2024.101586)

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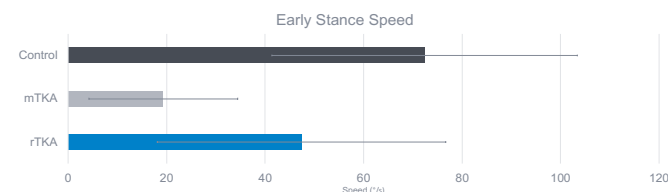
01 Study Design

A retrospective, gait analysis study of patients who received either robotic total knee arthroplasty (rTKA) or manual instrumented TKA (mTKA).

- rTKA: n=12
 - Surgical technique: Restricted kinematic alignment.
 - Implant: cemented Persona® Medial Congruent (Persona MC) Knee System.
- mTKA: n=12
 - Surgical technique: unrestricted kinematic alignment.
 - Implant: medial pivot (GMK® Sphere, Medacta International).
- Healthy Control: n=12
 - Compared to the rTKA and mTKA cohorts, the control group was younger, predominantly female, and tended to have a lower BMI.
- Gait analysis was conducted at minimum nine months post-operative.

02 Key Findings

- The presence of weight acceptance, as a measure of the load response, during the stance phase was more prevalent in controls (54.5%) and rTKA patients (36.4%) compared to mTKA patients (9.1%).
- rTKA patients were less likely to lose the natural knee flexion pattern compared to mTKA patients, though the difference did not reach statistical significance.
- Early stance speed was greater in the rTKA compared to mTKA cohort.
- rTKA patients displayed a more efficient transition between double support and single stance phase compared to mTKA patients.
- There were no differences between rTKA and mTKA for knee Range of Motion (ROM) during stance or swing phase, walking speed, step length, trunk lean or center of gravity.



03 Clinical Significance

Restricted kinematic alignment with ROSA Knee is associated with less deviation in knee kinematics during the loading and early stance phases of gait compared with an unrestricted manual TKA in the early post-operative period.

The ROSA® Knee System: Eight steps for performing Inverse Kinematic Alignment

Reference:

Eijking, H.M., Dorling, I., van Haaren, E. et al. **Image-based robotic (ROSA® knee system) total knee arthroplasty with inverse kinematic alignment compared to conventional total knee arthroplasty.** J Orthop Surg Res 20, 47 (2025).

<https://doi.org/10.1186/s13018-024-05427-y>

Study was funded by Zimmer Biomet

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01 Study Design

A randomized, controlled trial protocol investigating patient-reported outcomes, adverse events, and implant survival between the ROSA® Knee System (raTKA) and conventional total knee arthroplasty (cTKA).

- cTKA patients will receive mechanically aligned TKAs.
- Alignment in raTKA patients will be performed with Inverse Kinematic Alignment (iKA).
- The iKA strategy involves an eight-step technique that prioritizes:
 - Gap balancing in both knee flexion and extension, with slight lateral laxity in flexion
 - Mid-flexion stability
 - Functional knee alignment
 - Restoration of the joint-line orientation and posterior condylar offset
 - Preservation of patella height
 - Minimal soft tissue releases, with consideration for necessary adjustments during surgery

02 Key Findings

The eight steps for iKA include:

1. Setting the tibial slope with a goal of replicating the native slope, with specific limits (e.g., 0-10 degrees), depending on implant used.
2. Aligning the tibia in varus/valgus, matching the Medial Proximal Tibial Angle (MPTA) and allowing for varus deviation within set limits, while limiting valgus deviation in knees with correctable valgus deformities.
3. Determining femoral rotation with a maximum of 5 degrees external rotation.
4. Matching medial posterior resection to the total component thickness, aiming for 9 mm resection.
5. Aligning tibia resection level to accommodate total implant thickness.
6. Refining femur alignment in varus/valgus to achieve balanced gap extension and adjusting the distal femur resection level for uniform gap balance. Then fine-tuning the tension of the medial collateral ligament (MCL), especially in extension, to achieve optimal soft tissue balance.
7. Limiting distal femur resection to 9 mm, with special considerations for extensions deficits or hyperextensions.
8. Adjusting femur size to a stylus height between 0 and 0.5 mm, while limiting femoral flexion between 2-4°.

03 Clinical Significance

This study protocol presents a detailed algorithm to perform Inverse Kinematic Alignment with the assistance of the ROSA Knee System with minimal alterations to standard surgical workflow.

The ROSA® Knee System: High Variability in Soft Tissue Laxity During Total Knee Arthroplasty

Reference:

Weiner TR, Shah RP, Neuwirth AL, Geller JA, Cooper HJ. **Soft tissue laxity is highly variable in patients undergoing total knee arthroplasty.** *Arthroplasty.* 2024;6(1):45. Published 2024 Aug 7.

[doi:10.1186/s42836-024-00268-w](https://doi.org/10.1186/s42836-024-00268-w)

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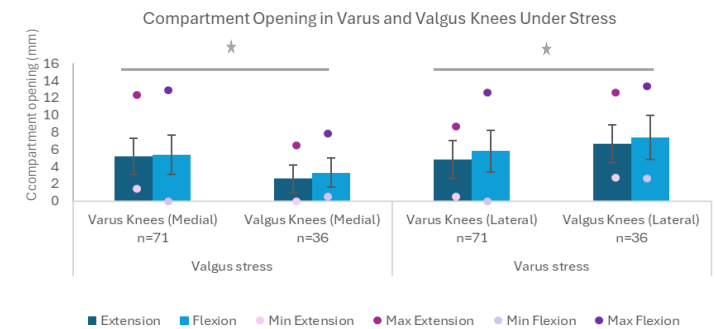
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01 Study Design

- A single institution retrospective study evaluating pre-operative deformity data and assessing intra-operative maximal medial and lateral opening during dynamic stress tests in flexion (85–95°) and extension (-5–20°) using the ROSA® Knee System in Total Knee Arthroplasty (TKA) patients.
- n=113
 - Pre-operative varus deformity n=71
 - Pre-operative valgus deformity n=36
 - Neutral pre-operative alignment n=6

02 Key Findings

- Valgus stress opened the medial compartment by 4.3 mm in extension and 4.6 mm in flexion (average across all knees).
- Varus stress opened the lateral compartment by 5.4 mm in extension and 6.2 mm in flexion (average across all knees).
- Soft tissue laxity showed high variability (0–13 mm).



*Statistical significance based on comparisons between varus and valgus knees under stress conditions

03 Clinical Significance

Soft tissue laxity in TKA varies widely (0–13 mm) and has limited predictability based on pre-operative deformity. The ROSA Knee System enables real-time, intra-operative assessment that may help surgeons adopt a “patient-specific” approach to better anticipate bone resections and soft tissue releases to optimize gait balance.

The ROSA® Knee System: Key Predictors for Deep Medial Collateral Ligament (MCL) Release in Total Knee Arthroplasty

Reference:

Thongpulsawasdi, N., Achawakulthep, C., Intiyanaravut, T. et al. **Predictive factors for deep medial collateral ligament release in adjusted mechanical alignment total knee arthroplasty.** J Orthop Surg Res 19, 594 (2024).

<https://doi.org/10.1186/s13018-024-05046-7>

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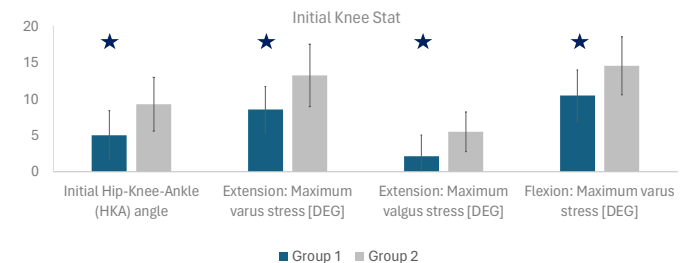
01 Study Design

A retrospective study examining the correlation between pre-operative factors, initial knee conditions, and the need for deep medial collateral ligament (MCL) release in adjusted mechanical alignment with ROSA® Knee for total knee arthroplasty (TKA).

- n= 61.
- Patients were divided into two groups:
 - Without soft tissue release (group 1): n=29.
 - With soft tissue release (group 2): n=32.
- Soft tissue release was performed when clinically indicated.

02 Key Findings

- 52% of patients (32/61) required deep MCL release.
- Patients in group 1 had lower pre-operative hip-knee-ankle (HKA) angles, less varus alignment in stress tests and a greater range of motion during flexion vs. group 2.



* Significantly different from Group 2.

- There were no significant differences between the groups in femoral component position and post-operative soft tissue laxity during stress tests.
- A pre-operative HKA of 6.25 degrees or greater was predictive of the need for soft tissue release.

03 Clinical Significance

The study emphasizes the role of the initial HKA angle and stress tests with ROSA Knee in predicting deep MCL release during TKA, with the HKA angle threshold helping to reduce unnecessary soft tissue release.

The ROSA® Knee System: Assessing and Classifying Intra-operative Knee Laxity

Reference:

Kenanidis, E., Milonakis, N., Maslaris, A. et al. **Robotic evaluation of articular laxity (REAL) classification: a new intraoperative knee soft-tissue laxity classification using ROSA robotic software.** Eur J Orthop Surg Traumatol 35, 139 (2025).

<https://doi.org/10.1007/s00590-025-04265-w>

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01 Study Design

A two-phase study evaluating the ROSA Knee System for categorizing intra-operative knee laxity in imageless robotic-assisted total knee arthroplasty (ra-TKA).

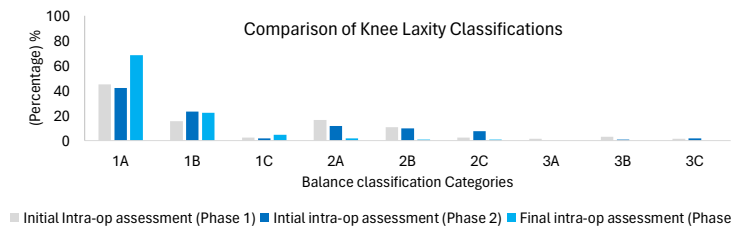
- Phase 1 (N=120):** Medial and lateral knee laxity were measured in both extension and 90° flexion. The difference of these values was used to form a new classification system.
 - Laxity was categorized into three groups based on a standard deviation of about 2.5 mm
 - Mild: Medial/Lateral difference < 2.5 mm
 - Moderate: Medial/Lateral difference 2.5 mm – 5 mm
 - Severe: Medial/lateral difference > 5 mm
- Phase 2 (N=102):** Validated the classification by assessing knee laxity before and after surgery.

02 Key Findings

- The combination of extension and flexion categories resulted in nine distinct knee laxity phenotypes:

Extension Category	Flexion Category A (<2.5 mm)	Flexion Category B (2.5–5 mm)	Flexion Category C (>5 mm)
1 (<2.5 mm)	1A	1B	1C
2 (2.5–5 mm)	2A	2B	2C
3 (>5 mm)	3A	3B	3C

- In phase 2, 93% of patients had a “balanced knee” (1A) or “almost balanced knee” (2A, 1B respectively).



03 Clinical Significance

The study identified nine intra-operative knee laxity patterns, highlighting ROSA Knee’s ability to assess soft-tissue balance intra-operatively.

The ROSA® Knee System: Highly Accurate Resection Thickness in vivo

Reference:

Gamie, Z., Kenanidis, E., Douvli, G., Milonakis, N., Maslaris, A. and Tsiridis, E. (2024), **Accuracy of the Imageless Mode of the ROSA Robotic System for Targeted Resection Thickness in Total Knee Arthroplasty: A Prospective, Single Surgeon Case-Series Study.** Int J Med Robot, 20: e70029.

<https://doi.org/10.1002/rcs.70029>

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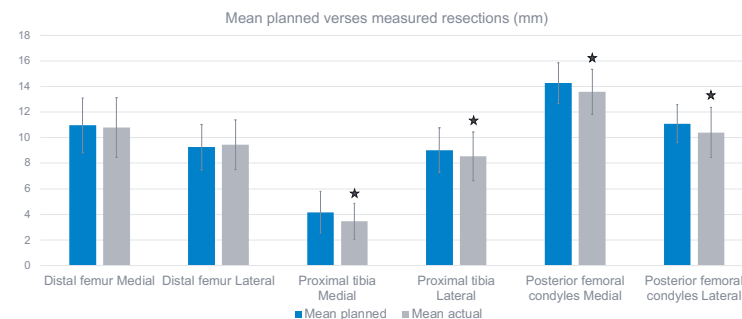
01 Study Design

A single-surgeon, single-center prospective cohort study investigating the accuracy of bone resection depth with the ROSA® Knee System in total knee arthroplasty (TKA).

- N=44 patients indicated for TKA with primary osteoarthritis diagnosis.
- All TKAs performed were imageless.
- Resected bone from the medial and lateral aspect of 3 regions (distal femur, proximal tibia, posterior femoral condyles) were measured with calipers and compared to the intra-operative plan.

02 Key Findings

- The mean difference between planned and measured resection thickness ranged from 0.67 mm to 1.1 mm for all six measured parameters.
- Resection accuracy was greatest in the distal femur and least in the posterior femoral condyles.
 - Medial and lateral mean difference of 0.67 and 0.94 mm, with 84.1% and 77.% of resection differences less than 1 mm, respectively.
 - Medial and lateral mean difference of 1.1 and 1.04 mm, with 56.8% and 65.9% of resection differences less than 1 mm, respectively.



* Significantly different from planned resection.

03 Clinical Significance

The ROSA Knee System achieves precise bone resections in patients undergoing primary total knee arthroplasty.

The ROSA® Knee System: Excellent Knee Function in Patients with Severe Extra-articular Deformities

Reference:

Eu WC, Yuik Ho JP, Kunalan G. **Functional alignment is a feasible alignment strategy in robotic assisted total knee arthroplasty for knee osteoarthritis with extra-articular deformity - A case series.** SICOT J. 2025;11:2.

doi: [10.1051/sicotj/2024059](https://doi.org/10.1051/sicotj/2024059).

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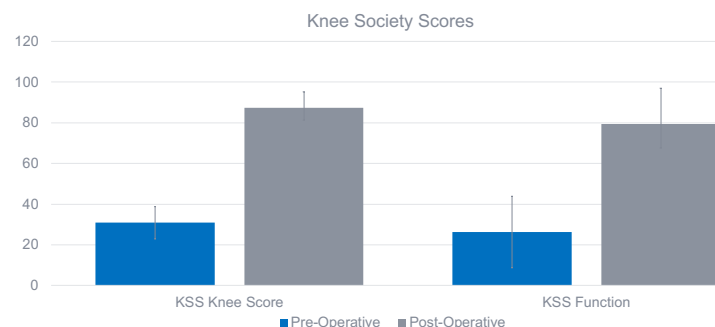
01 Study Design

A retrospective, single cohort analysis of osteoarthritic patients with extra-articular deformities secondary to fracture malunion who received ROSA® Knee total knee replacement (rTKA) and a functional alignment technique.

- **N = 8.**
- Mean pre-operative coronal femur and tibial deformities were 18.8° and 11.2° varus, respectively.
 - One patient presented with a 15° valgus femoral deformity.
 - A second presented with an 8.3° valgus tibial deformity.
- Mean pre-operative sagittal femur and tibial deformities were 12.3° and 6.7° varus procurvatum, respectively.
- Radiographic, range of motion (ROM), and Knee Society Scores were collected pre-operatively through one-year follow-up.

02 Key Findings

- The hip-knee-ankle angle (HKA) was corrected from 17.6° varus to 5.2° varus post-operative.
 - Patients with valgus deformity HKA were corrected from 21° pre-operative to 2.5° valgus post-operative.
- Flexion and extension ROM significantly improved by approximately 20° and 10°, respectively.



03 Clinical Significance

Functional alignment with ROSA Knee can restore lower limb alignment approaching the native knee and producing satisfactory outcomes in TKA patients with extra-articular deformities.

The ROSA® Knee System: Similar Learning Curve Between ROSA Knee and Mako Knee

Reference:

Kang LB, Jeong S, Lee JW, et al. **Comparison of learning curves and short-term outcomes: ROSA versus MAKO robotic-assisted total knee arthroplasty.** *Curr Orthop Pract.* 2025;36(2):e1285.

[doi:10.1097/BCO.0000000000001285.](https://doi.org/10.1097/BCO.0000000000001285)

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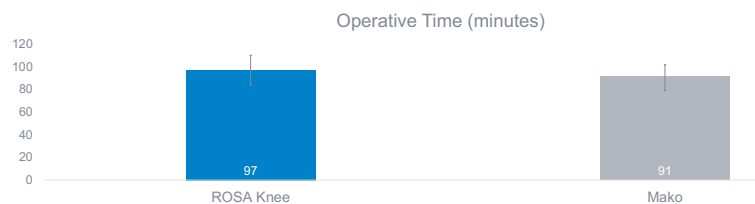
01 Study Design

A single-surgeon, retrospective review comparing learning curves and clinical outcomes between the ROSA® Knee System and Mako Total Knee.

- ROSA Knee System (n=95).
- Mako Total Knee (n=115).
- Patient demographics, operative data, and post-operative complications were collected.
- The following patient-reported outcomes (PROs) were assessed and collected pre-operatively and at six months and one-year post-operatively:
 - Oxford Knee Score
 - SF-12 Version 1
 - Knee Injury and Osteoarthritis Outcome Score for Joint Replacement
- Steady state is the average manual total knee arthroplasty (TKA) operative time of the surgeon.

02 Key Findings

- Steady state was reached at nine cases in the ROSA Knee System and six cases with the Mako robotic-arm.
- Operative time was significantly longer in the ROSA Knee compared to Mako cohort.
 - Variations in operative time may be due to the location of the surgeries, with longer times observed in ambulatory surgery centers (ASCs) compared to hospitals; 35% of ROSA Knee cases were performed in ASCs, while all Mako cases took place in hospitals.



- There were no significant differences in PROs, 90-day complications or all-cause revisions.
- Significantly more ROSA Knee patients were discharged to homes compared to Mako (66.3% vs. 22%).

03 Clinical Significance

Both the ROSA Knee System and Mako Total Knee exhibit minimal learning curves of nine and six cases, respectively, with no significant differences in post-operative outcomes at one-year post-surgery.

The ROSA® Knee System: Excellent Limb Alignment in Moderate to Severe Valgus Deformity

Reference:

Ang CPT, Ganthe K, Ho JPY, Devi K, Cheong JKY. **The utility of robotic-assisted surgery in total knee arthroplasty for moderate and severe valgus deformities: a case series.** J Orthop Surg Res. 2025;20(1):145. Published 2025 Feb 7.

[doi:10.1186/s13018-024-05443-y](https://doi.org/10.1186/s13018-024-05443-y)

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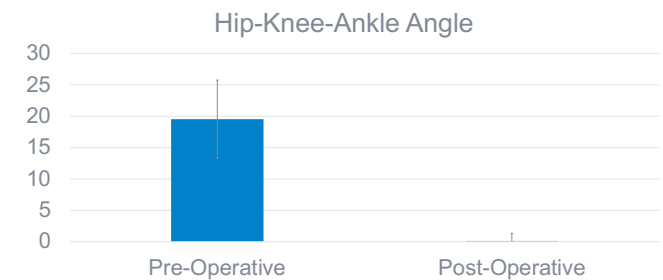
01 Study Design

A single-surgeon case series in patients with moderate to severe valgus deformities undergoing robotic-assisted total knee arthroplasty (raTKA).

- N=14
- Valgus deformity was graded based on the hip-knee-ankle angle (HKA).
 - Moderate: 10-20° valgus
 - n=10
 - Severe: >20° valgus
 - n=4
- The surgeon planned to restore the HKA to within 3° of neutral.
- Range of motion was assessed pre- and immediately post-operative from ROSA Knee logs.
- Satisfaction and the Forgotten Joint Score (FJS) were assessed at one-year post-operative.

02 Key Findings

- The mean pre-operative HKA was 19.5° (range: 11° to 34.9°) and was restored to within 3° of neutral in all patients.
- Flexion ROM improved from 108.2° to 119.3° post-operative.
- Only one patient required a constrained protheses.
- The FJS improved by an average of 89.9 points, and all patients achieved the Patient Acceptable Symptom State (minimum 77.1 points) at one-year post-operative.
- At one year follow-up, 100% of patients were satisfied with their TKA.



03 Clinical Significance

This small case series of moderate to severe valgus deformities demonstrated that raTKA can be used to achieve neutral alignment (within 3°) with high levels of patient satisfaction at one-year follow-up.

The ROSA® Knee System: Significant Reduction in Operative Time After 10 Cases

Reference:

Petrillo S, Moretti G, Bordignon N, Romagnoli S. **Rapid reduction in surgical time and high level of accuracy in alignment and femoral component size prediction in robotic-assisted total knee arthroplasty with ROSA Knee System.** J Exp Orthop. 2025; 12:e70148.

<https://doi.org/10.1002/jeo2.70148>

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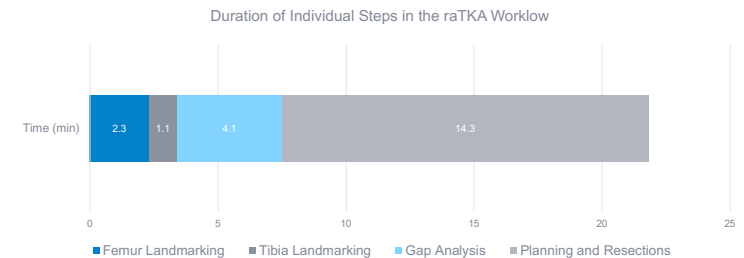
01 Study Design

A single-surgeon, retrospective analysis of the learning curve and implant sizing accuracy of the ROSA® Knee System in robotic-assisted total knee arthroplasty (raTKA).

- N=54
 - All patients received a Persona® The Personalized Knee® System (fully cemented, CR femur, UC polyethylene) retaining implant.
- Follow-up: 9 months.
- Total operative time (TOT, incision to closure) and total robotic time (TRT, landmark to bone cuts) were analyzed with cumulative sum analysis (CUSUM).
- Individual steps in the raTKA workflow were assessed.
- Planned and post-operative hip-knee-ankle angle (HKA) was also compared.

02 Key Findings

- CUSUM analysis of TOT revealed a learning curve of 10 cases, based upon the inflexion point.
- Significant differences were found for TOT between the learning phase (62.6 ± 7.9 min) and the proficiency phase (49.9 ± 8.1 min).
- Proficiency was achieved in TRT following 30 cases.
 - TRT comprised approximately 42% of the TOT, with planning and resections comprising approximately 65% of the TRT.
- Femoral component size prediction was accurate in 92.6% of cases, and 100% of cases were within 2 sizes of the prediction.
- The mean absolute difference between planned and post-operative HKA was 1.1° .



03 Clinical Significance

The ROSA Knee System has a rapid initial learning curve (10 cases), with proficiency being achieved after 30 cases. The system is accurate in implant size prediction and its ability to achieve the planned alignment.

Exceeding National Institute for Occupational Safety and Health (NIOSH) guidelines for Noise Levels in Total Knee Arthroplasty (TKA), Mako SmartRobotics™ can.

Reference:

Pagan, D. N., Cruz-Ossa, N., Cade, W., D'Apuzzo, M. R., Carvajal, J. A., & Hernandez, V. H. (2025). **Noise-Related Injury During Robotic Versus Manual Total Knee Arthroplasty.** The Journal of Arthroplasty.

doi.org/10.1016/j.arth.2025.02.022

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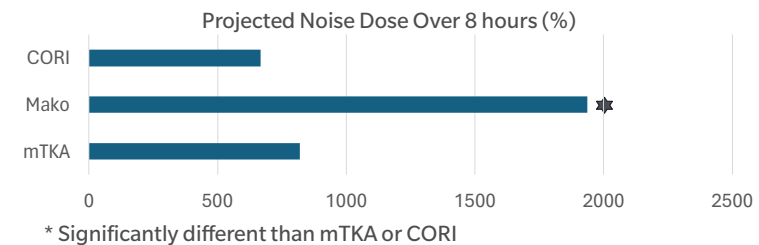
01 Study Design

A three-surgeon, single-center, study comparing surgeon noise exposure during total knee arthroplasty (TKA) between manual (mTKA) and two robotic-assisted (raTKA) TKA platforms.

- Noise metrics compared: maximum & average decibels (dBs), projected noise dose over 8 hours, and time-weight average noise (TWA).
 - Noise doses are reported as percent maximum allowable noise per day.
- TWA was also compared to the NIOSH guideline of a maximum of 85 dBs as an 8-hour TWA.
- mTKA: n=20
- Mako (raTKA): n=21
- CORI (raTKA): n=25

02 Key Findings

- The mean average dB level was significantly greater for Mako compared to mTKA or CORI (97.6 dB vs. 92.7 dB and 92.7 dB, respectively).
- The mean noise dose was significantly greater in Mako compared to mTKA or CORI (235.7% vs. 114.1% and 83.6%, respectively).
- The mean TWA was significantly greater in Mako compared to mTKA or CORI (88.3 dB vs. 83.8 and 82.8 dB, respectively).
- Only Mako exhibited mean TWA noise exposure levels above NIOSH guidelines.
- The projected noise dose over 8 hours was also significantly greater in Mako compared to mTKA or CORI.



03 Clinical Significance

Noise levels in some raTKA systems exceed recommended safety guidelines.

The ROSA® Knee System: Reduced Soft Tissue Releases and Larger Reduction in Early Post-Operative Pain

Reference:

Clapp IM, Braathen DL, Blackburn BE, Archibeck MJ, Peters CL, **Robotic-Assisted Primary Total Knee Arthroplasty Requires Fewer Soft-Tissue Releases and is Associated with a Larger Reduction in Early Postoperative Pain**, The Journal of Arthroplasty (2025).

doi: <https://doi.org/10.1016/j.arth.2025.02.066>.

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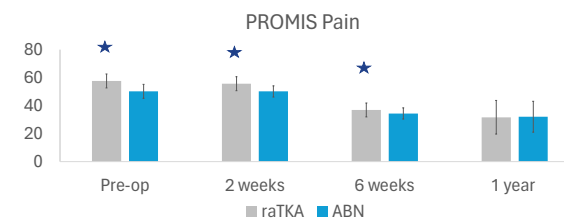
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01 Study Design

- A retrospective study comparing functional outcomes and soft tissue release rates in primary TKA using raTKA (robotic-assisted total knee arthroplasty), CONV (conventional instrumentation), and ABN (accelerometer-based navigation).
- N= 2,338
 - CONV: n=1,216
 - ABN (iAssist®): n=724
 - raTKA (ROSA® Knee): n=398
- PROMIS (Patient-Reported Outcomes Measurement Information System), KOOS, JR (Knee Injury and Osteoarthritis Outcome Score, JR), and pain scores were collected at 2 weeks, 6 weeks, and 1 year post-operatively.

02 Key Findings

- Soft tissue releases (p<0.05):
 - raTKA: 29.9%
 - ABN: 74.4%
 - CONV: 47.9%
- Medial releases in varus knees (p<0.05):
 - raTKA: 19.9%
 - ABN: 68.8%
 - CONV: 46.3%
- Lateral releases in valgus knees (p<0.05):
 - raTKA: 33.7%
 - ABN: 46.6%
 - CONV: 61.6%
- The raTKA cohort showed a greater pain reduction (4.5 points) by 6 weeks post-operative.



*Significantly different than ABN

- The raTKA cohort “had a significantly greater increase in KOOS, JR scores from the pre-operative to 6 weeks post-operative.”
- No differences were observed in PROMIS at any time-point.

03 Clinical Significance

Fewer soft tissue releases and greater short-term pain reduction with raTKA compared to CONV and ABN TKA.

The ROSA® Knee System: Evaluating the Initial Learning Curve for Robotic-assisted Total Knee Arthroplasty (TKA)

Reference:

Neira I, Llopis R, Cuadrado L, et al. **Analysis of the Initial Learning Curve for Robotic-Assisted Total Knee Arthroplasty Using the ROSA® Knee System.** J Clin Med. 2024;13(11):3349. Published 2024 Jun 6.

[doi:10.3390/jcm13113349](https://doi.org/10.3390/jcm13113349). 2025.02.003

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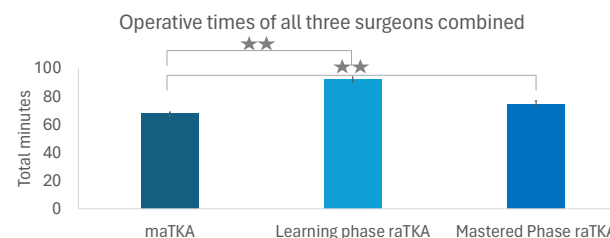
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01 Study Design

- A prospective, single-center study examined the learning curve of raTKA (robotic-assisted total knee arthroplasty) using the ROSA® Knee System across three surgeons vs. maTKA (manual TKA).
- n= 180
 - raTKA n=90.
 - maTKA n=90.
- Surgeon 1: >15 years of maTKA experience.
 - Conducted all maTKAs
 - Participated in all raTKAs.
- Surgeons 2 and 3: <5 years of maTKA experience.
- Learning curve was estimated using the cumulative summation analysis (CUSUM).

02 Key Findings

- CUSUM analysis revealed learning curves of:
 - 43 cases for surgeon 1.
 - 61 cases for all participating surgeons.
- raTKA had longer operative times (86.0 minutes) vs. maTKA (67.5 minutes).
- Operative times for the experienced surgeon in maTKA and the mastered phase of raTKA were similar (p=0.087).



*Statistically significant differences

- The study was limited by:
 - Operative times may have been influenced by procedural dynamics, where two surgeons handled different steps and the lack of pre-surgical cadaveric training due to COVID-19 lockdowns.

03 Clinical Significance

The learning curve for ROSA Knee System varies based on the surgeon's prior experience with manual TKA. Experienced surgeons can expect a return to manual TKA operative times following the initial learning curve.

The ROSA® Knee System: Automated Femoral Rotation Enhances Knee Function

Reference:

Hohmann AL, Leipman JH, Dipane MV, et al. **Automated versus Manual Femoral Component Rotation Planning in Robotic-Assisted and Conventional Total Knee Arthroplasty: A Retrospective Comparison.** The Journal of Arthroplasty. Published online March 9, 2025.

[DOI: 10.1016/j.arth.2025.03.009](https://doi.org/10.1016/j.arth.2025.03.009)

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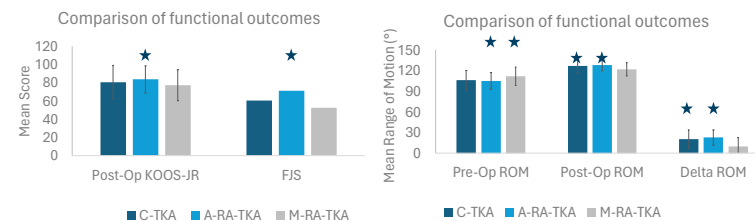
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01 Study Design

- Multi-center, retrospective study.
- TKA with:
 - Automated femoral rotation planning in robotic-assisted total knee arthroplasty (A-RA-TKA, n=152).
 - Manual femoral rotation planning with gap balancing algorithm and RA-TKA (M-RA-TKA n=111).
 - Conventional TKA (C-TKA) with measured resection (n=108).
- Intra-operative laxity and component rotation, association with outcome measures, including range of motion (ROM), KOOS-JR, and Forgotten Joint Score (FJS).

02 Key Findings

- Automated femoral rotation in RA-TKA associated with higher FJS, improved ROM, and better KOOS, JR scores vs. manual RA-TKA and conventional TKA.



- M-RA-TKA had a significantly higher incidence of excessive femoral internal rotation (>4.5°).
- Intercompartmental gaps were larger in manual RA-TKA in flexion and extension
- Femoral rotation was significantly lower in A-RA-TKA (1.00°) compared to M-RA-TKA (4.27°)
- Manual femoral rotation planning was associated with significantly lower ROM improvement.

03 Clinical Significance

- A-RA-TKA femoral rotation planning using ROSA Knee enhanced objective and subjective functional outcomes compared to C-TKA and M-RA-TKA.

The ROSA® Knee System: Addressing Flexion Contracture Intra-Operatively

Reference:

Hishimura R, Iwasaki K, Suzuki Y, et al. **Elucidation of the association between additional distal femoral resection and extension angle improvement following the actual surgical steps with the Robot-TKA system.** *Knee.* 2024;49:36-44.

[doi:10.1007/s00402-025-05844-6](https://doi.org/10.1007/s00402-025-05844-6).

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01 Study Design

A single-center prospective study assessed how additional distal femoral resection affected knee extension using the ROSA® Knee System in total knee arthroplasty (TKA).

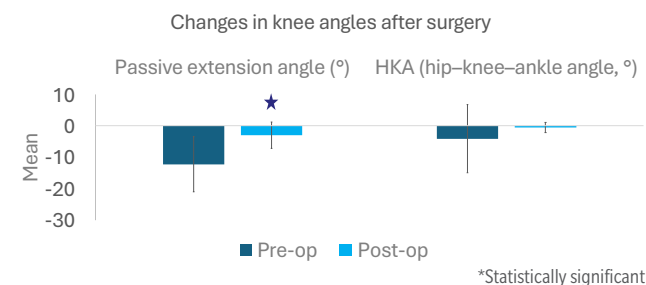
N=11

Extension angles were measured pre- and post-operatively, with distal femoral resection guided by trial insert thickness and robotic-assisted knee range of motion (ROM) assessment.

- Initial resection plan:
 - > 10° contracture: 9.0 mm resected.
 - < 10° contracture: 7.0 mm resected.
- Coronal alignment targets:
 - Femoral and tibial component: 90°.
- Sagittal alignment targets:
 - Femoral component: 0°, tibial: 87°.

02 Key Findings

- Each additional 1.0 mm of distal femoral resection improves knee extension by 2.0° (SE 0.6°), within a range of 1.0–3.3 mm.
- Post-operative evaluation showed a significant reduction in flexion contracture:



- Implant Alignment:
 - Coronal plane: Mean 89.3° (±1.2°) femur, 89.3° (±0.9°) tibia.
 - Sagittal plane: Mean 2.2° (±0.6°) femur, 87.7° (±0.9°) tibia.
 - No outliers deviated more than 3.0° from the planned angle.

03 Clinical Significance

Assessing intra-operative extension ROM with ROSA Knee allowed for precise distal femoral resections, showing that each additional 1 mm of distal femoral resection may improve knee extension by 2° in patients with flexion contracture.

The ROSA® Knee System: Efficiency Improves with Experience

Reference:

Braathen, D. L., Wallace, C., Clapp, I. M., Blackburn, B. E., Peters, C. L., & Archibeck, M. J. (2025).

Improved Efficiency and Intraoperative Planning With 1 Robot-Assisted Total Knee Arthroplasty System. *Arthroplasty Today*, 33, 101684.

doi.org/10.1016/j.artd.2025.101684

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01 Study Design

A retrospective, single high-volume institution, two-surgeon, study evaluating improvements in efficiency following adoption of the ROSA Knee System with Persona® Knee.

- N=150
 - First 75 cases by each surgeon
- All cases were imageless with functional alignment
- The operating team remained constant for all cases
- Total operating time was recorded as inflation of the tourniquet to removal.
- The following time metrics were collected from ROSA logs:
 - Knee evaluation time
 - Landmarking time
 - Planning time
 - Femoral and tibial cut time

02 Key Findings

- Operating time significantly decreased between the surgeon's first 20 cases compared to the final 20 cases (61.4±8.9 vs. 56.7±8.6 min).
- Improvements in planning time were the greatest contributor to the reduced operating times.
 - Improved knee state evaluation times also contributed to improved efficiency; however, the difference between the first and last 20 cases was not statistically significant.

03 Clinical Significance

The technical steps in the ROSA Knee System workflow quickly translate from previous techniques, and reductions in operating time over the first 75 cases are primarily driven by improvements in intra-operative planning efficiency.

The ROSA® Knee System: Two° External Rotation Minimizes Femoral Overstuffing

Reference:

Maslaris A, Kenanidis E, Mylonakis N, et al. **External femoral rotation of 2 degrees is associated with the lowest stuffing rates around the femur in functionally aligned TKA.** Knee Surg Sports Traumatol Arthrosc. Published online March 28, 2025.

[doi:10.1002/ksa.12662](https://doi.org/10.1002/ksa.12662)

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01 Study Design

A single-center prospective study evaluated the influence of femoral rotation on over and understuffing using intra-operative alignment data from the ROSA® knee system following total knee arthroplasty.

N=69

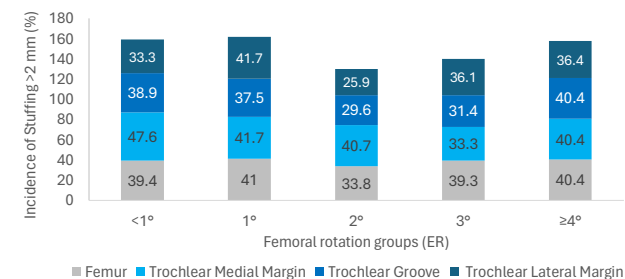
All patients received robotic-assisted tibial-based functional alignment.

Stuffing was assessed in the medial, central, and lateral compartments at five anatomical locations:

- Anterior trochlea (AT)
- Oblique trochlea (OT)
- Distal condyles (DC)
- Posterior condyles (PC)
- Tibia (TIB)

02 Key Findings

- 2° external femoral rotation with tibia-based functional alignment led to the lowest incidence of femoral overstuffing (>2 mm and ≥4 mm).



- Femoral rotation ($3.8^\circ \pm 2.6^\circ$) influenced anterior ($r = -0.40$) and posterior ($r = 0.71$) stuffing to a greater extent than the oblique or distal portion of the trochlea.

03 Clinical Significance

Functional alignment with two degrees of external femoral rotation with the ROSA Knee System resulted in the lowest rates of femoral overstuffing.

The ROSA® Knee System: Robotic vs. Manual Sagittal Alignment Definitions

Reference:

An, H.-M., Wen, J.-X., Gu, W., Chen, J.-Y., Chai, W., & Li, R. (2024). **Discrepancies in sagittal alignment of the lower extremity among different brands of robotic total knee arthroplasty systems.** The Journal of Arthroplasty, 39(9), 2248–2253.

<https://doi.org/10.1016/j.arth.2024.03.029>

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01 Study Design

The study aimed to compare the lower extremity sagittal alignment among seven robotic total knee arthroplasty (TKA) systems available in China.

N=72

- System 1: Mako® Knee
- System 2: Cori Surgical
- System 3: Rosa® Knee System
- System 4: Hurwa Robot-Assisted TKA
- System 5: Yuanhua-TKA
- System 6: Skywalker Robotic
- System 7: Arthrobot Knee

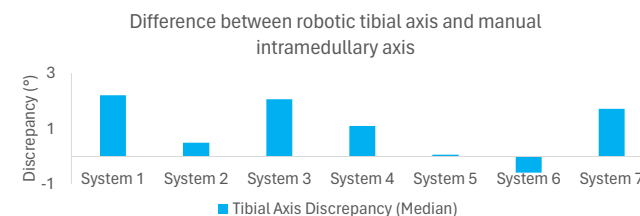
Alignment Measurement:

- Femoral axis: Defined as the centerline of the distal femoral medullary canal (same for all systems).
- Tibial axis: Defined differently across systems, but all systems aligned the tibial knee center with the ankle center.

The intramedullary axis was chosen to mimic the manual TKA intramedullary canal and was used as the baseline to compare how each robotic system aligned the knee.

02 Key Findings

- Femoral alignment:
 - Robotic femoral axes deviated by 2.41° (1.58°, 3.38°) from the intramedullary axis.
- Tibial alignment:
 - Six systems created a more flexed tibial axis, decreasing the posterior tibial slope.
 - One system (System 6) produced a more extended tibial axis, indicating an increased posterior tibial slope compared to the manual reference.



03 Clinical Significance

Surgeons accustomed to using the intramedullary axis may experience deviations when switching to a robotic system and should ensure consistency in selecting the appropriate landmarks.

The ROSA® Knee System: Similar Operative Time to Conventional TKA

Reference:

Barahona M, Bustos F, Hinzpeter J, et al. (May 14, 2025) Evaluation of the Learning Curve in Robotic-Assisted Total Knee Arthroplasty: A Time-Series Analysis of Surgical Time. Cureus 17(5): e84120. doi:10.7759/cureus.84120

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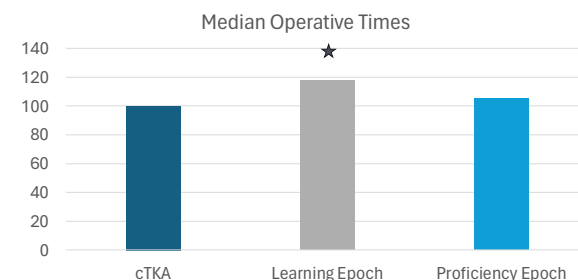
01 Study Design

A prospective, time-series analysis evaluating the efficiency and safety of the ROSA® Knee System over a single, low volume (~ 30 TKA/year) surgeon's first 50 cases.

- A Markov-switching model was used to identify the learning and proficiency epochs with ROSA Knee
- Skin-to-skin operative time was compared between conventional TKA and the ROSA Knee learning and proficiency epoch.
- Adverse events were collected through 60-days post-operative.
- cTKA (conventional total knee arthroplasty): n=75
- raTKA (robotic-assisted total knee arthroplasty): n=50

02 Key Findings

- The transition from learning to proficiency epoch occurred at the 21st case.
- Operative time for raTKA was significantly less in the proficiency (105 min) compared to learning (118 min) epoch.
- Operative time was similar between cTKA (100 min) and the proficiency epoch of raTKA.
- No severe adverse events were observed through 60-days post-operative.



★ Significantly different from cTKA and proficiency epoch

03 Clinical Significance

Lower volume surgeons can achieve operative times with the ROSA Knee System comparable to conventional TKA in as few as 20 cases.

ROSA® Knee System: No Learning Curve for Achieving Pre-Operative Plan

Reference:

Druel J, Claudel S, Fabre-Aubrespy M, et al. **Learning curve of robotic assisted total knee arthroplasty within a surgical team: A prospective study of 115 cases.** Orthop Traumatol Surg Res. Published online June 30, 2025. doi:10.1016/j.otsr.2025.104325

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01 Study Design

A single-center, retrospective study evaluating the learning curve and influence of surgeon experience to achieve the pre-operative plan with the ROSA® Knee System.

- Four TKA surgeons without robotic-assisted TKA experience performed the anatomic-functional implant positioning technique.
- N=115 (Full data was available for 101 cases)
- Knee Society Score (KSS) at one-year follow-up
- The learning curve was assessed via CUSUM analysis for:
 - Operative time
 - Gap balance
 - Planned vs. post-operative
 - Hip-knee-ankle (Δ HKA)
 - Coronal plane alignment of the knee change (Δ CPAK)
 - Joint line obliquity change (Δ JLO)

02 Key Findings

- A short learning curve of 11 cases was reported for operative time.
- The JLO was restored to native anatomy in 91% of cases and the Δ HKA was $2.0 \pm 1.0^\circ$.
- The ability to carry out the pre-operative plan was not influenced by experience with the ROSA Knee System.
 - No learning curve was identified for:
 - Gap balance
 - Δ HKA
 - Δ CPAK
 - Δ JLO
- Significant improvements in the Objective KSS score (~47 points) and KSS Functional score (~50 points) were not influenced by surgeon experience with the ROSA Knee System.

03 Clinical Significance

Surgeons without previous robotic experience can achieve proficiency in as little as 11 cases with the ROSA Knee System, without compromising accuracy or functional outcomes.

The ROSA® Knee System: Addressing Flawed Research Methods and Measurement Validity in Sagittal Accuracy

Reference:

Eggermont, E., Janssens, R., Ulrix, M. et al. **Sagittal accuracy and functional impact of tibial slope in imageless robotic-assisted Total Knee Arthroplasty.** International Orthopaedics (SICOT) (2025). <https://doi.org/10.1007/s00264-025-06472-w>

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01 Study Design

A single-center comparative study evaluating accuracy in applying tibial slope (TS) with the ROSA® Knee System (rTKA) vs manual techniques (mTKA).

- n= 82 (rTKA)
- n=110 (mTKA)
- Tibial slope was evaluated using a short lateral knee X-ray, measured relative to the posterior tibial cortex, with a target angle of 3°.

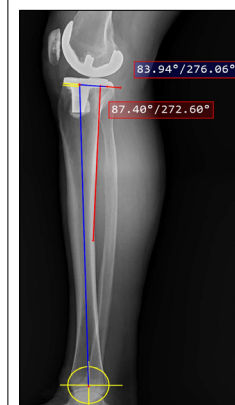
1. Zaidi F, Goplen CM, Fitz-Gerald C, Bolam SM, Hanlon M, Munro JT, Monk AP (2024). High in-vivo accuracy of a novel robotic-arm-assisted system for total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc.*
2. Yoo, Jae Ho et al. (2008). Anatomical References to Assess the Posterior Tibial Slope in Total Knee Arthroplasty: A Comparison of 5 Anatomical Axes. *The Journal of Arthroplasty*, Volume 23, Issue 4, 586 - 592
3. Ishii Y, Noguchi H, Sato J, Takahashi I, Ishii H, Ishii R et al (2022) Comparison of the tibial posterior slope angle between the tibial mechanical Axis and various diaphyseal tibial axes after total knee arthroplasty. *Arthroplasty Today* 17:137-141

02 Key Findings

- mTKA achieved a mean post-operative TS of $3.11^\circ \pm 2.12^\circ$, with 92.87% within 3° of the target. rTKA had a TS of $-0.11^\circ \pm 1.93^\circ$, with 56.63% within 3°.

Limitations

- The measurements used to assess slope do not match the methods used by the ROSA Knee System:
- Eggermont et al. assessed TS using the posterior tibial cortex (PTC).
 - Post-operative short lateral films limit the ability to identify the mechanical axis (MA).
 - Zaidi et al.¹ recognized this limitation and requested outliers return for long-leg films.
 - TS measurements can be off by a couple of degrees dependent upon the axis selected:
 - Yoo et al.² reported variations between the MA and the PTC of $2.9^\circ \pm 1.1^\circ$.
 - Ishii et al.³ found differences of more than 2° between different axes, the greatest difference being the PTC.
 - TS measures are more reliable when using the MA².



Mechanical Axis (Slope = 83.94°)
(consistent with the ROSA Knee System)

Posterior Tibial Cortex (Slope = 87.4°)
(consistent with standard short sagittal films by Eggermont et al.)

03 Clinical Significance

The use of short lateral knee X-rays and the PTC axis are inconsistent with the measure of tibial slope using the mechanical axis. Long-leg X-rays and assessing TS with the MA are necessary to accurately assess the precision of the ROSA Knee System in the sagittal plane.

The ROSA® Knee System: Evaluating Institutional Proficiency

Reference:

Gordon, M., Rivkin, G., Greenberg, A., Kandel, L., Liebergall, M., & Perets, I. (2025). **Robotic Guided Knee Arthroplasty-Group Learning Curve and Early Outcomes.** Arthroplasty Today, 34, 101746. doi.org/10.1016/j.artd.2025.101746

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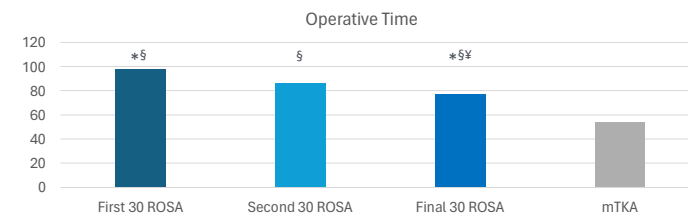
01 Study Design

A retrospective review evaluating the learning curve and early clinical outcomes of the first 90 institutional ROSA® Knee System cases performed by six high-volume surgeons.

- ROSA Knee cases were clustered chronologically into three groups of 30 patients.
- Operating time, range of motion (ROM), and complications through one-year follow-up were compared.

02 Key Findings

- Significant reductions in operative time were observed:
 - Surgeons were at different stages in the learning curve and contributed an unequal number of cases to the analysis.
 - Two of the six surgeons contributed zero cases to the first 30 institutional ROSA Knee cases.
 - Because of these limitations, caution should be taken when comparing between ROSA Knee and manual TKA
- ROM was no different between groups at six-weeks post-operative after controlling for differences in pre-operative ROM and surgeon.



*Significantly different than Second 30 ROSA; § Significantly different than mTKA; ¥ Significantly different than First 30 ROSA

03 Clinical Significance

Institutional proficiency with ROSA Knee continues to improve through the first 90 cases across multiple surgeons without an increased risk of complications.

The ROSA® Knee System: Accurate Distal Femoral Resurfacing

Reference:

Claudel S, Ollivier M, Fabre-Aubrespy M, et al. **Robotic anatomic-functional alignment total knee arthroplasty accurately resurfaces the distal femur and preserves joint line obliquity: A prospective 3D modelling study.** Knee Surg Sports Traumatol Arthrosc. Published online July 7, 2025. doi:10.1002/ksa.12772

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01 Study Design

A prospective, observational study evaluating metrics of anatomic-functional alignment with the ROSA® Knee System.

- N=100
- **Objective 1:** Achieve symmetrical (1-3 mm of laxity) medial and lateral gaps in extension, and asymmetrical (an additional 1.5 mm lateral laxity) gaps in flexion.
- **Objective 2:** Maintain joint line obliquity (JLO) by restoring the lateral distal femoral angle (LDFA) to 3° of varus or valgus.
- **Objective 3:** Restore the hip-knee-ankle angle (HKA) between 176° to 182°.
 - JLO and HKA were assessed with post-operative radiographs.
 - Femoral resurfacing was assessed with post-operative CT.

02 Key Findings

- The distal femoral articular surface was restored within 2.27 ± 1.60 mm.
- JLO was restored in 91% of cases.
- The mean absolute difference between targeted and post-operative HKA was $2.1^\circ \pm 1.8^\circ$.
- Slight laxity of the lateral joint in flexion was achieved in 85% of knees.
- Full gap balance in extension and flexion were achieved in 78% of varus knees and 69% of valgus knees.

03 Clinical Significance

The ROSA Knee System is a reliable tool for achieving the objectives of anatomic-functional alignment in total knee arthroplasty.

The ROSA[®] Knee System: Assessing the Dynamic HKA During Passive ROM Evaluations

Reference:

Qordja F, Valpiana P, Andriollo L, Rossi SMP, Salvi AG, Bocchino G, Zepeda K, Benazzo F, Indelli PF. **The HKA axis varies significantly with knee motion: A robot-assisted intraoperative evaluation during total knee arthroplasty supports the use of dynamic, not static, alignment classifications.** J Exp Orthop. 2025 Jul 18;12(3):e70370. doi: 10.1002/jeo2.70370.

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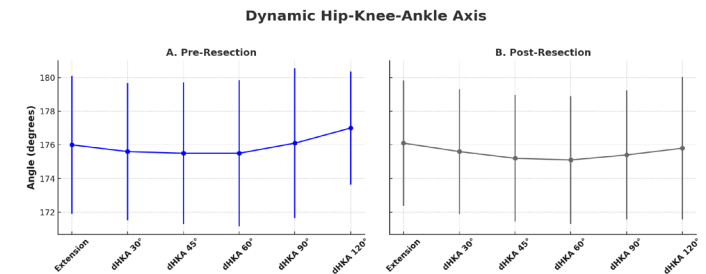
01 Study Design

A prospective, two-center study evaluating the relationship between radiographic static hip-knee-ankle axis (sHKA) and dynamic (dHKA) during flexion using the ROSA[®] Knee System.

- N=107
- Long leg coronal X-rays were taken pre-operatively and at six-weeks post-operative.
- dHKA was assessed with ROSA Knee at full extension and at 30°, 45°, 60°, 90°, and 120° of flexion pre-resection and post-resection during component trialing.
 - dHKA was compared between positions.
- Outliers were defined as pre- and post-resection dHKA >3° compared to the respective sHKA.

02 Key Findings

- Pre- and post-resection, the dHKA tended to decrease as flexion ROM increased through 60°.
- Pre-resection knees displayed a more pronounced trend for an increase in dHKA with flexion ROM exceeding 60° compared to post-resected knees.
- The frequency of dHKA outliers increased with increasing ROM through 120° in pre-resected knees and leveled off at 90° in post-resected knees.



03 Clinical Significance

The HKA varies from the standing, radiographic HKA throughout the intra-operative arc of ROM. The ROSA Knee system can detect dynamic HKAs intra-operatively.

The ROSA® Knee System: Addressing Flawed Radiographic Methods Assessing Sagittal Accuracy

Reference:

Aflatooni J., Winger A., Sullivan T., Brown T., Park, K. (2025). **Accuracy of Sagittal Plane Component Alignment in Robotic-Assisted Total Knee Arthroplasty**. *Arthroplasty Today*, Volume 34, 101774. doi.org/10.1016/j.artd.2025.101774

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01 Study Design

A retrospective, two-surgeon, single-institution study evaluating the sagittal tibial and femoral accuracy of two different robotic-assisted total knee arthroplasty systems.

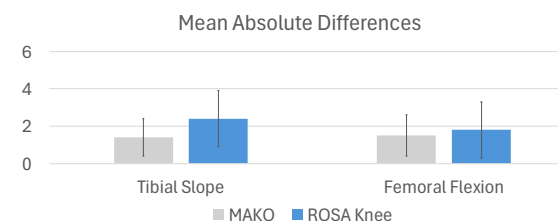
- MAKO®, N=73
- ROSA® Knee, N=96
- The sagittal femoral (femoral flexion) and tibial (tibial slope) angles were assessed with post-operative short lateral radiographs and compared to intra-operative planned alignments.
- No statistical comparisons were made between systems.

1. Yoo, Jae Ho et al. Anatomical References to Assess the Posterior Tibial Slope in Total Knee Arthroplasty: A Comparison of 5 Anatomical Axes. *The Journal of Arthroplasty*, Volume 23, Issue 4, 586 - 592
2. Ishii Y, Noguchi H, Sato J, Takahashi I, Ishii H, Ishii R et al (2022) Comparison of the tibial posterior slope angle between the tibial mechanical Axis and various diaphyseal tibial axes after total knee arthroplasty. *Arthroplasty Today* 17:137–141

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02 Key Findings

- According to post-operative X-rays, both systems tended to align the tibial component with less tibial slope (TS) compared to the intra-operative plan.
- Limitations:
 - The measurements used to assess slope do not match the mechanical axis (MA) methods used by the ROSA Knee System.
 - Short lateral films limit the ability to identify the MA.
 - Aflatooni et al. appears to measure TS with the central anatomical axis (CAA).
 - TS measures may be off by a couple of degrees dependent upon the axis selected:
 - Yoo et al.¹ reported variations between MA and CAA of $-2.2^\circ \pm 0.7^\circ$
 - Ishii et al.² reported variations between MA and CAA of $-1.6^\circ \pm 2.0^\circ$



03 Clinical Significance

The use of short lateral knee X-rays and the CAA axis are inconsistent with the measure of tibial slope using the mechanical axis. Long-leg X-rays and assessing TS with the MA are necessary to accurately assess the sagittal plane precision of the ROSA Knee System.

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Evaluating the Learning Curve Across Different raTKA Systems

Reference:

Di Gialleonardo E, Bocchino G, Capece G, et al. **Evaluation of the learning curve in robot-assisted knee arthroplasty: A Systematic review.** J Exp Orthop. 2025;12(3):e70292. doi:10.1002/jeo2.70292

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01 Study Design

A systematic review of literature evaluating the learning curve of robotic-assisted knee arthroplasty.

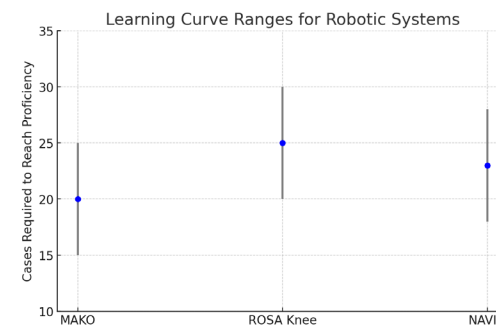
- Included studies assessed the learning curve through operative time, accuracy, and post-operative complications
- 28 studies were included
- Multiple studies were found for three systems
- MAKO®: n=10 studies
- ROSA®: n=7 studies
- NAVIO: n=5 studies

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02 Key Findings

- Considering all studies, the number of cases to surpass an initial learning curve averaged 20.5 cases.
- The implants selected were not found to impact the learning curve.
- Results from three studies indicate experienced surgeons exceed the initial learning curve quicker than inexperienced surgeons (15-30 cases vs. 30-50 cases).
- The authors did not compare learning curves between robotic systems.



03 Clinical Significance

The learning curve for all robotic systems are similar. Learning curves appear to be independent of implant used. It seems reasonable that efficiency gains are the result of the surgeon mastering the robotic platform.

The ROSA® Knee System: Correcting Methodological Flaws and Validating Measurements in Sagittal Plane

Reference:

Petrillo S, Migliorini F, Moretti G, Romagnoli S. **Accuracy of ROSA Knee System in Bone Cuts Orientation During Total Knee Arthroplasty: An Observational Study.** Journal of Clinical Medicine. 2025; 14(15):5205. <https://doi.org/10.3390/jcm14155205>

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01 Study Design

A single-surgeon, retrospective analysis evaluating the accuracy of the ROSA® Knee System.

- N=55
- Medial proximal tibial angle (MPTA), lateral distal femoral angle (LDFA), tibial slope (TS), and distal femoral flexion (DFF) were evaluated with three-month post-operative radiographs
- Long-leg antero-posterior radiographs were used for the MPTA and LDFA
- Short-leg lateral radiographs were used for the TS and DFF
- Outliers were defined as mean absolute errors greater than 3°



Scan or click for further discussion

1. Yoo, Jae Ho et al. (2008). Anatomical References to Assess the Posterior Tibial Slope in Total Knee Arthroplasty: A Comparison of 5 Anatomical Axes. The Journal of Arthroplasty, Volume 23, Issue 4, 586 - 592
2. Ishii Y, Noguchi H, Sato J, Takahashi I, Ishii H, Ishii R et al (2022) Comparison of the tibial posterior slope angle between the tibial mechanical Axis and various diaphyseal tibial axes after total knee arthroplasty. Arthroplasty Today 17:137-141

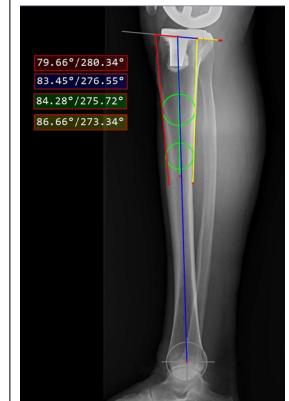
[Table of Contents](#)

02 Key Findings

- The outlier rate was zero for LDFA and 5.7% for MPTA
- Post-operative tibial slope was significantly different than the planned angle ($6.46 \pm 1.2^\circ$ vs. $7.0 \pm 0.0^\circ$, respectively)

Limitations

1. The measurements used to assess slope do not match the methods used by the ROSA Knee System.
 - Petrillo et al. assessed TS using the anterior tibial cortex (ATC)
 - Post-operative short lateral films limit the ability to identify the mechanical axis (MA)
 - TS measurements can be off by a couple of degrees dependent upon the axis selected:
 - Yoo et al.¹ reported variations between the MA and the ATC of $3.2^\circ \pm 1.3^\circ$
 - Ishii et al.² found differences of more than 3° between the ATC and MA
 - TS measures are more reliable when using the MA¹



Mechanical Axis (Slope = 83.94°)
(consistent with the ROSA Knee System)

Posterior Tibial Cortex (Slope = 79.7°)
(consistent with standard short sagittal films by Petrillo et al.)
* Image courtesy of Nathan Cafferky, MD

03 Clinical Significance

The use of short-leg lateral knee X-rays and the ATC axis are inconsistent with the measure of tibial slope using the mechanical axis. Long-leg X-rays and assessing TS with the MA are necessary to more accurately assess the precision of the ROSA Knee System in the sagittal plane.

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Common Functional Alignment Resections with the ROSA® Knee System

Reference:

Braathen DL, Clapp IM, et al. **Common adjustments made in robotic total knee arthroplasty to achieve functional alignment and minimize soft tissue releases.** J Orthop. Published online August 25, 2025. doi:10.1016/j.jor.2025.08.051.

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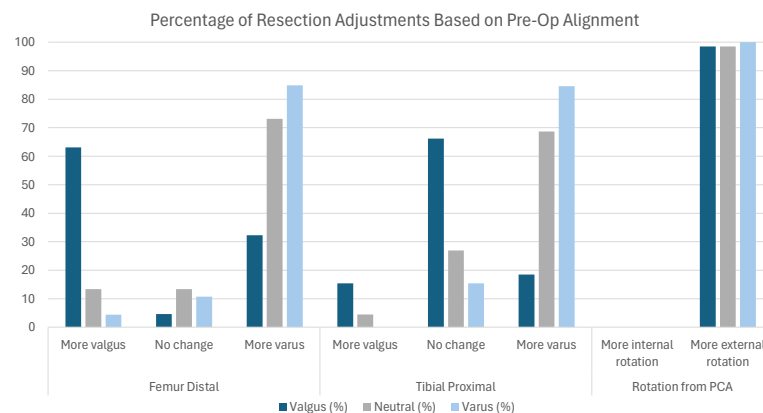
01 Study Design

A single institution, retrospective analysis evaluating the femoral and tibial resection adjustments needed to balance the knee in flexion and extension with the ROSA Knee System assisted total knee arthroplasty (TKA) based on pre-operative alignment.

- N=292
- Patients were categorized into two groups based on hip-knee-ankle alignment (HKA):
 - Pre-operative varus: $> 3^\circ$ varus HKA: n=160 (58.4%)
 - Pre-operative valgus: $> -3^\circ$ valgus HKA: n=65 (22.3%)
 - Pre-operative neutral: -3° to 3° : n=67 (22.9%)
- All patients were implanted with a functional alignment technique, aiming to minimize soft tissue manipulations.

02 Key Findings

Patients with pre-operative varus or neutral knee alignment are typically balanced with tibial varus resections. In contrast, valgus alignment are usually balanced with femoral valgus resections.



03 Clinical Significance

Consistent patterns in resections based on pre-operative deformity were observed in functional alignment. The ROSA Knee System demonstrates the potential to accommodate soft tissue variability and support achieving balanced functional alignment.

ZBEdge[®]

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The ROSA Knee 2024 Clinical Evidence Summary [Link](#):

For discussions related to Accuracy,
Efficiency and Clinical Outcomes

ONE Planner[®] Hip: Provides High Templating Accuracy

Reference:

Buchan GBJ, Hecht CJ 2nd, Rodriguez-Elizalde S, Kabata T, Kamath AF*. Automated Digital Templating of Component Sizing is Accurate in Robotic Total Hip Arthroplasty when Compared to Predicate Software. Medical Engineering and Physics 2024; 124 doi: 10.1016/j.medengphy.2024.104105

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01 Study Design

A single center retrospective analysis of patients who received conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA).

- cTHA: n=93
- rTHA: n=106

Pre-operative templating was performed with:

- ONE Planner Hip and Joints[®] Plan for rTHA
- Joints Plan for cTHA

Differences between templated and implanted component sizes were calculated for acetabular cup, femoral head and stem, as well as for the geometry of the femoral stem neck.

02 Key Findings

- Component sizing prediction and differences in templated versus implanted femoral stem geometry were similar between ONE Planner Hip and the predicate software.
- ONE Planner Hip led to:
 - > 90% accuracy within 1 size for acetabular cup and femoral cup and 75% for femoral stem
 - > 90% match for the femoral head geometry
 - 11% improvement in femoral stem sizing; however, this difference was not statistically significant

03 Clinical Significance

ONE Planner Hip has a similar high level of accuracy as the predicate software supporting its use for pre-operative planning with fluoroscopy-based robotic-assisted THA.

The ROSA® Hip System: Shows Similar Total Operative Room Time and Improved Cup Accuracy

Reference:

Buchan GB, Hecht II CJ, Liu D*, Mokete L*, Kendoff D, Kamath AF*. Improved accuracy of a novel fluoroscopy-based robotically assisted THA System compared to Manual THA. *Journal of Robotic Surgery*. 2023;17(5):2073-2079. doi: 10.1007/s11701-023-01623-w

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01 Study Design

A single center retrospective analysis of consecutive patients who received conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA)

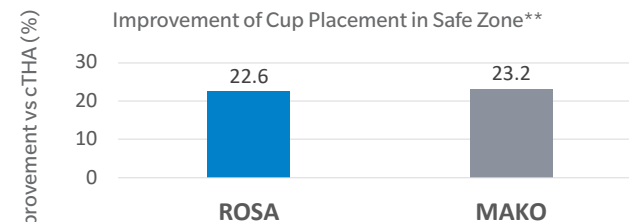
- cTHA: n=100
- rTHA: n=98

For all patients, an acetabular cup anteversion angle of 15° and inclination angle of 40° were targeted.

Differences in cup inclination, anteversion, percentage of cups positioned in the Lewinnek safe zone, operative and overall room time were compared between study groups.

02 Key Findings

- The ROSA Hip group had a significantly:
 - Higher accuracy for acetabular anteversion than the manual THA cohort (18.5° vs. 21.7°). Cup inclination was not different between the two groups ($p=0.976$)
 - Lower variance for both acetabular anteversion (26.0 vs. 44.5) and inclination (26.8 vs. 46.7)
 - Greater proportion of acetabular cups placed within the Lewinnek safe zone compared to manual THA (81.6% vs. 59%)
- The ROSA Hip group had a slightly longer operative time (39.0 vs. 35.3 min); however, total operating room time was similar between groups



**Domb BG et al (2020) Minimum 5-year outcomes of robotic-assisted primary total hip arthroplasty with a nested comparison against manual primary total hip arthroplasty: a propensity score-matched study. *J Am Acad Orthop Surg* 28:847-856

03 Clinical Significance

The ROSA Hip System increases the accuracy of acetabular cup placement and the percentage of cups within the safe zone with no increase in overall case time.

The ROSA® Hip System: High Accuracy in Cup Placement and Excellent Functional Outcomes at 1 year

Reference:

Liu D *, Kamath AF *, Cholewa J **, Stoenica L **, Anderson MB **, Lennox H. **Cup accuracy and early-term clinical outcomes of a novel, pinless, robotic-assisted total hip arthroplasty system: A first-in-human pilot study.** Arthroplasty. 2025;7(1):20. Published 2025 Mar 20.

[doi:10.1186/s42836-025-00299-x](https://doi.org/10.1186/s42836-025-00299-x)

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01 Study Design

A pre-market pilot study (first in human), two-surgeon/single site, prospective analysis of consecutive patients who received fluoroscopy-based robotic-assisted Total Hip Arthroplasty (rTHA) via the direct anterior approach

- rTHA: n = 19

Accuracy was calculated between the intra-operative plan and:

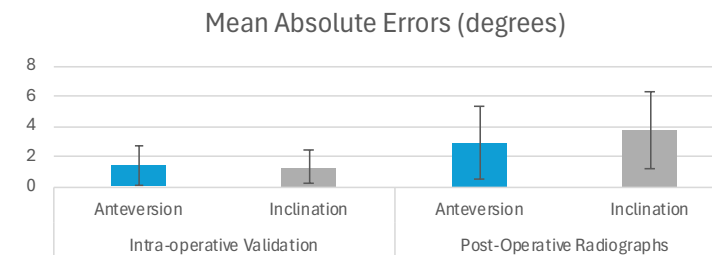
- Intra-operative values (robotic validation)
- Post-operative X-Ray (4 weeks)

Patient reported outcome measures (PROMs) were assessed pre-operatively and at four weeks, three months and one-year post-operative.

- OHS = Oxford Hip Score
- NRPS = Numeric Pain Rating Scale
- HOOS-12 = Hip Osteoarthritis Outcome Score-12

02 Key Findings

- Versus intra-operative planning:
 - Analysis of the 4 weeks post-operative radiographs showed:
 - 77.8% of cases were within 5° of the targeted angles for both anteversion and inclination
 - In 88.9% of cases, the cup was within the Lewinnek and in 61.1% of cases within the Callanan safe zone
- At the one-year follow up:
 - There were no revisions, complications, or radiolucencies greater than 2 mm
 - All PROMs (OHS, NRPS, HOOS-12) significantly improved
 - 100% of patients were satisfied or very satisfied



03 Clinical Significance

ROSA® Hip leads to accurate acetabular cup placement, improvement in PROMs and excellent patient satisfaction as early as 4 weeks post-surgery.

The ROSA® Hip System: Improved Accuracy and Reproducibility Compared to Manual Instrumentation

Reference:

Kamath AF*, Durbhakula SM*, Pickering T*, Cafferky NL*, Murray TG*, Wind MA Jr*, Méthot S.** **Improved Accuracy and Fewer Outliers with a Novel CT-free Robotic THA System in Matched-pair Analysis with Manual THA.** Journal of Robotic Surgery. 2022;16(4):905-913.

[doi: 10.1007/s11701-021-01315-3](https://doi.org/10.1007/s11701-021-01315-3)

Study funded by Zimmer Biomet

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01 Study Design

A matched-pair cadaveric study comparing the accuracy of ROSA® Hip (rTHA) with conventional instrumentation (cTHA). Fluoroscopic guidance was used in both groups:

- rTHA: N = 33
- cTHA: N = 33

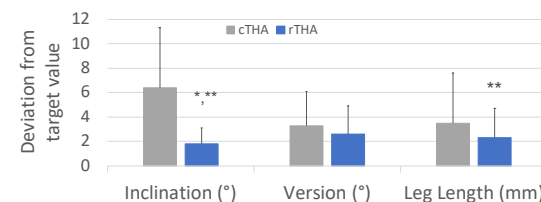
Surgeries were conducted by 14 high-volume surgeons.

For all cases, an acetabular cup anteversion angle of 15°, inclination angle of 40° and leg length discrepancy of 0 mm were targeted.

Differences in leg length, cup inclination, anteversion, and percentage of cups positioned in the Lewinnek/Callanan safe zone were compared between study groups.

02 Key Findings

- Compared to conventional instrumentation, ROSA Hip demonstrated a lower mean absolute error and a lower variance (fewer outliers) for:
 - Acetabular Component Orientation
 - Acetabular component inclination was significantly more accurate and more reproducible (fewer outliers) than conventional instrumentation. The version was similar between groups.
 - Leg Length Discrepancy (LLD)
 - LLD was significantly more reproducible than conventional instrumentation (fewer outliers)
- ROSA Hip resulted in significantly more cases within the safe zones (fewer outliers) for the acetabular component orientation.
 - 100% of robotic cases vs. 73% for conventional instrumentation.



* Mean absolute error, t-test $p < 0.05$

** Variance, F Test, $p < 0.05$

03 Clinical Significance

The ROSA Hip System reduces the leg length discrepancy and increases the reproducibility of the the accuracy of acetabular cup placement and the percentage of cups within the safe zone. The data supports the clinical use of the system for primary total hip arthroplasty.

The ROSA® Hip System: High Accuracy in Restoring Leg Length Discrepancy and Offset

Reference:

Buchan GBJ, Hecht II CJ, Nugent M, Heckmann ND, Kanaji A, Kamath AF*. **Efficacy of a novel, fluoroscopy-based robotic-assisted total hip arthroplasty system in restoring limb length and offset.** Arch Orthop Trauma Surg. 2025 Mar 5; 145(1): 175

[doi: 10.1007/s00402-024-05648-0](https://doi.org/10.1007/s00402-024-05648-0)

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01 Study Design

A single-center retrospective analysis of consecutive patients who received fluoroscopy-based, robotic-assisted Total Hip Arthroplasty (rTHA) via the direct anterior approach.

- rTHA: n = 98

For all patients, an acetabular cup anteversion angle of 15° and inclination angle of 40° were targeted.

Accuracy was calculated between the pre-operative templated* parameters and:

- Intra-operative values (robotic logs)
- Post-operative X-ray (6 weeks)

* ONE Planner® Hip was used for pre-operative planning

Please refer to Table 4 of the manuscript for a detailed overview.

Definitions:

LLD = leg length discrepancy; FO = femoral offset; GO = global offset.

02 Key Findings

- Versus pre-operative templated values:
 - Compared to the intra-operative robotic logs:
 - All parameters for LLD and offset were within 3.5 mm.
 - The proportion of patients that achieved less than 10 mm difference was 89% for LLD, 90% for FO and 79% for GO.
 - Both version and inclination of the acetabular cup were within 1.5°.
 - Compared to the 6-week post-operative radiographs:
 - All parameters for LLD and offset were within 1.5 mm.
 - The proportion of patients that achieved less than 10 mm difference was 92% for LLD, 93% for FO and 91% for GO.
- Femoral head size or femoral neck geometry target plans were adjusted intra-operatively for 44% of the patients.
- Accuracy levels for LLD and offset are comparable with CT-based robotic systems for THA (literature review).#

03 Clinical Significance

The ROSA® Hip System can restore templated LLD and offset parameters with high accuracy. This offers a degree of intra-operative flexibility, a key parameter of hip biomechanics.

The ROSA® Hip System is More Time Efficient when Compared with a CT-based Robotic Platform for THA

Reference:

Ong CB, Buchan GBJ, Hecht II CJ, Lawrie CM*, DeCook CA, Sculco PK*, Kamath AF*. Robotic-assisted total hip arthroplasty utilizing a fluoroscopy-guided system resulted in improved intra-operative efficiency relative to a computerized tomography-based platform. J Robot Surg 2023 Dec; 17(6): 2841:2847 doi: [10.1007/s11701-023-01723-7](https://doi.org/10.1007/s11701-023-01723-7)

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01 Study Design

Retrospective data analysis from patients who underwent RTHA via the direct anterior approach using two different robotic platforms fluoroscopy-based (ROSA® Hip System) vs. CT-based (Mako® Total Hip replacement)

- fRTHA, n=107
- ctRTHA, n=159

Abbreviation	Definition
THA	Total Hip Arthroplasty
RTHA	Robotic Total Hip Arthroplasty
fRTHA	Fluoroscopy-based Robotic Total Hip Arthroplasty
ctRTHA	CT-based Robotic Total Hip Arthroplasty

02 Key Findings

- Average surgical and operating room (OR) times were shorter in fRTHA ($p<0.001$)
- Surgical and OR times were also more consistent (less variance, $p<0.001$)
- Mean ROSA Hip total active time was 24.43 ± 6.30 min:
 - Cup impaction time: 5.16 ± 1.63 min
 - Cup verification time: 2.37 ± 1.68 min
 - Trial and validation time: 16.9 ± 5.7 min

System	Surgical Times	
	Skin-Skin	Wheels-in – Wheels-out
fRTHA	38.7 ± 7.0	101.4 ± 12.2
ctRTHA	75.3 ± 11.4	156.74 ± 17.79

03 Clinical Significance

The ROSA Hip System leads to time savings when compared to a robotic CT-based system. The reduction in variance for surgical and total OR time allows for more efficient management of hospital resources.

The ROSA® Hip System: Shows Less Early Pain Outcomes and Low Complication Rate

Reference:

Buchan, GB*, Hecht II CJ*, Sculco PK*, Chen JB*, Kamath AF*. Improved short-term outcomes for a novel, fluoroscopy-based robotic-assisted total hip arthroplasty system compared to manual technique with fluoroscopic assistance. Archives of Orthopaedic and Trauma Surgery. Published online 2023. doi: 10.1007/s00402-023-05061-z

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01 Study Design

A single-center retrospective analysis of consecutive patients who received conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA)

- cTHA: n= 105
- rTHA: n= 107

Rates of complications within 90 days post-surgery, length of hospital stay (LOS), and visual analog scale (VAS) pain scores were compared between the study groups.

02 Key Findings

- Versus manual THA, the ROSA Hip group had significantly:
 - Lower pain scores at 2 weeks post-operative (3.3 vs. 2.5; $p=0.048$), with both groups achieving similar pain scores at 6 weeks
 - Greater proportion of patients undergoing outpatient surgeries (3.8% vs. 37.4%; $p < 0.001$)
 - Shorter hospital length of stay (39.5h vs. 26h; $p < 0.001$)
 - Lower complication rate (6.7% vs. 0.9%; $p=0.029$)

Complications

Type	cTHA (n)	rTHA (n)
Reoperations	2	0
DVT* without PE**	3	1
Delirium	1	0
Hematoma	1	0

*DVT: Deep Venous Thrombosis

**PE: Pulmonary Embolism

03 Clinical Significance

The ROSA Hip System leads to an earlier reduction in pain levels and a decrease in length of stay by 34.2%, allowing a greater proportion of outpatient cases with no increase in complication rate or inpatient rehabilitation compared to a manual technique.

The ROSA[®] Hip System: Minimizes the Difference Between Left and Right Cup Placement

Reference:

Ong CB, Buchan GBJ, Hecht II CJ, Homma Y, Harmon DJ, Kendoff DO, Petterwood J, Kamath AF*. Fluoroscopy-based robotics in total hip arthroplasty mitigates laterality-based differences in acetabular cup placement when compared to the manual, fluoroscopic- assisted technique Technol Health Care. 2023 Nov 9. doi: 10.3233/THC-231126

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01 Study Design

A single center retrospective analysis of consecutive patients who received unilateral (left or right) conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA) performed by one right-hand-dominant surgeon.

For all patients, an acetabular cup anteversion angle of 15° and inclination angle of 40° were targeted.

Differences in cup inclination, anteversion and percentage of cup positioning in the Lewinnek safe zone were compared between study groups.

- cTHA: n=106
 - Left, n=40
 - Right, n=66
- rTHA: n=102
 - Left, n=48
 - Right, n=54

02 Key Findings

- In the cTHA cohort, the left operated hip had a significantly smaller cup inclination angle when compared with the right one ($41.1^{\circ} \pm 7.4^{\circ}$ vs. $44^{\circ} \pm 6.3^{\circ}$, $p=0.04$)
- The anteversion cup angle and the proportion of left and right cups placed within the Lewinnek safe zone were similar for cTHA
- In rTHA, all measured parameters were similar between the left and right hips
- The rTHA had a higher proportion of right cups placed within the safe zone when compared with the cTHA (80% vs. 59%, $p=0.03$)
- When combining the left and right hips, there was a significantly larger proportion of hips placed with the Lewinnek safe zone in the rTHA group (78% vs. 59%, $p=0.003$)

03 Clinical Significance

The ROSA Hip System standardizes the THA procedure by reducing differences in placement of left or right acetabular cups, which may lead to more homogenous outcomes across different surgical scenarios.

The ROSA® Hip System: More Cost Effective than Manual THA Over Time

Reference:

Ong CB, Buchan GBJ, Acuña AJ, Hecht II CJ, Homma Y, Shah RP*, Kamath AF*. Cost-effectiveness of a novel, fluoroscopy-based robotic-assisted total hip arthroplasty system: a Markov analysis. Int J Med Robot. 2023; e2582 doi: 10.1010.1002/rcs.258202/

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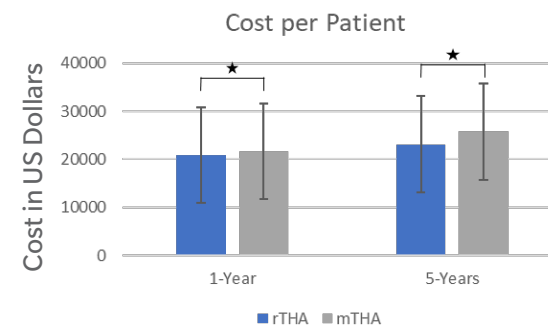
01 Study Design

A Markov analysis comparing the cost-effectiveness of robotic-assisted THA (rTHA) vs manual THA (mTHA)

- Quality-adjusted life years (QALY) were calculated for 1- and 5-years post-operative
- Cost-effectiveness was calculated by dividing the difference in cost between treatments by the difference in utility
- Input data was extracted from the literature and combined with available institutional rTHA data

02 Key Findings

- rTHA had significantly lower costs with an average savings of \$795 at 1-year and \$2631 at 5-years
- rTHA gained significantly more QALYS at 1- and 5-years
 - rTHA was significantly more cost effective per QALY at 1- and 5-years
- Probability sensitivity analysis revealed rTHA was more cost effective in 67.1% to 75.2% of cases at 5-years
 - The largest driver of cost-effectiveness was a lower probability of no complication revision with rTHA



03 Clinical Significance

Robotic-assisted total hip arthroplasty with the ROSA Hip System leads to lower treatment costs and improved utility through at least 5-years post-operative.

The ROSA[®] Hip System: Operative Times Show a Learning Curve of 12 Cases

Reference:

Buchan GBJ, Hecht II CJ, Lawrie CM*, Sculco PK*, Kamath AF*. The learning curve for a novel, fluoroscopy-based robotic-assisted total hip arthroplasty system. The International Journal of Medical Robotics and Computer Assisted Surgery 2023;19(4). doi: 10.1002/rcs.2518

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01 Study Design

A single center retrospective analysis of consecutive patients who received robotic Total Hip Arthroplasty (rTHA)

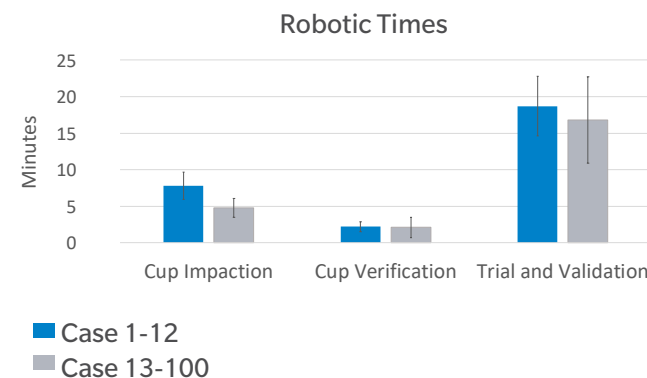
- rTHA: n=100

Analyzed parameters included:

- Operative times
- Duration of specific steps of the surgical workflow when the robot was active
- Acetabular cup orientation
- Radiographic outcomes
- Complication rate

02 Key Findings

- The ROSA Hip System had a learning curve of 12 cases with an operative time of 44.3 ± 4.4 min in the learning phase vs. 38.0 ± 7.1 min in the proficiency phase
- Cup impaction time was significantly longer in the learning phase: 7.8 ± 1.9 vs. 4.8 ± 1.3 min
- No significant differences in acetabular cup anteversion and inclination between the two different learning phases
- No complications reported for up to six months follow-up in the learning phase group



03 Clinical Significance

The ROSA Hip System is associated with a brief learning curve of 12 cases, with the most significant improvements in surgical efficiency realized during acetabular cup placement.

The ROSA[®] Hip System: Leads to Less Opioid Consumption up to Six Weeks Post-Operatively

Reference:

Buchan GBJ, Bernhard Z, Hecht II CJ, Davis GA, Pickering T*, Kamath AF*. Improved perioperative narcotic usage patterns in patients undergoing robotic-assisted compared to manual total hip arthroplasty. *Arthroplasty*. 2023 Nov 4;5(1):56. doi: 10.1186/s42836-023-00211-5.2582

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01 Study Design

A single center retrospective analysis of consecutive patients who received conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA) performed by one surgeon.

All patients followed standardized pain medication protocols. The peri-operative and early post-operative opioid consumption was compared between the two study groups.

- cTHA: n= 104
- rTHA: n= 107

Sub-group analysis was performed for opioid-naïve and opioid-tolerant patients in both conventional and robotic cohorts.

02 Key Findings

- Narcotics use was significantly lower in the rTHA cohort during:
 - Immediate peri-operative period, independent of patients' previous exposure to opioids (opioid-naïve vs. opioid-tolerant):
 - Total in-hospital stay (42.3 vs. 66.4 MME**, $p < 0.001$)
 - Hospital floor stay (29.1 vs. 55.0 MME, $p < 0.001$)
 - Post-operative period up to six weeks (103.7 vs. 127.8 MME, $p < 0.05$)
 - Differences between rTHA and cTHA existed for the opioid-naïve and opioid-tolerant subgroups, but only the opioid-tolerant sub-group reached statistical significance
- Patient-reported pain scores were similar between the two study groups peri- and post-operatively

**MME = morphine miligrams equivalents

03 Clinical Significance

Similar pain, but less opioid use, suggests that patients receiving cTHA required more opioids to manage the pain. The ROSA Hip System may play a role in rapid recovery protocols and mitigation of post-operative opioid burden.

The ROSA® Hip System: Shows Similar Radiation Exposure Compared to Manual C-arm Imaging

Reference:

Buchan GBJ, Ong CB, Hecht II CJ, Tanous TJ, Peterson B*, Hasegawa A, Kamath AF*. Equivalent radiation exposure with robotic total hip replacement using a novel, fluoroscopic-guided (CT-free) system: case –control study versus manual technique. *Journal of Robotic Surgery*. 2023;17(4):1561-1567. doi: 10.1007/s11701-023-01554-6

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01 Study Design

A single-center retrospective analysis of consecutive patients who received conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA)

- cTHA: n=100
- rTHA: n=100

Differences in number of fluoroscopic images, radiation dose, and duration of radiation exposure per procedure were compared between study groups.

02 Key Findings

- Statistically greater radiation (1.0+0.8 vs. 3.0+1.4 mGy) and fluoroscopic images (4.3 vs. 7.5) were recorded in the ROSA Hip group, however:
 - The difference between groups was not clinically significant
 - The amount of radiation recorded for the ROSA Hip group was similar to the normal range of radiation (0.3 to 2.97 mGy) reported for conventional procedures
- No learning curve was present. The first 20 and last 80 cases both required the same number of images (7.2 vs. 7.6)

03 Clinical Significance

The ROSA Hip System shows no clinically significant increase in radiation exposure to the patient compared to manual approaches.

The ROSA® Hip System: Improves Acetabular Cup Placement for Obese Patients

Reference:

Ong CB, Buchan GBJ, Hecht II CJ, Kendoff DO, Homma Y, Kamath AF*. Fluoroscopy-based robotic assistance for total hip arthroplasty improves acetabular cup placement accuracy for obese patients compared to the manual, fluoroscopic-assisted technique. Technol Health Care. 2023 Nov 9. doi: 10.3233/THC-231127

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01 Study Design

A single center retrospective analysis of obese and non-obese consecutive patients who received conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA) performed by one surgeon.

For all patients, an acetabular cup anteversion angle of 15° and inclination angle of 40° were targeted.

Differences in cup inclination, anteversion, placement consistency** and percentage of cup positioning in the Lewinnek safe zone were compared between study groups.

- cTHA: n=105
 - Obese, n=47
 - Non-Obese, n=58
- rTHA: n=102
 - Obese, n=50
 - Non-Obese, n=52

** Cup placement consistency/variances were calculated using the square of standard deviation for cup placement angle.

02 Key Findings

- The obese vs non-obese population in the cTHA cohort had:
 - Significant larger cup inclination angle ($44.8^\circ \pm 6.5^\circ$ vs. $41.4^\circ \pm 6.8^\circ$, $p=0.009$) in obese patients
 - Significantly smaller proportion of cup within the Lewinnek safe zone (48% vs. 67%, $p=0.027$) in obese patients
 - Similar angles for cup anteversion and no differences in cup placement consistency for both inclination and anteversion measurements
- There were no differences between obese and non-obese patients in the rTHA group for any of the measured accuracy or consistency parameters

Accuracy of Cup Placement with ROSA

Measurement	Obese	Non-Obese
Inclination	$6^\circ \pm 6.2^\circ$	$5.2^\circ \pm 4.1^\circ$
Anteversion	$4.7^\circ \pm 5^\circ$	$4.8^\circ \pm 4.5^\circ$

03 Clinical Significance

The ROSA Hip System allows for accurate cup placement independent of obesity status, minimizing the risk of over-abducted “open” cups when using a minimally invasive direct anterior approach for THA.

The ROSA® Hip System: Leads to greater improvements in PROMs at one year

Reference:

Buchan GBJ, Ong CB, Hecht CJ II, DeCook CA*, Spencer-Gardner LS, Kamath AF*. Use of a fluoroscopy-based robotic-assisted total hip arthroplasty system produced greater improvements in patient-reported outcomes at one year compared to manual, fluoroscopic-assisted technique. Archives of Orthopaedic and Trauma Surgery; Feb 2024 doi: <https://doi.org/10.1007/s00402-024-05230-8>

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01 Study Design

A single-center retrospective analysis of consecutive patients who received conventional (cTHA) or robotic Total Hip Arthroplasty (rTHA) via the direct anterior approach.

- cTHA: n=91
- rTHA: n=85

Pre- to post-operative differences in several patient-reported outcomes (VR12, HOOS and UCLA scores) were compared between study groups.

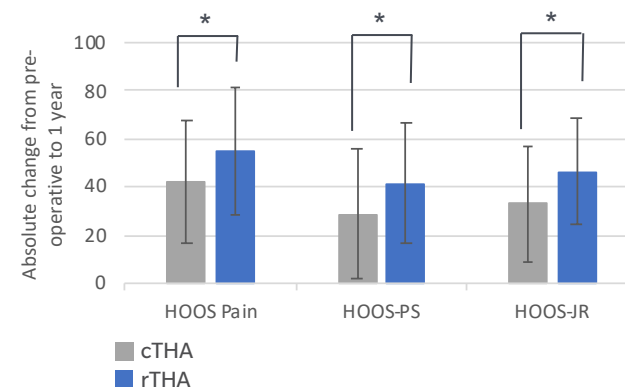
Sub-group analysis was performed for patients with cup placement in and outside the Lewinnek safe zone in both conventional and robotic cohorts.

Pre-operative evaluation, surgical technique and post-operative workflow were identical between the study cohorts.

02 Key Findings

- The rTHA group experienced significant improvements between pre- and post-operative HOOS sub-scores compared to the cTHA cohort (mean absolute values).
- A similar effect was also observed in the robotic group for patients with cup placement outside the Lewinnek safe zone.
- There was no difference in post-operative values for VR-12, HOOS and UCLA Activity scores between the two study cohorts.

HOOS sub-Scores



03 Clinical Significance

The ROSA® Hip System leads to greater improvements in pain, physical function and joint replacement HOOS sub-scores compared to fluoroscopy based-manual technique one year after surgery.

The ROSA® Hip System: shows similar PROMs at 1 year when compared with a CT-based robotic platform for THA

Reference:

Ong CB, Buchan GBJ, Hecht II CJ, Liu D*, Petterwood J, Kamath AF*. Use of a fluoroscopy-based robotic-assisted total hip arthroplasty system resulted in greater improvements in hip-specific outcome measures at one-year compared to a CT-based robotic-assisted system. Int J Med Robot. 2024;e2650. doi: <https://doi.org/10.1002/rcs.2650>

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01 Study Design

A single-center retrospective analysis of consecutive patients who received THA via the direct anterior approach using two different robotic platforms (fluoroscopy-based (ROSA Hip System) vs. CT-based (Mako® Total Hip replacement))

- fTHA: n=85
- ctTHA: n=125

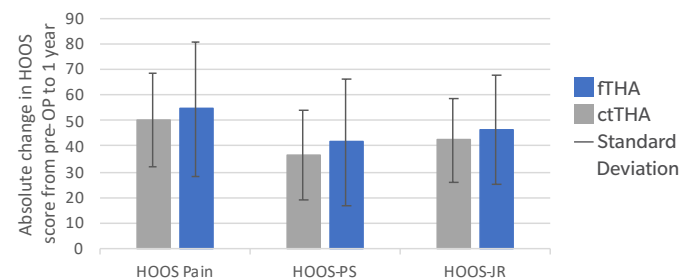
PROMs analysis: Pre- to one-year post-operative differences in several patient-reported outcomes (VR12, HOOS and UCLA scores) were compared between study groups.

Abbreviation	Definition
fTHA	Fluoroscopy-based robotic Total Hip Arthroplasty
ctTHA	CT-based robotic Total Hip Arthroplasty

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02 Key Findings

- The fTHA group experienced a significantly greater improvement of 4.99 points between pre- and post-operative HOOS-PS compared to the ctTHA cohort
 - All other PROMs were similar between the two groups.
- There were no differences in major complication rate, radiographic outcomes at six weeks post-operative and percentage of cups within the Lewinnek safe zone between the two study cohorts.
- Surgical time was significantly shorter in the fTHA group (38.7 vs 75.5 min)



03 Clinical Significance

The ROSA® Hip System leads to a greater improvement in HOOS-PS score one-year post-operatively when compared to a CT-based robotic technique. This finding needs to be interpreted with care given that the reported difference did not reach the minimal clinically important difference of 10.01*.

mymobility[®] Care Management Platform: Similar clinical and functional outcomes to standard of care post-operative physical therapy

Reference:

Crawford DA, Duwelius PJ, Sneller MA, Morris MJ, Hurst JM, Berend KR, Lombardi AV*. 2021 Mark Coventry Award: Use of a smartphone-based care platform after primary partial and total knee arthroplasty: a prospective randomized controlled trial. Bone Joint J. 2021 Jun;103-B(6 Supple A):3-12. doi: 10.1302/0301-620X.103B6.BJJ-2020-2352.R1

Study was funded by Zimmer Biomet

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01 Study Design

A prospective, 15-site multicenter, randomized controlled trial comparing the mymobility[®] Care Management Platform to the standard of care following total knee arthroplasty (TKA) and partial knee arthroplasty (PKA).

- Control patients (N=244, PKA: n=59, TKA: n=185) received standard of care post-operative therapy.
- mymobility patients (N=208, PKA: n=48, TKA: n=160) received digital pre- and post-operative education and exercise modules.
- Patient reported outcome measures (PROMs) and objective measures of function were assessed pre-operatively and at one- and three-months post-operative.

1. Hung M, Bounsanga J, Voss MW, Saltzman CL. Establishing minimum clinically important difference values for the Patient-Reported Outcomes Measurement Information System Physical Function, hip disability and osteoarthritis outcome score for joint reconstruction, and knee injury and osteoarthritis outcome score for joint reconstruction in orthopaedics. World J Orthop. 2018 Mar 18;9(3):41-49.

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02 Key Findings

- The number of patients participating in post-operative physical therapy was higher in the control group (94.4% vs. 59.3%) compared to mymobility.
- There were significantly more patients requiring emergency room visits (8.2% vs. 2.5%) and a non-significant (p=0.056) trend for more admissions (6.7% vs. 2.5%) in the control group compared to mymobility.
- There were no significant differences in single leg stance time, timed Up and Go test, or passive flexion range of motion at one- or three-months post-operatively between the control or mymobility.
- At three-months post-operative, Knee Osteoarthritis and Injury Scores for Joint Replacement (KOOS JR) were greater in the control group than the mymobility group (73.6 ± 13.4 vs. 70.4 ± 12.6).
 - However, the KOOS JR difference between groups of 3.2 does not exceed the minimal clinically important difference of approximately 8 points.¹

03 Clinical Significance

The use of a smartphone-based care platform resulted in fewer knee arthroplasty patients participating in physical therapy and reporting to the emergency department post-operatively. Clinical and functional outcomes were similar between the groups.

mymobility[®] Care Management Platform: Similar one-year outcomes to standard of care with a smartphone-based care platform

Reference:

Alexander JS, Redfern RE*, Duwelius PJ, Berend KR, Lombardi AV Jr**, Crawford DA. Use of a Smartphone-Based Care Platform After Primary Partial and Total Knee Arthroplasty: 1-Year Follow-Up of a Prospective Randomized Controlled Trial. *J Arthroplasty*. 2023 Jul;38(7 Suppl 2):S208-S214. doi: 10.1016/j.arth.2023.02.082.

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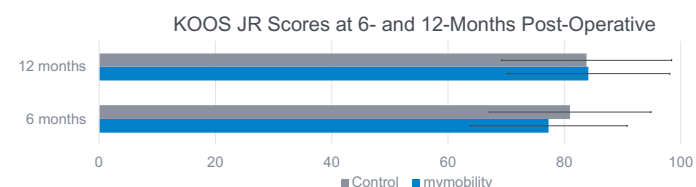
01 Study Design

A prospective, multicenter, randomized controlled trial comparing the mymobility[®] Care Management Platform to the standard of care following total (TKA) and partial knee arthroplasty (PKA) at six- and twelve-months post-operative.

- Control patients (N=241, PKA: n=56, TKA: n=185) received standard of care post-operative therapy.
- mymobility patients (N=160, PKA: n=41, TKA: n=119) received digital post-operative education and exercise modules.
- Patient reported outcome measures (PROMs) were assessed at 6 months and 1 year, and days to return to functional activity were assessed at 3 months post-operative.

02 Key Findings

- Significantly more patients in the control cohort required physical therapy visits compared to the mymobility cohort (94.6% vs. 60.6%).
- There were no differences in KOOS JR or EQ-5D-5L scores between the control and mymobility groups at one-year post-operative.
- There were no differences in satisfaction with sitting, lying in bed, getting out of bed, light household activities or recreation between groups.
- The mymobility group returned to walking without an assistive device significantly sooner than the control group (23.1 ± 17.1 vs. 28.5 ± 23.2 days).
- There were no differences between groups in time to return to driving independently or returning to work or household activities.



03 Clinical Significance

The results of this study demonstrate that the use of a smartphone-based care platform result in similar one-year clinical outcomes with less need for physical therapy visits compared to the standard of care following total and partial knee arthroplasty.

Comparable Rehabilitation Outcomes in Total Knee Arthroplasty (TKA) Between mymobility® Care Management Platform and Traditional Physical Therapy (PT)

Reference:

Tripuraneni KR, Foran JRH, Munson NR, Racca NE, Carothers JT. **A Smartwatch Paired With A Mobile Application Provides Postoperative Self-Directed Rehabilitation Without Compromising Total Knee Arthroplasty Outcomes: A Randomized Controlled Trial.** J Arthroplasty. 2021;36(12):3888-3893.

[doi:10.1016/j.arth.2021.08.007](https://doi.org/10.1016/j.arth.2021.08.007)

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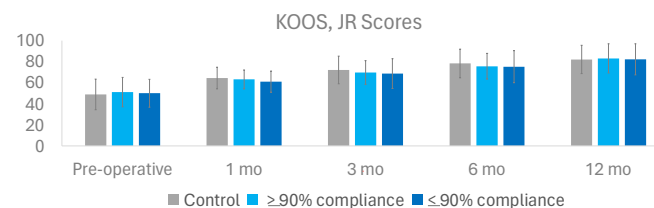
01 Study Design

A multi-center, prospective, randomized clinical study evaluating post-operative outcomes using the mymobility® Care Management Platform after total knee arthroplasty (TKA).

- n=337
 - Control group using traditional physical therapy (PT):
 - n=184.
 - mymobility group:
 - n=153.
 - High exercise compliance group (completion > 90%): n=90.
 - Low exercise compliance group (completion < 90%): n=63.
- Patient-reported outcome measures (PROMs), including KOOS, JR, EQ-5D-5L, along with range of motion (ROM) and manipulation under anesthesia, were assessed.

02 Key Findings

- The low-compliance group showed significantly less improvement in KOOS, JR scores from pre-operative levels at 3 and 6 months vs. control group.
- For the high compliance group there was no difference in KOOS, JR and EQ-5D-5L scores at 12 months vs. control group.
- The control group showed greater improvements in KOOS, JR scores from pre-operative levels at 6 months vs. the high compliance group
 - None of the significant differences in KOOS, JR scores reached the 8.02 unit threshold for minimal clinically important difference.
- No significant differences were found in: PROMs at other time intervals, manipulation under anesthesia rates, or range of motion (ROM).



03 Clinical Significance

At 1-year post-operative, clinical outcomes were similar between self-directed and traditional PT. A self-directed mobile application for patient recovery may be an appropriate alternative to traditional PT following TKA.

mymobility[®] Care Management Platform Can Help Reduce Post-operative Costs Following Knee Arthroplasty

Reference:

Lonner JH*, Naidu-Helm A**, VanAnandel DC**, Anderson MB**, Ditto R**, Redfern RE**, and Foran J* **Smartphone-Based Care Platform Versus Traditional Care in Primary Knee Arthroplasty in the United States: Cost Analysis** uHealth and mHealth. 2025, In press.

[doi:10.2196/46047](https://doi.org/10.2196/46047)

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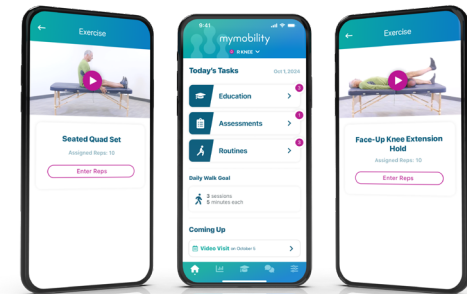
01 Study Design

A multi-center randomized controlled study aimed at evaluating early outcomes with the use of a smartphone-based exercise and educational care management system after knee arthroplasty.

- Partial and total knee arthroplasty patients.
- N=244 control arm.
- N=208 treatment arm.
- Reviewed all healthcare utilization 90 days after surgery:
 - Physical therapy (PT)
 - Readmission
 - Emergency department visit
 - Manipulation Under Anesthesia (MUA)
 - Physician office visit
- Cost from public sources and literature applied across the number of each type of visit.
- One and two-way sensitivity analyses performed across cohort.

02 Key Findings

- After considering the cost of the platform, average cost reduction per patient 90-days postoperative was \$732.
- The cost reduction was attributed mainly to the reduction in PT visits, where the total number of visits in the control arm was 1,736 vs. 799 in the treatment group.
- One and two-way sensitivity analyses demonstrated cost reductions of at least \$195 and up to \$759 per patient.



03 Clinical Significance

This patient care management app has the potential to reduce post-operative costs without negatively impacting outcomes resulting in improved value for knee arthroplasty patients.

Evaluating Stair Count and Speed in Total Knee Arthroplasty and Partial Knee Arthroplasty Patients

Reference:

Berend M, Redfern RE*, Van Andel DC*, Anderson MB*, Ren AN*, Neher Re, and Foran J. **Comparison of Stair Count and Speed Recovery in Patients Following Partial or Total Knee Arthroplasty.** ISTA Annual Congress. Maui, HA, September 2022.

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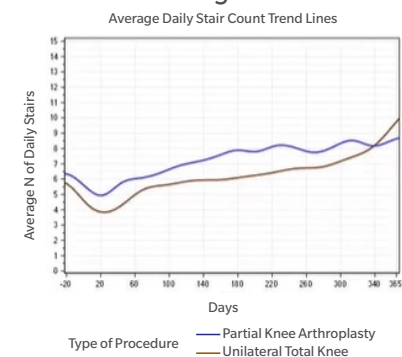
01 Study Design

Secondary data analysis from a prospective, longitudinal study for patients prescribed the use of the mymobility® Care Management Platform.

- N = 1,040.
- Includes both Total Knee Arthroplasty (TKA) and Partial Knee Arthroplasty (PKA) patients reporting a multi-level home environment.
- The stair climbing test performed in clinic has been shown to be a better indicator of performance/capacity than some other measures.

02 Key Findings

- Stair flight count exceeded pre-operative means for both TKA and PKA ($p=0.02$) patients by 6 months post-operative ($p=0.001$).
- Mean stair ascending and descending speed increased from pre-op to one year for PKA patients.
 - Ascending: Pre-operative (0.27, $n=80$, $p=0.79$), 1-year (0.30, $n=13$, $p=0.06$).
 - Descending: Pre-operative (0.30, $n=83$, $p=0.61$), 1-year (0.32, $n=13$, $p=0.0110$).
- Fewer TKA patients met Range of Motion (ROM) goals, but did not appear to affect Patient Reported Outcome Measures (PROMs) or objective stair climbing metrics.



03 Clinical Significance

PKA patients performed more steps at all time points, but both recovered their stair climbing behaviors by six months post op and exceeded pre-op at one year. PKA and TKA patients demonstrated similar function by KOOS JR scores, stair counts, and stair speeds at 1-year post op.

Reviewing Passively Collected Gait Metrics with the mymobility[®] Care Management Platform on Recovering Total Knee Arthroplasty Patients

Reference:

Fary C**, Cholewa J*, Abshagen S*, Van Andel D*, Ren NA*, Anderson MB*, Tripuraneni KR. **Stepping Beyond Counts in Recovery of Total Knee Arthroplasty: A Prospective Study on Passively Collected Gait Metrics.** *Sensors.* 2023, 23, 5588. [doi: 10.3390/s23125588](https://doi.org/10.3390/s23125588)

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01 Study Design

Secondary data analysis from a prospective cohort study to evaluate pre- and post-operative gait quality to assess recovery following primary total knee arthroplasty (TKA). Study participants used the mymobility[®] Care Management Platform which monitored patient progress, leading up to and post-surgery.

- N = 686.
- Evaluated 6 weeks pre-operative through 24 weeks post-operative.
- “Recovery was defined as the post-operative week when the respective gait metric was no longer statistically inferior to the pre-operative value.”
- The mymobility application passively recorded patient activity, as collected by the participant’s smartphone.

02 Key Findings

- “Walking speed and step length were lowest, and timing asymmetry and double support percentage were greatest at week 2 post-operative ($p < 0.0001$).”
- “Walking speed recovered at 21 weeks (1.00 m/s, $p = 0.063$) and double support percentage recovered at week 24 (32%, $p = 0.089$).”
- “Asymmetry percentage was recovered at 13 weeks (14.0%, $p = 0.23$) and was consistently superior to pre-operative values at week 19 (11.1% vs. 12.5%, $p < 0.001$).”
- “Step length did not recover during the 24 week period (0.60 m vs. 0.59 m, $p = 0.004$).”
- “The data suggests that gait quality metrics are most negatively affected 2 weeks post-operatively, recover within the first 24-weeks following TKA.”

03 Clinical Significance

The results of this study demonstrate the ability to collect gait quality metrics via commercially available sensor-based smartphone technologies and provides recovery curves that may be used to assist remote monitoring of self-directed rehabilitation.

Evaluating Correlation Between One-Month Post-Op Pain and Three-Month Post-Op Dissatisfaction in Total Knee Arthroplasty (TKA)

Reference:

Tripuraneni KR, Cholewa JM*, Anderson MB*, Van Andel DC*, Surmacz K*, Redfern RE*, Smith K, Barnett SL. **I Can't Get No Satisfaction: One-Month Post-Operative Pain Predict Three-Month Post-Operative Dissatisfaction in Total Knee Arthroplasty.** AAOS Annual Meeting. San Francisco, CA. February 2024.

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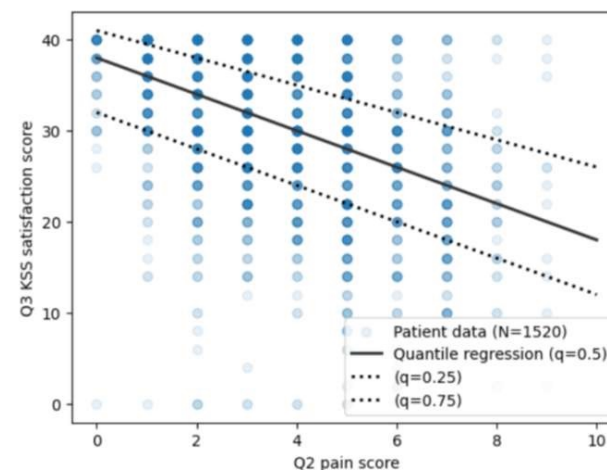
01 Study Design

Secondary analysis from data collected in a multicenter longitudinal cohort study comprised of Total Knee Arthroplasty (TKA) patients utilizing the mymobility[®] Care Management Platform.

- n=1520.
- Evaluating the correlation between 1-month pain scores and 3-month post-operative satisfaction.
- Pain assessed via a Numeric Rating Scale (NRS).
- Satisfaction assessed via the Knee Society composite satisfaction score (KSS).

02 Key Findings

- The 1-month mean NRS was 3.7 ± 2.0 .
- 624 (41.1%) patients were dissatisfied at 3-months post-operative.
- There was a moderate correlation between 1-month NRS pain and 3-month satisfaction ($r=-0.39$).



03 Clinical Significance

1-month post-op pain scores greater than 4.0 were associated with patient dissatisfaction at 3-months post-op. Assessing pain in the immediate post-operative period may help detect patients who may be dissatisfied 3-months following TKA.

Reviewing Passively Collected Gait Metrics Captured via mymobility® Care Management Platform on Recovering Total Hip Arthroplasty Patients

Reference:

Fary C**, Cholewa J*, Abshagen S*, Van Andel D*, Ren AN*, Anderson MB*, Tripuraneni KR. **Stepping Beyond Counts in Recovery of Total Hip Arthroplasty: A Prospective Study on Passively Collected Gait Metrics.** Sensors. 2023;23:6538.

🔗 doi: [10.3390/s23146538](https://doi.org/10.3390/s23146538)

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01 Study Design

Secondary data analysis from a prospective cohort study to evaluate pre- and post-operative gait quality to assess recovery following primary total hip arthroplasty (THA). Data collected by participant's smartphone recorded gait data, including walking speed, step length, asymmetry percentage and double support percentage.

- N = 612.
- Evaluated 6 weeks pre-operative through 24 weeks post-operative.
- "Recovery was defined as the post-operative week when the respective gait metric was no longer statistically inferior to the pre-operative value."
- Gait metrics captured passively via mymobility® Care Management Platform.

02 Key Findings

- "Walking speeds and step length were lowest, and timing asymmetry and double support percentage were greatest at week 2 post-operative ($p < 0.001$)."
- "Walking speed (1.00 ± 0.14 m/s, $p = 0.04$), step length (0.58 ± 0.06 m/s, $p = 0.02$), asymmetry ($14.5 \pm 19.4\%$, $p = 0.046$), and double support percentage ($31.6 \pm 1.5\%$, $p = 0.0089$) recovered at 9, 8, 7 and 10 weeks post-operative, respectively."
- "Walking speed, step length, asymmetry, and double support all recovered beyond pre-operative values at 13, 17, 10, and 18 weeks, respectively ($p < 0.002$)."

03 Clinical Significance

Gait quality metrics are most negatively affected at 2 weeks post-operative. Pre-operative levels are recovered approximately 10 weeks following THA.

mymobility[®] Care Management Platform Shows Positive Impacts in Patient Engagement and Effective Remote Monitoring – Survey Results

Reference:

Rossi SMP, Panzera RM, Sangaletti R, Andriollo L, Giudice L, Lecci F, Benazzo F.* **Problems and Opportunities of a Smartphone-Based Care Management Platform: Application of the Wald Principles to a Survey-Based Analysis of Patients' Perception in a Pilot Center.** Healthcare. 2024;12:153.

[doi: 10.3390/healthcare12020153](https://doi.org/10.3390/healthcare12020153)

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01 Study Design

Analysis from a single-center pilot study in Italy. Aim was to explore objectives, functionalities, outcomes, problems and opportunities of the mymobility[®] Care Management Platform.

- n = 218 (217 patients, one bilateral).
 - 64 responses received.
 - Gender distribution: 56.5% male and 43.5% female.
 - Average age: 63.45 years.
 - Standard deviation: 9.3 years.
 - All received a Total Knee Replacement (TKA) with ROSA[®] Knee robotic technology.
- Survey sent to active mymobility users:
 - Nine questions related to technical aspects of the platform.
 - Ten questions explored general satisfaction and behavior preferences.

02 Key Findings

- 100% of patients found mymobility easy to use from registration onward.
- 93.3% reported feeling more informed since using mymobility.
- 75% said that the Education feature was the most valuable.
- 87.5% claimed success in achieving rehab goals.
- 93.3% felt a reduction in surgical anxiety through normal mymobility usage.
- There is an existing need to further integrate the recruitment process and create a more comprehensive patient experience journey within mymobility.

03 Clinical Significance

Survey results indicated that mymobility usage led to impactful patient engagement and remote education. 100% of patients reported appreciation that their care team had visibility to monitor their progress. Some design aspects and care team engagement updates represent potential opportunities for improvement.

Direct Anterior Approach Showcases Early Post-Operative Patient Reported Outcome Measures (PROMs) Improvement Versus the Posterior Approach for Total Hip Arthroplasty

Reference:

Sarhan O, Megalla M, Imam N, Ren AN*, Redfern R*, Klein GR**. **Improved patient reported outcomes with the direct anterior approach versus the posterior approach for total hip arthroplasty in the early post-operative period.** Archives of Orthopaedic and Trauma Surgery. 2024;144:2373-2380. doi:10.1007/s00402-024-05271-z

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01 Study Design

Secondary data analysis from a prospective cohort study utilizing mymobility® Care Management Platform following Total Hip Arthroplasty (THA). This study compared PROM scores between the direct anterior (DAA) and the posterior approach (PA).

- N = 1,364 (524 DAA, 840 PA).
- Evaluating change in HOOS JR and EQ-5D-5L from baseline to 1 year.

02 Key Findings

- “DAA was significantly associated with higher average HOOS JR through 6 months ($p=0.03$) and EQ-5D-5L through 3 months ($p=0.005$), but not at 12 months ($p=0.89$ and $p=0.56$).”
- PROM differences may not be clinically significant, as they were not evident 1 year post-operative.
- Some baseline characteristics impact change in HOOS JR (age, BMI, and gender) in addition to the approach utilized.
- Comorbidities impacted absolute score, but not change from baseline (age and BMI were not related to absolute HOOS JR, but impacted change).

03 Clinical Significance

In this study, direct anterior approach patients demonstrated earlier improvements in HOOS JR and EQ-5D-5L. These findings are not maintained longer term.

mymobility[®] Care Management Platform Demonstrates Higher Patient Reported Outcome Measures (PROMs) Completion Compliance – Results from a Randomized Controlled Trial

Reference:

Miller MD, Redfern RE**, Anderson MB**, Abshagen S**, Van Andel D**, Lonner JH*. **Completion of Patient-Reported Outcome Measures Improved With Use of a Mobile Application in Arthroplasty Patients: Results From a Randomized Controlled Trial.** *Journal of Arthroplasty.* 2024;39-7:1656-1662.

[doi: 10.1016/j.arth.2024.01.007](https://doi.org/10.1016/j.arth.2024.01.007)

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01 Study Design

Secondary analysis from a multicenter randomized controlled trial.

- N = 835
 - 451 control group (245 knees / 206 hips).
 - 384 mymobility[®] Care Management Platform group (210 knees / 174 hips).
- Control group received practice standard of care, and PROMs via email link or via paper in clinic.
- mymobility group received self-directed rehabilitation through the platform, and PROMs via this application or via paper in clinic.
- Follow-up occurred through one year.

* Comprehensive care for joint replacement model. Centers for Medicare & Medicaid Services.

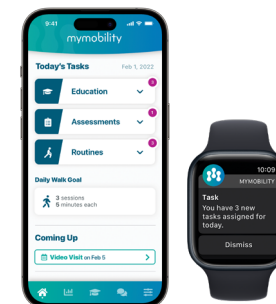
[Link to Model](#)

[Overview and methodology](#)

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02 Key Findings

- Compliance was higher in the mymobility group pre-operatively in both knee (98.1% versus 86.9%) and hip cohorts (96.0% versus 88.4%), and post-operatively, including at one year (knees: 72.2% versus 53.7%, hips: 71.1% versus 49.2%).
- Most patients in the experimental group, including those over 65 years of age, completed PROMs using mymobility as opposed to paper methods.
- Users of mymobility were significantly more likely to be compliant with pre-operative and post-operative PROMs completion within Comprehensive Care for Joint Replacement (CJR) Model* defined timeframes.



03 Clinical Significance

“A smartphone mobile application that engages patients during recovery after knee and hip joint arthroplasty improved compliance with completion of preoperative and postoperative PROMs compared to other electronic and paper methods.”

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Remote Rehabilitation with mymobility® Care Management Platform is Easy to Use and Motivating – Survey Results

Reference:

Booth MW, Riegler V, King JS, Barrack RL, Hannon CP. Patients' Perceptions of Remote Monitoring and App-Based Rehabilitation Programs: A Comparison of Total Hip and Knee Arthroplasty. J Arthroplasty. 2023 Jul;38(7s):S39-S43.

[doi:10.1016/j.arth.2023.04.032](https://doi.org/10.1016/j.arth.2023.04.032)

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01 Study Design

Single-center retrospective cohort study on patients that were involved in 1 of 2 clinical studies. Survey sent to patients that underwent total hip arthroplasty (THA), total knee arthroplasty (TKA), or unicompartmental knee arthroplasty (UKA).

- n=166 total responses (42 THA, 106 TKA, 18 UKA).
- Patients completed the survey 3-months post-operative.
- Study A: mymobility® smartphone app paired with an Apple Watch (n=78).
- Study B: FocusMotion smartphone app paired with a smart knee brace and a Fitbit (n=88).
- Purpose of survey was to evaluate patient perception of wearable remote monitoring technologies.

02 Key Findings

- 92% of patients found the mobile app easy to use.
- 94.5% of TKA/UKA patients felt the platform motivated them during their recovery.
- 81.9% of TKA/UKA patients felt the platform allowed surgeons to monitor their recovery closely, compared to 65.9% for THA patients (p=.009).
- 83% of patients recommended a combination of inpatient and app-based rehabilitation.
- 85.4% of THA patients believed these care management platforms/this platform could replace in-person rehabilitation post-surgery, compared to 41.3% of TKA/UKA patients.

03 Clinical Significance

This study suggests that remote monitoring rehabilitation is easy to use and increases motivation. THA patients felt strongly that these care management platforms could replace in-person post-surgical rehabilitation.

mymobility[®] Care Management Platform Can Help Reduce Post-operative Costs Following Knee Arthroplasty

Reference:

Lonner JH*, Naidu-Helm A**, VanAnandel DC**, Anderson MB**, Ditto R**, Redfern RE**, and Foran J* **Smartphone-Based Care Platform Versus Traditional Care in Primary Knee Arthroplasty in the United States: Cost Analysis** uHealth and mHealth. 2025, In press.

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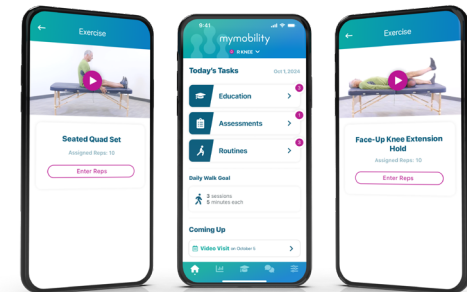
01 Study Design

A multi-center randomized controlled study aimed at evaluating early outcomes with the use of a smartphone-based exercise and educational care management system after knee arthroplasty.

- Partial and total knee arthroplasty patients.
- N=244 control arm.
- N=208 treatment arm.
- Reviewed all healthcare utilization 90 days after surgery:
 - Physical therapy (PT)
 - Readmission
 - Emergency department visit
 - Manipulation Under Anesthesia (MUA)
 - Physician office visit
- Cost from public sources and literature applied across the number of each type of visit.
- One and two-way sensitivity analyses performed across cohort.

02 Key Findings

- After considering the cost of the platform, average cost reduction per patient 90-days postoperative was \$732.
- The cost reduction was attributed mainly to the reduction in PT visits, where the total number of visits in the control arm was 1,736 vs. 799 in the treatment group.
- One and two-way sensitivity analyses demonstrated cost reductions of at least \$195 and up to \$759 per patient.



03 Clinical Significance

This patient care management app has the potential to reduce post-operative costs without negatively impacting outcomes resulting in improved value for knee arthroplasty patients.

Rehabilitation With Smartphone Apps and Wearable Devices: A Randomized Control Trial Systematic Review

Reference:

Gordon AM, Nian P, Baidya J, Scuderi GR*, Mont MA. **Randomized Controlled Studies on Smartphone Applications and Wearable Devices for Postoperative Rehabilitation After Total Knee Arthroplasty: A Systematic Review.** J Arthroplasty. E-published ahead of print January 20, 2025.

doi: [10.1016/j.arth.2025.01.034](https://doi.org/10.1016/j.arth.2025.01.034)

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01 Study Design

A systematic review including only Level 1 and Level 2 published studies that investigated smartphone applications and wearables for monitoring recovery post-operative total knee arthroplasty (TKA).

- 31 studies were evaluated:
 - 18 – smartphone applications
 - 8 – wearables
 - 5 – both
- Four mymobility® publications were included in this article:
 - ****Alexander et al (2024) – “Use of Smartphone-Based Care Platform... 1 Year Follow-up”**
 - ****Crawford et al (2021) – “Use of a Smartphone-Based Care Platform...”**
 - ****Tripuraneni et al (2021) – “A Smartwatch Paired with a Mobile Application...”**
 - ****Miller et al (2024) – “Completion of Patient-Reported Outcome Measures...”**

**Study funded by Zimmer Biomet.

02 Key Findings

- 17/18 studies on smartphone applications highlighted benefits including **patient satisfaction, improved gait, guided pain management and medication prescription, cost savings, and improved functional outcomes.**
- 7/8 studies on wearable technologies showed positive outcomes, accuracy in monitoring gait and motion, improved recovery, enhanced return to function, cost savings, and better pain management.
- 5/5 studies showcasing both smartphone applications and wearables emphasized patient satisfaction and overall mobility enhancement at 3 months post-operative.
- Smartphone applications can aid in post-operative recovery, decrease hospital readmissions, enhance satisfaction and improve engagement with healthcare teams.
- Enhanced early mobilization was a recurring theme throughout the studies analyzed.

03 Clinical Significance

Smartphone applications and wearable devices offer enhancements in post-operative rehabilitation following total knee arthroplasty. Improved adherence to care plans were prevalent, and data showed direct patient benefits and a promising potential of cost savings.

Comparable Rehabilitation Outcomes in Total Knee Arthroplasty (TKA) Between mymobility® Care Management Platform and Traditional Physical Therapy (PT)

Reference:

Tripuraneni KR, Foran JRH, Munson NR, Racca NE, Carothers JT. **A Smartwatch Paired With A Mobile Application Provides Postoperative Self-Directed Rehabilitation Without Compromising Total Knee Arthroplasty Outcomes: A Randomized Controlled Trial.** J Arthroplasty. 2021;36(12):3888-3893.

[doi:10.1016/j.arth.2021.08.007](https://doi.org/10.1016/j.arth.2021.08.007)

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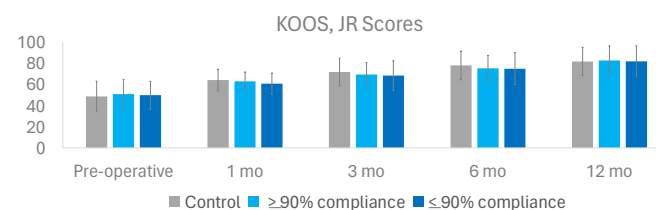
01 Study Design

A multi-center, prospective, randomized clinical study evaluating post-operative outcomes using the mymobility® Care Management Platform after total knee arthroplasty (TKA).

- n=337
 - Control group using traditional physical therapy (PT):
 - n=184.
 - mymobility group:
 - n=153.
 - High exercise compliance group (completion > 90%): n=90.
 - Low exercise compliance group (completion < 90%): n=63.
- Patient-reported outcome measures (PROMs), including KOOS, JR, EQ-5D-5L, along with range of motion (ROM) and manipulation under anesthesia, were assessed.

02 Key Findings

- The low-compliance group showed significantly less improvement in KOOS, JR scores from pre-operative levels at 3 and 6 months vs. control group.
- For the high compliance group there was no difference in KOOS, JR and EQ-5D-5L scores at 12 months vs. control group.
- The control group showed greater improvements in KOOS, JR scores from pre-operative levels at 6 months vs. the high compliance group
 - None of the significant differences in KOOS, JR scores reached the 8.02 unit threshold for minimal clinically important difference.
- No significant differences were found in: PROMs at other time intervals, manipulation under anesthesia rates, or range of motion (ROM).



03 Clinical Significance

At 1-year post-operative, clinical outcomes were similar between self-directed and traditional PT. A self-directed mobile application for patient recovery may be an appropriate alternative to traditional PT following TKA.

Lower Risk of Revision but Higher Odds of Delayed Wound Healing with the Direct Anterior Approach for Total Hip Arthroplasty within One-Year Post-operative

Reference:

Sarhan O, Imam N, Levine HB†, Redfern RE*, Ren AN*, Seidenstein†, Klein GR†. **Anterior Total Hip Arthroplasty is Associated with Lower Risk of Revision but Higher Odds of Delayed Wound Healing.** *Archives of Orthopaedic and Trauma Surgery.* 2025; 145,218. doi:10.1007/s00402-025-05844-6.

[doi:10.1007/s00402-025-05844-6](https://doi.org/10.1007/s00402-025-05844-6)

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01 Study Design

Secondary data analysis from a prospective cohort study (NCT03737149) utilizing the mymobility® digital care platform following THA. This study aims to compare common THA complications between Direct Anterior Approach (DAA) and Posterior Approach (PA)

- n=1722 (664 DAA, 1,058 PA)
- Incidence of revision, intra-operative fracture, and delayed wound healing
- One year follow-up data included
- Adjusted for age, BMI, comorbidities, pre-operative function, and sex

02 Key Findings

- Incidence of all complications varied on simple incidence analysis:
 - Intra-op fracture – 1.04% PAA vs 0.15% DAA, p=0.04.
 - Delayed wound healing – 0.95% PAA vs 2.56% DAA, p=0.02.
 - Revision – 2.08% PAA vs 0.75% DAA, p=0.04.
- After considering baseline characteristics, odds of peri-prosthetic fracture was no longer significantly associated with approach
- Only BMI and anterior approach were associated with delayed wound healing, with 3 times increased risk of wound healing problems associated with DAA compared to PAA
- Only anterior approach was associated with odds of revision after considering patient characteristics, with Odds Ratio OR=0.367 (95%CI 0.122 – 0.903, p=0.045) compared to posterior approach (reduced risk)

03 Clinical Significance

Direct anterior approach appeared to be associated with reduced risk of revision within one-year post-operative but higher rates of wound healing problems.

Improved Activity After Total Knee Arthroplasty (TKA): Analysis of the mymobility[®] Clinical Study

Reference:

Wu KA, Kugelman DN, Goel RK, et al. **Wearable health technology finds improvements in daily physical activity levels following total knee arthroplasty: A prospective study.** Knee Surg Sports Traumatol Arthrosc. Published online April 13, 2025.

doi:10.1002/ksa.12675

Patients must have internet access and a text-capable device or compatible smart phone to use mymobility[®]; not all features are available on the web-based version and patients should be assessed as clinically appropriate for remote care.

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01 Study Design

Secondary analysis of the mymobility observation cohort study from a subgroup of participants at Duke University:

- N=152
- Total Knee Arthroplasty (TKA) patients only
- Reviewed pre-operative through 12 months

Objective daily gait data collected via smartphone and smartwatch: step count, steadiness, standing hours, gait speed and 6-minute walk test (6MWT)

PROs collected during the study:

- KOOS JR (Knee Injury and Osteoarthritis Outcome Score
- Joint Replacement)EQ-5D (EuroQoL Five-Dimensional Questionnaire)

02 Key Findings

- Activity improvement was greatest at six months post-operative and persisted through 12 months post-operative (5180±260 steps, p<0.001).
- Gait speed increased to 1.01±0.01m/s, p=0.006 at 12 months post-operative.
- Daily standing hours also peaked at six months post-operative (11.47 vs. 9.99 hours, p<0.001) and maintained through the study period.
- There were significant improvements in KOOS, JR Scores with preoperative KOOS, JR scores improving from 52.09 ± 11.89 to 82.48 ± 13.22 at the 12-month post-operative period (p < 0.001). Likewise, EQ-5D scores demonstrated improvements from the pre-operative period (73.90 ± 17.83) to the 12-month post-operative period (85.69 ± 11.60)(p < 0.001)

03 Clinical Significance

The findings suggest there may be a “critical window” for recovery within the first six months post-operative. This study demonstrates the feasibility and value of the integration of wearable technology in post-operative monitoring of recovery in that crucial window.

WalkAI™ Identifies Patients Expected to Exhibit Low Gait Speed Early in Recovery After Arthroplasty

Reference:

Surmacz K*, Redfern RE,* Van Andel DC*, Kamath AF**. Machine learning model identifies patient gait speed throughout the episode of care, generating notifications for clinician evaluation. Gait Posture. 2024 Sep 6;114:62-68. doi: 10.1016/j.gaitpost.2024.09.001. PMID: 39260073.

*Zimmer Biomet Employee

**Zimmer Biomet Paid Consultant

WalkAI is available only to iPhone 8 or higher users, using iOS 14 or newer and are having or had a TKA, THA, or PKA.

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01 Study Design

A commercial and study database from a smartphone-based care management platform passively collected mobility data pre- and post-lower limb arthroplasty and was used to create a machine learning (ML) model to identify patients at risk of low gait speed. Notifications are sent to surgeons for patients identified.

- 2,680 patients from 203 unique sites were included:
 - 1,003 total hip arthroplasty
 - 1,920 total knee arthroplasty
 - 332 partial knee arthroplasty
- Model predicted 90-day gait speed and was compared to actual speed at 90-days to calculate performance.

02 Key Findings

- The model using data-based thresholds for notifications performed better than literature-based thresholds for gait speed.
- The described predictive model exhibited 95 % specificity to detect poor gait speed.
- Specificity was valued over sensitivity to prevent alarm fatigue.
- Prediction intervals from the model provide confidence in the prediction and the gait features that contributed to notification.
- This model allows for additional data to be included for retraining as populations evolve.

03 Clinical Significance

- Utilization of ML to predict gait recovery following total joint replacement is feasible with excellent specificity, enabling notification of physicians to intervene if necessary. Clinical team feedback will be useful to improve clinical utility of notifications.

ZBEdge™: Integration of Pre-, Intra-, and Post-operative Data with the mymobility® Care Management Platform and the ROSA® Knee System

Reference:

Lonner JH**, Anderson MB*, Redfern RE*, Van Andel D*, Ballard JC**, Parratte S.** An orthopaedic intelligence application successfully integrates data from a smartphone-based care management platform and a robotic knee system using a commercial database. *International Orthopaedics*. 2022;47(2):485-494. doi:10.1007/s00264-022-05651-3

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01 Study Design

Secondary data analysis of 131 patients from a commercial database who underwent robotic-assisted total knee arthroplasty (raTKA).

There were three categories:

- Balanced
- Slightly imbalanced
- Imbalanced

Collection of pre-operative to six-week post-operative step counts and KOOS-JR scores, were analyzed alongside intra-operative laxity measures to assess if intra-operative variables are associated with post-operative outcomes.

02 Key Findings

- There were higher step counts at six-weeks post-operatively in knees with >2 mm laxity in both the lateral compartment in extension and medial compartment in flexion ($p < 0.05$)
- Knees balanced in flexion within <0.5 mm had higher KOOS-JR scores at six-weeks post-operative ($p = 0.034$) compared to slightly imbalanced knees (0.5 – 1.5 mm difference in laxity between compartments)
- Slightly imbalanced and imbalanced knees (> 1.5mm difference in laxity between compartments) in extension had significantly greater step counts at six-weeks compared to balanced knees

03 Clinical Significance

The study demonstrates the feasibility of data collection throughout the episode of care.

The ability of the mymobility® Care Management Platform to be integrated with intra-operative data from the ROSA® Knee System using an intelligence platform consisting of commercial data is feasible.

ROSA Knee Topics

Jump To:

- 2024 ROSA Knee Clinical Evidence Summary

Data-Driven

- High Variability in Soft Tissue Laxity During TKA
- Predictive factors for MCL release
- Assessing and Classifying Intra-operative Knee Laxity

Surgeon-Centred

- Personalised Alignment
- Eight Steps for Performing Inverse Kinematic Alignment
- Less Physician Stress and Strain

Accurate

- Low Volume Surgeons
- Compared to Conventional Instrumentation
- Compared to Navigated Technology
- Cutting Angles and Impact Placement
- Superior Precision
- Fewer Outliers Compared to Conventional
- Accuracy Across the Workflow – Meta-analysis
- Achieving Precise Bone Resections

Efficient

- Compared to Conventional After 70 Cases
- Good Accuracy Without Added Time
- Similar Times Compared to Conventional After 30 Cases
- Efficiency Improvements in Planning Time



ROSA Knee Topics (cont.)

Jump To:

Initial Learning Curve

- Learning Curve of 6-11 Cases
- Learning Curve in Three Cases
- No Learning Curve for Achieving Pre-Operative Plan
- Evaluating Across Different Robotic-Assisted TKA Systems
- Evaluating the Initial Learning Curve With Three Surgeons
- Evaluating Institutional Proficiency
- Significant Reduction in Operative Time After 10 Cases

Clinical Efficacy:

- Implant Positioning
- No Differences in Pin-Site Complications
- Faster Post-Operative Improvements
- Recovery of Range of Motion
- Study Limitations
- Odds of Early Revision

Surgical Technique/Philosophy

- Improved Recovery
- Less Deviations
- Personalised Alignment
- Achieving Balanced Functional Alignment
- Eight Steps for Performing Inverse Kinematic Alignment
- Accurate Distal Femoral Resurfacing



ROSA Knee Topics (cont.)

Jump To:

Outcomes

- Successful One-Year Outcomes
- Challenging the 80% Satisfaction Rate
- Compared to Imageless Navigation
- In Severe Deformities
- Excellent Knee Function in Patients

Versus Mako Total Knee

- Significantly Shorter Operative Times than Mako
- Significantly Less Radiation Exposure than Mako
- After 30 Cases
- Component Positioning Accuracy
- Similar Learning Curve between ROSA Knee and Mako Knee

Designed for Advanced Detection

- Assessing the Dynamic Hip-Knee-Ankle Axis

Additional Perspective

- Addressing Flawed Research Methods
- Regarding Flawed Radiographic Methods
- Showed Flawed Research Methods and Measurement Validity
- Correcting Methodological Flaws and Validation Measurements



The ROSA® Knee System: High Variability in Soft Tissue Laxity During Total Knee Arthroplasty

Reference:

Weiner TR, Shah RP, Neuwirth AL, Geller JA, Cooper HJ. **Soft tissue laxity is highly variable in patients undergoing total knee arthroplasty.** *Arthroplasty.* 2024;6(1):45. Published 2024 Aug 7.

[doi:10.1186/s42836-024-00268-w](https://doi.org/10.1186/s42836-024-00268-w)

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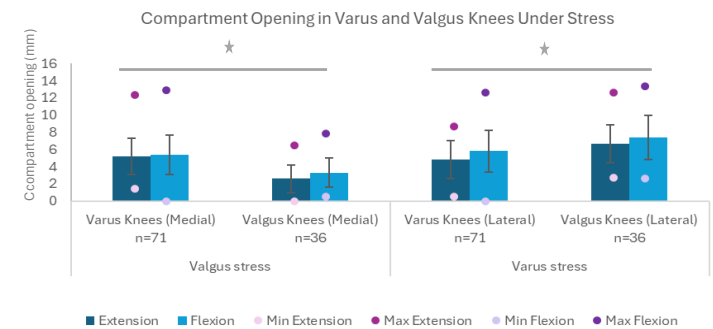
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01 Study Design

- A single institution retrospective study evaluating pre-operative deformity data and assessing intra-operative maximal medial and lateral opening during dynamic stress tests in flexion (85–95°) and extension (-5–20°) using the ROSA® Knee System in Total Knee Arthroplasty (TKA) patients.
- n=113
 - Pre-operative varus deformity n=71
 - Pre-operative valgus deformity n=36
 - Neutral pre-operative alignment n=6

02 Key Findings

- Valgus stress opened the medial compartment by 4.3 mm in extension and 4.6 mm in flexion (average across all knees).
- Varus stress opened the lateral compartment by 5.4 mm in extension and 6.2 mm in flexion (average across all knees).
- Soft tissue laxity showed high variability (0–13 mm).



*Statistical significance based on comparisons between varus and valgus knees under stress conditions

03 Clinical Significance

Soft tissue laxity in TKA varies widely (0–13 mm) and has limited predictability based on pre-operative deformity. The ROSA Knee System enables real-time, intra-operative assessment that may help surgeons adopt a “patient-specific” approach to better anticipate bone resections and soft tissue releases to optimize gait balance.

The ROSA® Knee System: Key Predictors for Deep Medial Collateral Ligament (MCL) Release in Total Knee Arthroplasty

Reference:

Thongpulsawasdi, N., Achawakulthep, C., Intiyanaravut, T. et al. **Predictive factors for deep medial collateral ligament release in adjusted mechanical alignment total knee arthroplasty.** J Orthop Surg Res 19, 594 (2024).

<https://doi.org/10.1186/s13018-024-05046-7>

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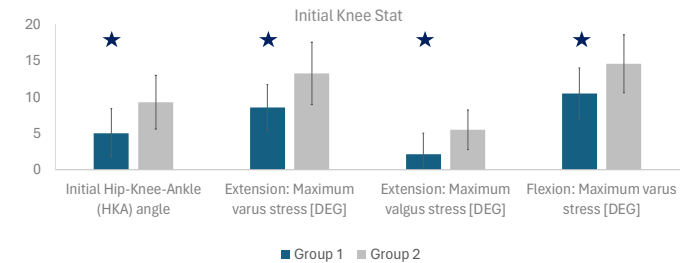
01 Study Design

A retrospective study examining the correlation between pre-operative factors, initial knee conditions, and the need for deep medial collateral ligament (MCL) release in adjusted mechanical alignment with ROSA® Knee for total knee arthroplasty (TKA).

- n= 61.
- Patients were divided into two groups:
 - Without soft tissue release (group 1): n=29.
 - With soft tissue release (group 2): n=32.
- Soft tissue release was performed when clinically indicated.

02 Key Findings

- 52% of patients (32/61) required deep MCL release.
- Patients in group 1 had lower pre-operative hip-knee-ankle (HKA) angles, less varus alignment in stress tests and a greater range of motion during flexion vs. group 2.



* Significantly different from Group 2.

- There were no significant differences between the groups in femoral component position and post-operative soft tissue laxity during stress tests.
- A pre-operative HKA of 6.25 degrees or greater was predictive of the need for soft tissue release.

03 Clinical Significance

The study emphasizes the role of the initial HKA angle and stress tests with ROSA Knee in predicting deep MCL release during TKA, with the HKA angle threshold helping to reduce unnecessary soft tissue release.

The ROSA® Knee System: Assessing and Classifying Intra-operative Knee Laxity

Reference:

Kenanidis, E., Milonakis, N., Maslaris, A. et al. **Robotic evaluation of articular laxity (REAL) classification: a new intraoperative knee soft-tissue laxity classification using ROSA robotic software.** Eur J Orthop Surg Traumatol 35, 139 (2025).

<https://doi.org/10.1007/s00590-025-04265-w>

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01 Study Design

A two-phase study evaluating the ROSA Knee System for categorizing intra-operative knee laxity in imageless robotic-assisted total knee arthroplasty (ra-TKA).

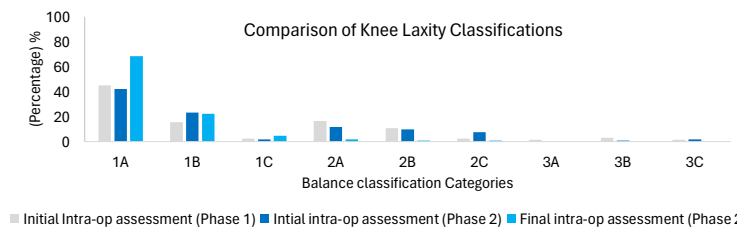
- **Phase 1 (N=120):** Medial and lateral knee laxity were measured in both extension and 90° flexion. The difference of these values was used to form a new classification system.
 - Laxity was categorized into three groups based on a standard deviation of about 2.5 mm
 - Mild: Medial/Lateral difference < 2.5 mm
 - Moderate: Medial/Lateral difference 2.5 mm – 5 mm
 - Severe: Medial/lateral difference > 5 mm
- **Phase 2 (N=102):** Validated the classification by assessing knee laxity before and after surgery.

02 Key Findings

- The combination of extension and flexion categories resulted in nine distinct knee laxity phenotypes:

Extension Category	Flexion Category A (<2.5 mm)	Flexion Category B (2.5–5 mm)	Flexion Category C (>5 mm)
1 (<2.5 mm)	1A	1B	1C
2 (2.5–5 mm)	2A	2B	2C
3 (>5 mm)	3A	3B	3C

- In phase 2, 93% of patients had a “balanced knee” (1A) or “almost balanced knee” (2A, 1B respectively).



03 Clinical Significance

The study identified nine intra-operative knee laxity patterns, highlighting ROSA Knee’s ability to assess soft-tissue balance intra-operatively.

The ROSA® Knee: Personalized Alignment Surgical Technique

Reference:

Massé V*, Cholewa J** and Shahin M (2023) **Personalized alignment™ for total knee arthroplasty using the ROSA® Knee and Persona® knee systems: Surgical technique.** *Front. Surg.* 9:1098504. doi: 10.3389/fsurg.2022.1098504

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01 Study Design

Dr. Vincent Massé describes how to perform a personalized technique with restricted kinematic alignment (rKA) using ROSA® Knee and the Persona® Knee systems.

This surgical technique paper covered the following topics:

- Differences between rKA and mechanical alignment.
- rKA boundaries.
- Image-based and imageless pre-operative planning.
- Anatomic landmarking.
- Intra-operative evaluation, planning and adjustment, and validation.
- Laxity assessments.
- Expected outcomes.

02 Key Findings

- The purpose of rKA is to recreate pre-arthritis anatomy by maintaining a patient's individual native soft tissue tensions.
- The boundaries for rKA are:
 - Arithmetic hip-knee-ankle angle: 0 ± 3
 - Distal femoral coronal angle: $0 \pm 5^\circ$
 - Proximal tibial coronal angle: $0 \pm 5^\circ$
- ROSA Knee allows the surgeon to perform valgus and varus stress tests at 10° and 90° to assess native ligament laxity and maximal deformity correction.
- Robotic validation is performed after the femoral and tibial resections, and allows the surgeon to adjust the pre-operative plan and obtain final information on the accuracy of the resections. The Personalized Alignment technique minimizes soft tissue release, however, anatomical corrections in excess of $2\text{-}3^\circ$ will often necessitate ligament releases.

03 Clinical Significance

The ROSA® Knee System allows for a personalized approach using a restricted kinematic alignment philosophy in primary total knee arthroplasty.

The ROSA® Knee System: Eight steps for performing Inverse Kinematic Alignment

Reference:

Eijking, H.M., Dorling, I., van Haaren, E. et al. **Image-based robotic (ROSA® knee system) total knee arthroplasty with inverse kinematic alignment compared to conventional total knee arthroplasty.** J Orthop Surg Res 20, 47 (2025).

<https://doi.org/10.1186/s13018-024-05427-y>

Study was funded by Zimmer Biomet

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01 Study Design

A randomized, controlled trial protocol investigating patient-reported outcomes, adverse events, and implant survival between the ROSA® Knee System (raTKA) and conventional total knee arthroplasty (cTKA).

- cTKA patients will receive mechanically aligned TKAs.
- Alignment in raTKA patients will be performed with Inverse Kinematic Alignment (iKA).
- The iKA strategy involves an eight-step technique that prioritizes:
 - Gap balancing in both knee flexion and extension, with slight lateral laxity in flexion
 - Mid-flexion stability
 - Functional knee alignment
 - Restoration of the joint-line orientation and posterior condylar offset
 - Preservation of patella height
 - Minimal soft tissue releases, with consideration for necessary adjustments during surgery

02 Key Findings

The eight steps for iKA include:

1. Setting the tibial slope with a goal of replicating the native slope, with specific limits (e.g., 0-10 degrees), depending on implant used.
2. Aligning the tibia in varus/valgus, matching the Medial Proximal Tibial Angle (MPTA) and allowing for varus deviation within set limits, while limiting valgus deviation in knees with correctable valgus deformities.
3. Determining femoral rotation with a maximum of 5 degrees external rotation.
4. Matching medial posterior resection to the total component thickness, aiming for 9 mm resection.
5. Aligning tibia resection level to accommodate total implant thickness.
6. Refining femur alignment in varus/valgus to achieve balanced gap extension and adjusting the distal femur resection level for uniform gap balance. Then fine-tuning the tension of the medial collateral ligament (MCL), especially in extension, to achieve optimal soft tissue balance.
7. Limiting distal femur resection to 9 mm, with special considerations for extensions deficits or hyperextensions.
8. Adjusting femur size to a stylus height between 0 and 0.5 mm, while limiting femoral flexion between 2-4°.

03 Clinical Significance

This study protocol presents a detailed algorithm to perform Inverse Kinematic Alignment with the assistance of the ROSA Knee System with minimal alterations to standard surgical workflow.

The ROSA® Knee System: Less Physician Stress and Strain with ROSA Total Knee Arthroplasty

Reference:

Haffar A, Krueger CA, Goh GS, Lonner JH. Total Knee Arthroplasty with robotic surgical assistance results in less physician stress and strain than conventional methods. *The Journal of Arthroplasty*. 2022;37(6). doi:10.1016/j.arth.2021.11.021

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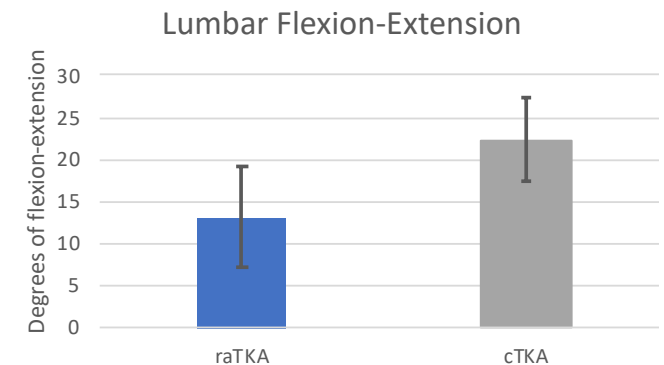
01 Study Design

A single center, single-surgeon study to evaluate surgeon stress and strain during robotic-assisted Total Knee Arthroplasty (rTKA) and conventional Total Knee Arthroplasty (cTKA)

- 40 consecutive unilateral TKAs (20 rTKAs, 20 cTKAs)
- The study utilized heart rate, heart rate variability, respiratory rate, minute ventilation, and energy expenditure as indicators of physiological stress. For assessing intraoperative ergonomics, measurements included cervical, lumbar, and shoulder movements

02 Key Findings

- Energy expenditure rate was lower in rTKA than cTKA
- Average heart rate was lower in rTKA
- rTKA resulted in less lumbar flexion and a reduction in the time spent in demanding lumbar flexion
- Neck rotation was significantly reduced by rTKA



03 Clinical Significance

Robotic-assisted TKA with the ROSA Knee System may improve the surgeon's operative experience by reducing the physiologic and ergonomic strain associated with total knee arthroplasty, however more studies are needed to support this.

The ROSA® Knee System: Improved Accuracy in Low-Volume Surgeons

Reference:

Byrne C, Durst C, Rezzadeh K, Rockov Z, Moon C, Rajae S. Robotic-assisted total knee arthroplasty reduces radiographic outliers for low-volume total knee arthroplasty surgeons. *Arthroplasty Today*. 2024;25:101303. doi: 10.1016/j.artd.2023.101303

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01 Study Design

A single, low-volume surgeon retrospective evaluation of early radiographic and clinical outcomes comparing robotic-assisted (raTKA) to conventional (cTKA) total knee arthroplasty (TKA).

- Surgeon averages 30 TKAs annually
- raTKA: n=19
- cTKA: n=41
- Radiographic analysis:
 - Tibial slope
 - Tibial coronal alignment
 - Presence of notching
- Patient-Reported Outcomes Measures Information System (PROMIS) assessed at one- and three-months post-operative

02 Key Findings

- Significantly less tibial slope outliers in raTKA compared to cTKA
 - (0% vs. 22%)
- Significantly less cases of notching in raTKA compared to cTKA
 - (0% vs. 20%)
- Length of stay was significantly less in raTKA by approximately 20 hours
- There were no differences in operative times between groups
- There were more manipulations under anesthesia (2 vs. 0) and revisions (2 vs. 5) with cTKA compared to raTKA
- There were no significant differences in PROMIS scores
 - Small sample size and high attrition resulted in low statistical power

03 Clinical Significance

Robotic-assisted TKA with the ROSA Knee System significantly decreases radiographic outliers and length of stay without affecting the rate of complications or early patient reported outcome measures in low-volume surgeons.

The ROSA® Knee System: Greater Precision and Reproducibility Compared to Conventional Instrumentation

Reference:

Seidenstein A, Birmingham M, Foran J, Ogden S. Better accuracy and reproducibility of a new robotically-assisted system for total knee arthroplasty compared to conventional instrumentation: A Cadaveric study. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2020;29(3):859-866. doi:10.1007/s00167-020-06038-w

*Cadaveric studies are not necessarily indicative of clinical performance. Study was funded by Zimmer Biomet.

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01 Study Design

A cadaveric study* comparing the accuracy of robotic vs. conventional Total Knee Arthroplasty (TKA)

- 14 robotically assisted (ROSA Knee System) vs. 20 conventional TKAs
- Performed by four high-volume, board-certified arthroplasty surgeons (only one with prior robotics experience) using three different implant systems
- Accuracy in angle/level of bone resections evaluated via optical navigation/caliper vs. plan

02 Key Findings

- Resection angles were more precise with the ROSA Knee System compared to conventional instruments for all four measured angles
 - The mean difference between the planned and executed angles was between 0.5 and 1.3° ROSA Knee compared to 1.1 to 2.4° with conventional instrumentation
- Two of three measured resection levels were more precise with ROSA Knee compared to conventional instrumentation
 - Mean differences between planned and executed levels was 0.6 to 0.7 mm for ROSA Knee compared to 1.0 to 2.4 mm for conventional

03 Clinical Significance

The ROSA Knee System produces more accurate and reproducible bone resection angles and levels compared to conventional instrumentation.

The ROSA® Knee System: Greater Precision and Reproducibility Compared to Navigated Technology

Reference:

Mancino F, Rossi SM, Sangaletti R, Caredda M, Terragnoli F, Benazzo F. Increased accuracy in component positioning using an image-less robotic arm system in primary total knee arthroplasty: A retrospective study. Archives of Orthopaedic and Trauma Surgery. Published online 2023. doi:10.1007/s00402-023-05062-y

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01 Study Design

A retrospective analysis comparing the accuracy and reproducibility of robotic-assisted Total Knee Arthroplasty (raTKA) to navigated Total Knee Arthroplasty (nTKA) by a three surgeons at a single institution

- raTKA: n=86
- nTKA: n=86
- Comparison of plan to 3-month post-operative radiographs
- Hip-knee-ankle (HKA) axis, femoral coronal alignment, femoral sagittal alignment, tibial coronal alignment, and tibial slope assessed

02 Key Findings

- There were fewer outliers ($>1^\circ$) for HKA in raTKA (47.7%) compared to nTKA (81.4%). The mean deviation was also less in raTKA (1.3° vs. 1.9°)
- Mean deviation from femoral sagittal target was less in raTKA (0.9° vs. 1.9°)
- Mean deviation from tibial coronal target was less in raTKA (0.8° vs. 1.5°)
- Mean tibial slope deviation was also less in raTKA (0.9° vs. 1.7°)
- There were no differences in femoral coronal angle deviations between groups

03 Clinical Significance

The ROSA Knee System produces more accurate and reproducible component position angles in the sagittal plane for both femoral and tibial components, and the coronal plane for the tibial component compared to navigated TKA.

The ROSA® Knee System: High Accuracy of Cutting Angles and Implant Placement

Reference:

Hasegawa M, Tone S, Naito Y, Sudo A. Two- and three-dimensional measurements following robotic-assisted total Knee Arthroplasty. The International Journal of Medical Robotics and Computer Assisted Surgery. 2022;18(6). doi:10.1002/rcs.2455

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01 Study Design

Single center study comparing radiographic (2D) and computed tomography (3D) measurements in robotic-assisted TKA. Discrepancies calculated between 2D and 3D measures of component alignments by comparing the intended angles, the actual cutting angles, and the confirmed implantation angles.

- n=38 patients undergoing TKA

02 Key Findings

- **The ROSA Knee System showed high accuracy** for the validated cutting angle compared to post-operative 2D radiographs
 - Zero outliers for the femoral or tibial coronal and sagittal angles with all cutting errors less than 0.8°
- **The ROSA Knee System showed high accuracy** for the validated cutting angle compared to post-operative 3D CT scans :
 - 1 outlier out of 38 cases
 - Femoral coronal and sagittal cutting errors of 0.9 and 1.7°, respectively
 - Tibial coronal and sagittal cutting errors of 1.2 and 1.0°, respectively
- **Interpretive note:** Although 3D CT scans are more reliable, 2D radiographs are more commonly performed clinically to evaluate post-operative component implantation but are more dependent on patient and X-ray positioning, which may introduce error
 - Regardless, the authors found **no difference in final implant positioning between 2D and 3D imaging**

03 Clinical Significance

“...this new robotic system demonstrated high accuracy [for resection angle and implant placement] in 2D and 3D measurements...”

The ROSA® Knee System: Superior Precision In Vivo Compared to Conventional Instrumentation

Reference:

Schrednitzki D, Horn CE, Lampe UA, Halder AM. Imageless robotic-assisted total knee arthroplasty is accurate in vivo: A retrospective study to measure the postoperative bone resection and alignment. Archives of Orthopaedic and Trauma Surgery. 2022;143(6):3471-3479. doi:10.1007/s00402-022-04648-2

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01 Study Design

Single center, retrospective study evaluating the precision of the ROSA Knee System for total knee arthroplasty (TKA) and its effectiveness in reducing outliers compared to conventional instruments

- n=71 robotic-assisted TKAs
- n=308 conventional TKAs
- Comparative analysis of bone sections intraoperatively planned vs. radiographically measured
- Analysis of post-operative alignment

02 Key Findings

- Significantly lower rate of the hip-knee-ankle angle outliers ($\pm 3^\circ$) in ROSA Knee compared to conventional TKA
 - Zero outliers in ROSA Knee cases compared to 75 (24.3%) in conventional TKA cases
 - Average deviation from the planned angle was significantly less with ROSA Knee compared to conventional TKA (1.01 vs. 2.05°, respectively)
- All ROSA Knee-assisted bone resections showed a high degree of precision
 - Average bony resection accuracies were within 0.4 mm for all six cuts
 - No resections in any cases were greater than 2 mm from the planned cut

03 Clinical Significance

“The [ROSA Knee System] is accurate in terms of the coronal alignment and bone resections. [This study] ... shows that the accuracy previously reported only in cadavers can also be achieved in patients.”

The ROSA® Knee System: High in-vivo Accuracy Across the Workflow

Reference:

Zaidi F, Goplen CM, Fitz-Gerald C, Bolam SM, Hanlon M, Munro JT*, Monk AP*. High in-vivo accuracy of a novel robotic-arm-assisted system for total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc.* 2024 May 20. doi: 10.1002/ksa.12272.

Study funded by Zimmer Biomet.

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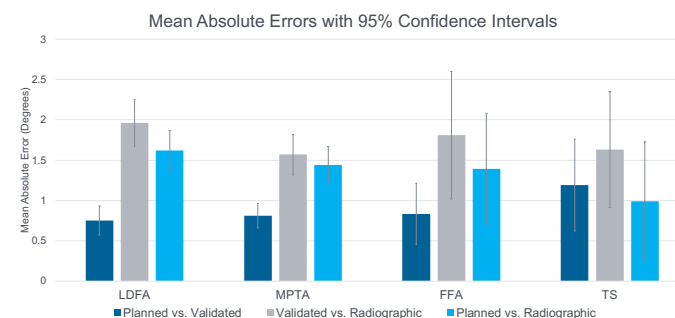
01 Study Design

A single center, multiple surgeon retrospective analysis of patients undergoing robotic-assisted total knee arthroplasty (raTKA) with The ROSA® Knee System.

- Three surgeons contributed a total of 74 cases.
- The pre-operative planned, robotic-validated, and three-month post-operative radiographically measured angles were compared for the:
 - Lateral distal femoral angle (LDFA)
 - Medial proximal tibial angle (MPTA)
 - Femoral flexion angle (FFA)
 - Tibial slope (TS)

02 Key Findings

- The mean absolute error between measures were all less than 2° for each angle investigated, without significant differences between planned, validated, and post-operative X-rays.
- High reliability was also reported, with the standard deviations of the errors all less than 1.5°.
- The proportion of cases with radiographically measured angles greater than 3° from the planned angle was 6.8%, 4.7%, 2.7%, and 5.4% for the LDFA, MPTA, FFA, and TS, respectively.



03 Clinical Significance

The ROSA Knee System supports high accuracy and reliability of executing the pre-operative plan in the coronal and sagittal planes across the surgical workflow.

The ROSA® Knee System: High Accuracy With Less Outliers Compared to Conventional TKA

Reference:

Zaidi F, Goplen CM, Bolam SM, Monk AP*. Accuracy and Outcomes of a Novel Cut-Block Positioning Robotic-Arm Assisted System for Total Knee Arthroplasty: A Systematic Review and Meta-Analysis. Arthroplast Today. 2024;29:101451. Published 2024 Aug 4. doi:10.1016/j.artd.2024.101451

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01 Study Design

A systematic review and meta-analysis evaluating the accuracy, precision, functional outcomes and complications of the ROSA® Knee System.

- A total of 17 studies were evaluated.
- 9 studies included a control group of conventional TKA (cTKA).
- 10 studies evaluated accuracy and precision.
 - 3 compared the intra-operative plan to post-operative radiographs
 - 7 compared the intra-operative plan to intra-operative ROSA Knee validated measure
 - Accuracy was defined as the mean difference between planned and post-operative radiographical angles.
 - Precision was the standard deviations of the mean differences.

02 Key Findings

- 5 of the included studies reported the percentage of hip-knee-ankle angle (HKA) outliers (>3° of planned) between ROSA Knee and cTKA.
 - 3 studies reported a significant difference favoring ROSA Knee,
 - 1 study reported no statistical difference,
 - 1 study reported 0 of 14 outliers in ROSA Knee and 5 of 25 (25%) in cTKA but did not conduct a statistical analysis.
- There were no differences in complications between ROSA Knee and cTKA.
- 2 studies reported significantly greater changes in Knee Society Score function at 6-months and 1-year post-operative with ROSA Knee compared to cTKA.
- 2 studies reported a learning curve of 5-15 cases and one reported 70 cases to become time neutral.

Pooled Accuracy as measured by Precision of ROSA Knee

	Mean Absolute Difference	Standard Deviation
Lateral Distal Femoral Angle	0.61	0.97
Medial Proximal Tibial Angle	0.61	1.26
Tibial Slope	0.75	1.34
Femoral Flexion	1.87	1.11

03 Clinical Significance

The ROSA Knee System demonstrates high accuracy and precision across multiple studies in this meta-analysis. TKA with ROSA Knee is associated with less HKA outliers and greater improvements in post-operative function.

The ROSA® Knee System: Highly Accurate Resection Thickness in vivo

Reference:

Gamie, Z., Kenanidis, E., Douvlis, G., Milonakis, N., Maslaris, A. and Tsiridis, E. (2024), **Accuracy of the Imageless Mode of the ROSA Robotic System for Targeted Resection Thickness in Total Knee Arthroplasty: A Prospective, Single Surgeon Case-Series Study.** Int J Med Robot, 20: e70029.

<https://doi.org/10.1002/rcs.70029>

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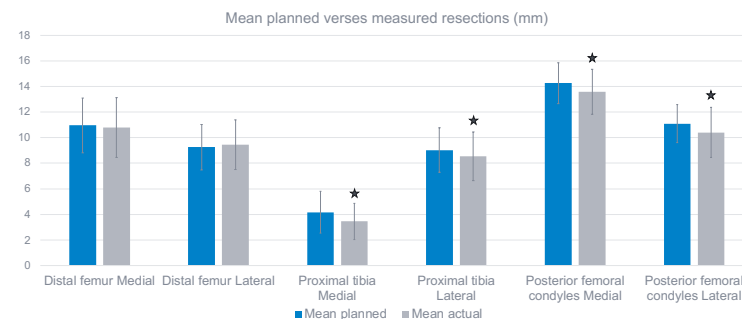
01 Study Design

A single-surgeon, single-center prospective cohort study investigating the accuracy of bone resection depth with the ROSA® Knee System in total knee arthroplasty (TKA).

- N=44 patients indicated for TKA with primary osteoarthritis diagnosis.
- All TKAs performed were imageless.
- Resected bone from the medial and lateral aspect of 3 regions (distal femur, proximal tibia, posterior femoral condyles) were measured with calipers and compared to the intra-operative plan.

02 Key Findings

- The mean difference between planned and measured resection thickness ranged from 0.67 mm to 1.1 mm for all six measured parameters.
- Resection accuracy was greatest in the distal femur and least in the posterior femoral condyles.
 - Medial and lateral mean difference of 0.67 and 0.94 mm, with 84.1% and 77.% of resection differences less than 1 mm, respectively.
 - Medial and lateral mean difference of 1.1 and 1.04 mm, with 56.8% and 65.9% of resection differences less than 1 mm, respectively.



* Significantly different from planned resection.

03 Clinical Significance

The ROSA Knee System achieves precise bone resections in patients undergoing primary total knee arthroplasty.

The ROSA® Knee System: No Differences in Operative Time Compared to Conventional Total Knee Arthroplasty After 70 Cases

Reference:

Kenanidis E, Boutos P, Sitsiani O, Tsiridis E. The Learning Curve to Rosa: Cases needed to match the surgery time between a robotic-assisted and a manual primary total knee arthroplasty. *European Journal of Orthopaedic Surgery & Traumatology*. 2023;33(8):3357-3363. doi:10.1007/s00590-023-03554-6

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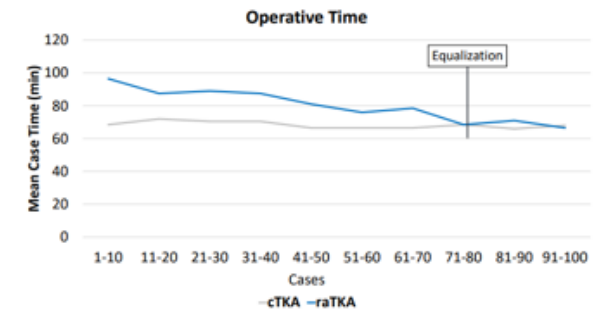
01 Study Design

A retrospective comparative cohort study between robotic-assisted (raTKA) and conventional (cTKA) total knee arthroplasty cases

- Single high-volume surgeon
- First 100 raTKA cases compared to 100 cTKA cases
- Operative time defined as first incision to wound closure
- Cases were grouped by ten and compared between techniques

02 Key Findings

- Average operative times were significantly less with cTKA after 71-80 cases
- Time neutrality with cTKA occurred between 63-72 cases
- No pin site or other raTKA specific complications were observed



03 Clinical Significance

Achieving a time neutral robotic procedure, compared to conventional TKA, is feasible and has been shown to require approximately 70 cases in this study for a senior surgeon.

The ROSA® Knee System: Shows Good Accuracy Without Increasing Operative Times

Reference:

Bolam SM, Tay ML, Zaidi F, et al. Introduction of rosa robotic-arm system for total knee arthroplasty is associated with a minimal learning curve for operative time. *Journal of Experimental Orthopaedics*. 2022;9(1) doi:10.1186/s40634-022-00524-5

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01 Study Design

A single center study by three high-volume orthopedic surgeons to evaluate the impact of integrating the ROSA Knee System into the surgical workflow.

- Prospective cohort
- 83 Conventional Jig-based TKAs vs. 53 Robotic Surgical Assistant (ROSA) system TKAs
- Cumulative Summation (CUSUM) for learning curves in operative times
- Outcomes Reviewed: Peri-operative and delayed complications (infection, periprosthetic fracture, thromboembolism, wound healing issues), and surgical revisions

02 Key Findings

- Proficiency using the ROSA Knee System was achieved after **8.7 cases on average** (range: 5-15 cases)
- **No significant differences in operating time** (skin-to-skin) between the learning phase or proficiency phase of the ROSA Knee System nor the conventional TKA procedure
 - Learning phase (114+17 minutes)
 - Proficiency phase (110+20 min)
 - Conventional TKA (110+20 min)
- **Component planning and implantation accuracy did not have a learning curve**
- There were **no adverse events, complications, or revisions** with the ROSA Knee System

03 Clinical Significance

“The learning curve associated with introducing the ROSA Knee System ... was relatively **short and did not lead to increases in operative time or any additional complications or adverse events** for case performed during the learning phase.”

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Robotic-Assisted TKA: Similar Operative Times to Conventional TKA After 30 Cases

Reference:

Ejnisman L, Antonioli E, Cintra L, de Oliveira Souza PG, Costa LAV, Lenza M. Robot-assisted knee arthroplasty: Analyzing the learning curve and initial institutional experience. *Comput Struct Biotechnol J*. 2024 Apr 12;24:343-349. doi: 10.1016/j.csbj.2024.04.013.

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01 Study Design

A single center, retrospective review of robotic-assisted (rTKA) and conventional (cTKA) cases using either the ROSA® Knee System or Mako®.

- 617 cases of rTKA and cTKA were performed by 80 surgeons.
 - rTKA: n=321
 - cTKA: n=296
- Surgeons who had performed more than 10 rTKA cases were classified as “proficiency stage surgeons”.
- Surgeons with less than 10 rTKA cases were classified as “initial stage surgeons”.
- Operative time was defined as the time between initial skin incision to final wound closure.

02 Key Findings

- Significant differences in operative times were found between the first and last 10 rTKA cases (177.5 vs. 145 minutes) for five surgeons who had reached the proficiency stage.
- There were no differences in operative times between the surgeon’s last 10 rTKA and cTKA cases (145 vs. 150 minutes).
- 30 rTKA cases were required by proficiency-stage surgeons to reach an rTKA operative time less than that of cTKA.
- The number of cases necessary to reach the proficiency stage was highly variable, depending on the level of surgeon experience, ranging from 12 to 41 cases.
- There was no difference in clinical outcome measures between the groups pre- or 90 days post-operatively.

03 Clinical Significance

Robotic-assisted TKA is associated with a learning curve of 12 to 40 cases, depending on individual skill. Surgeons may expect their rTKA operative times to be equal to or less than their cTKA operative times after approximately 30 rTKA cases.

The ROSA® Knee System: Efficiency Improves with Experience

Reference:

Braathen, D. L., Wallace, C., Clapp, I. M., Blackburn, B. E., Peters, C. L., & Archibeck, M. J. (2025).

Improved Efficiency and Intraoperative Planning With 1 Robot-Assisted Total Knee Arthroplasty System. *Arthroplasty Today*, 33, 101684.

doi.org/10.1016/j.artd.2025.101684

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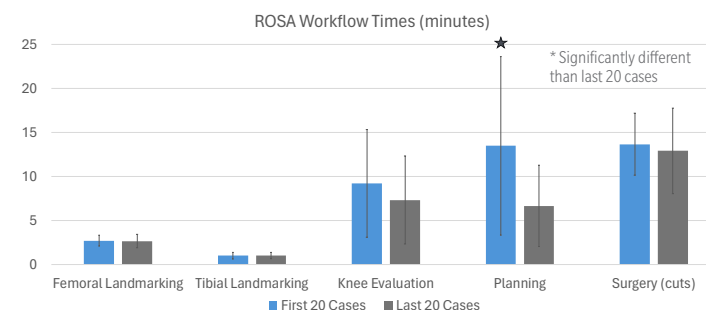
01 Study Design

A retrospective, single high-volume institution, two-surgeon, study evaluating improvements in efficiency following adoption of the ROSA Knee System with Persona® Knee.

- N=150
 - First 75 cases by each surgeon
- All cases were imageless with functional alignment
- The operating team remained constant for all cases
- Total operating time was recorded as inflation of the tourniquet to removal.
- The following time metrics were collected from ROSA logs:
 - Knee evaluation time
 - Landmarking time
 - Planning time
 - Femoral and tibial cut time

02 Key Findings

- Operating time significantly decreased between the surgeon's first 20 cases compared to the final 20 cases (61.4±8.9 vs. 56.7±8.6 min).
- Improvements in planning time were the greatest contributor to the reduced operating times.
 - Improved knee state evaluation times also contributed to improved efficiency; however, the difference between the first and last 20 cases was not statistically significant.



03 Clinical Significance

The technical steps in the ROSA Knee System workflow quickly translate from previous techniques, and reductions in operating time over the first 75 cases are primarily driven by improvements in intra-operative planning efficiency.

The ROSA® Knee System: An Initial Learning Curve of 6-11 Cases

Reference:

Vanlommel L, Neven E, Anderson MB, Bruckers L, Truijen J. The initial learning curve for the ROSA® knee system can be achieved in 6-11 cases for operative time and has similar 90-day complication rates with improved implant alignment compared to manual instrumentation in total knee arthroplasty. *Journal of Experimental Orthopaedics*. 2021;8(1). doi:10.1186/s40634-021-00438-8

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01 Study Design

A retrospective study to determine the learning curve for the ROSA Knee System in Total Knee Arthroplasty (TKA)

- n=180 patients
- Three high-volume orthopaedic surgeons (over 200 cases/year)
 - 90 underwent robotic-assisted TKA (raTKA) using the ROSA Total Knee System
 - 90 underwent manual TKA (mTKA)
- Follow-up: minimum three months

02 Key Findings

- A change point of 6 to 11 cases for each of three surgeons for operative times suggests a rapid initial learning curve
 - Total surgical times continued to decrease with time
- The proportion of outliers for the final hip-knee-ankle angle compared to planned was 5.2% (3/58) for the mastered raTKA compared to 24.1% (19/79) for mTKA ($p=0.003$)
- The absolute mean difference between the validated and planned resections for all angles evaluated was $<1^\circ$ for the mastered raTKA cases

03 Clinical Significance

The ROSA Knee System can be adopted rather quickly regarding the initial learning curve. This was measured as the initial cut point for reducing surgical time back to the mean surgical time. Improvements in accuracy compared to manual TKA were seen in the mastered robotic-assisted TKA cases.

The ROSA® Knee System: An Initial Learning Curve in as Little as Three Cases

Reference:

Dragosloveanu S, Petre M-A, Capitanu BS, Dragosloveanu CD, Cergan R, Scheau C. Initial learning curve for robot-assisted total Knee Arthroplasty in a dedicated Orthopedics Center. Journal of Clinical Medicine. 2023;12(21):6950. doi: 10.3390/jcm12216950

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01 Study Design

Single center, retrospective cohort study evaluating the learning curve, operative times, and complications of the ROSA Knee System

- Robotic-Assisted Total Knee Arthroplasty (raTKA): n=39
- Manual Total Knee Arthroplasty (mTKA): n=45
- Twelve surgeons performed the 39 raTKA

02 Key Findings

- Only 3 of the 12 surgeons reached the proficiency phase
- Proficiency stage was reached in 3-6 cases for those 3 surgeons
- There were no significant differences in proficiency operative times compared to manual TKA (86.43+19.09 vs. 80.56+17.03)
- No complications were recorded

03 Clinical Significance

Experienced surgeons may easily adopt the ROSA Knee System and quickly adapt without significant complications.

ROSA[®] Knee System: No Learning Curve for Achieving Pre-Operative Plan

Reference:

Druel J, Claudel S, Fabre-Aubrespy M, et al. **Learning curve of robotic assisted total knee arthroplasty within a surgical team: A prospective study of 115 cases.** Orthop Traumatol Surg Res. Published online June 30, 2025. doi:10.1016/j.otsr.2025.104325

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01 Study Design

A single-center, retrospective study evaluating the learning curve and influence of surgeon experience to achieve the pre-operative plan with the ROSA[®] Knee System.

- Four TKA surgeons without robotic-assisted TKA experience performed the anatomic-functional implant positioning technique.
- N=115 (Full data was available for 101 cases)
- Knee Society Score (KSS) at one-year follow-up
- The learning curve was assessed via CUSUM analysis for:
 - Operative time
 - Gap balance
 - Planned vs. post-operative
 - Hip-knee-ankle (Δ HKA)
 - Coronal plane alignment of the knee change (Δ CPAK)
 - Joint line obliquity change (Δ JLO)

02 Key Findings

- A short learning curve of 11 cases was reported for operative time.
- The JLO was restored to native anatomy in 91% of cases and the Δ HKA was $2.0 \pm 1.0^\circ$.
- The ability to carry out the pre-operative plan was not influenced by experience with the ROSA Knee System.
 - No learning curve was identified for:
 - Gap balance
 - Δ HKA
 - Δ CPAK
 - Δ JLO
- Significant improvements in the Objective KSS score (~47 points) and KSS Functional score (~50 points) were not influenced by surgeon experience with the ROSA Knee System.

03 Clinical Significance

Surgeons without previous robotic experience can achieve proficiency in as little as 11 cases with the ROSA Knee System, without compromising accuracy or functional outcomes.

Evaluating the Learning Curve Across Different raTKA Systems

Reference:

Di Gialleonardo E, Bocchino G, Capece G, et al. **Evaluation of the learning curve in robot-assisted knee arthroplasty: A Systematic review.** J Exp Orthop. 2025;12(3):e70292. doi:10.1002/jeo2.70292

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01 Study Design

A systematic review of literature evaluating the learning curve of robotic-assisted knee arthroplasty.

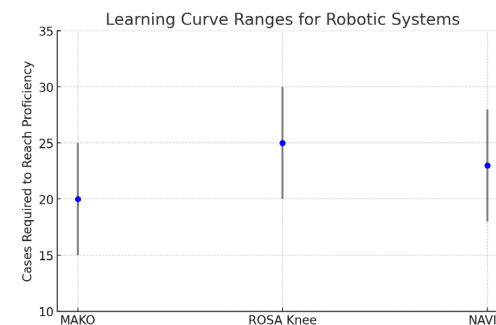
- Included studies assessed the learning curve through operative time, accuracy, and post-operative complications
- 28 studies were included
- Multiple studies were found for three systems
- MAKO®: n=10 studies
- ROSA®: n=7 studies
- NAVIO: n=5 studies

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02 Key Findings

- Considering all studies, the number of cases to surpass an initial learning curve averaged 20.5 cases.
- The implants selected were not found to impact the learning curve.
- Results from three studies indicate experienced surgeons exceed the initial learning curve quicker than inexperienced surgeons (15-30 cases vs. 30-50 cases).
- The authors did not compare learning curves between robotic systems.



03 Clinical Significance

The learning curve for all robotic systems are similar. Learning curves appear to be independent of implant used. It seems reasonable that efficiency gains are the result of the surgeon mastering the robotic platform.

The ROSA® Knee System: Evaluating the Initial Learning Curve for Robotic-assisted Total Knee Arthroplasty (TKA)

Reference:

Neira I, Llopis R, Cuadrado L, et al. **Analysis of the Initial Learning Curve for Robotic-Assisted Total Knee Arthroplasty Using the ROSA® Knee System.** J Clin Med. 2024;13(11):3349. Published 2024 Jun 6.

[doi:10.3390/jcm13113349](https://doi.org/10.3390/jcm13113349). 2025.02.003

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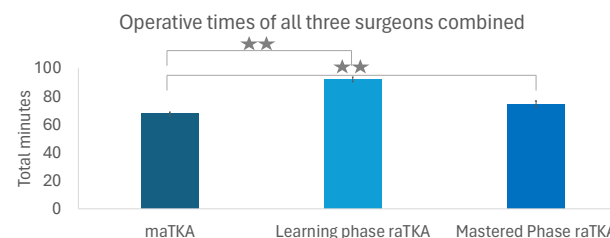
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01 Study Design

- A prospective, single-center study examined the learning curve of raTKA (robotic-assisted total knee arthroplasty) using the ROSA® Knee System across three surgeons vs. maTKA (manual TKA).
- n= 180
 - raTKA n=90.
 - maTKA n=90.
- Surgeon 1: >15 years of maTKA experience.
 - Conducted all maTKAs
 - Participated in all raTKAs.
- Surgeons 2 and 3: <5 years of maTKA experience.
- Learning curve was estimated using the cumulative summation analysis (CUSUM).

02 Key Findings

- CUSUM analysis revealed learning curves of:
 - 43 cases for surgeon 1.
 - 61 cases for all participating surgeons.
- raTKA had longer operative times (86.0 minutes) vs. maTKA (67.5 minutes).
- Operative times for the experienced surgeon in maTKA and the mastered phase of raTKA were similar (p=0.087).



*Statistically significant differences

- The study was limited by:
 - Operative times may have been influenced by procedural dynamics, where two surgeons handled different steps and the lack of pre-surgical cadaveric training due to COVID-19 lockdowns.

03 Clinical Significance

The learning curve for ROSA Knee System varies based on the surgeon's prior experience with manual TKA. Experienced surgeons can expect a return to manual TKA operative times following the initial learning curve.

The ROSA® Knee System: Evaluating Institutional Proficiency

Reference:

Gordon, M., Rivkin, G., Greenberg, A., Kandel, L., Liebergall, M., & Perets, I. (2025). **Robotic Guided Knee Arthroplasty-Group Learning Curve and Early Outcomes.** Arthroplasty Today, 34, 101746. doi.org/10.1016/j.artd.2025.101746

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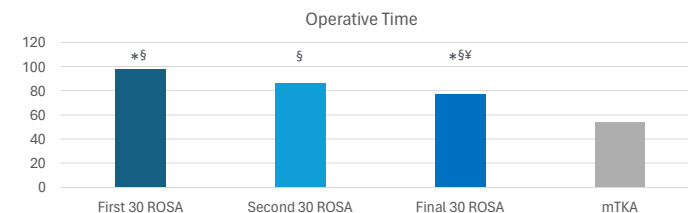
01 Study Design

A retrospective review evaluating the learning curve and early clinical outcomes of the first 90 institutional ROSA® Knee System cases performed by six high-volume surgeons.

- ROSA Knee cases were clustered chronologically into three groups of 30 patients.
- Operating time, range of motion (ROM), and complications through one-year follow-up were compared.

02 Key Findings

- Significant reductions in operative time were observed:
 - Surgeons were at different stages in the learning curve and contributed an unequal number of cases to the analysis.
 - Two of the six surgeons contributed zero cases to the first 30 institutional ROSA Knee cases.
 - Because of these limitations, caution should be taken when comparing between ROSA Knee and manual TKA
- ROM was no different between groups at six-weeks post-operative after controlling for differences in pre-operative ROM and surgeon.



*Significantly different than Second 30 ROSA; § Significantly different than mTKA; ¥ Significantly different than First 30 ROSA

03 Clinical Significance

Institutional proficiency with ROSA Knee continues to improve through the first 90 cases across multiple surgeons without an increased risk of complications.

The ROSA® Knee System: Significant Reduction in Operative Time After 10 Cases

Reference:

Petrillo S, Moretti G, Bordignon N, Romagnoli S. **Rapid reduction in surgical time and high level of accuracy in alignment and femoral component size prediction in robotic-assisted total knee arthroplasty with ROSA Knee System.** J Exp Orthop. 2025; 12:e70148.

<https://doi.org/10.1002/jeo2.70148>

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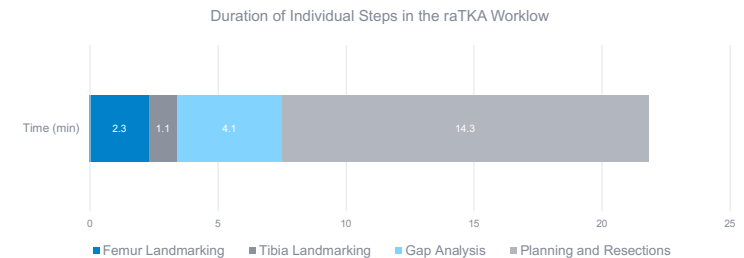
01 Study Design

A single-surgeon, retrospective analysis of the learning curve and implant sizing accuracy of the ROSA® Knee System in robotic-assisted total knee arthroplasty (raTKA).

- N=54
 - All patients received a Persona® The Personalized Knee® System (fully cemented, CR femur, UC polyethylene) retaining implant.
- Follow-up: 9 months.
- Total operative time (TOT, incision to closure) and total robotic time (TRT, landmark to bone cuts) were analyzed with cumulative sum analysis (CUSUM).
- Individual steps in the raTKA workflow were assessed.
- Planned and post-operative hip-knee-ankle angle (HKA) was also compared.

02 Key Findings

- CUSUM analysis of TOT revealed a learning curve of 10 cases, based upon the inflexion point.
- Significant differences were found for TOT between the learning phase (62.6 ± 7.9 min) and the proficiency phase (49.9 ± 8.1 min).
- Proficiency was achieved in TRT following 30 cases.
 - TRT comprised approximately 42% of the TOT, with planning and resections comprising approximately 65% of the TRT.
- Femoral component size prediction was accurate in 92.6% of cases, and 100% of cases were within 2 sizes of the prediction.
- The mean absolute difference between planned and post-operative HKA was 1.1° .



03 Clinical Significance

The ROSA Knee System has a rapid initial learning curve (10 cases), with proficiency being achieved after 30 cases. The system is accurate in implant size prediction and its ability to achieve the planned alignment.

The ROSA® Knee System: Improved Recovery with Anatomo-Functional Implant Positioning

Reference:

Parratte S, Van Overschelde P, Bandi M, Ozturk BY, Batailler C. An anatomo-functional implant positioning technique with robotic assistance for primary TKA allows the restoration of the native knee alignment and a natural functional ligament pattern, with a faster recovery at 6 months compared to an adjusted mechanical technique. *Knee Surgery, Sports Traumatology, Arthroscopy.* 2022;31(4):1334-1346. doi:10.1007/s00167-022-06995-4

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01 Study Design

Retrospective case control series assessing clinical outcomes of anatomo-functional implant positioning (AFIP) technique with robotic-assisted Total Knee Arthroplasty (raTKA) compared to adjusted mechanical alignment (aMA) with conventional Total Knee Arthroplasty (cTKA) instrumentation in Total Knee Arthroplasty (TKA)

- n=40 (AFIP)
- n=40 (aMA)
- 12-month follow-up

02 Key Findings

- The lateral gap was significantly more lax in flexion and no soft tissue release were required with AFIP raTKA
- Native femoral anatomy was retained with AFIP raTKA, while the femoral component was implanted significantly more varus in aMA cTKA
- Improvement of Knee and Function KSS at six months was better in the raTKA AFIP group vs. cTKA aMA group, with no peri-operative complications
- KSS Function PASS scores were only achieved in raTKA AFIP

03 Clinical Significance

“The AFIP concept allowed the restoration of the native knee anatomy and alignment with a natural ligament pattern.”

“With a more physiological target for ligament balancing, [robotically assisted] AFIP technique had equivalent clinical outcomes at 12 months compared to aMA, with a faster recovery.”

The ROSA[®] Knee System: No Difference in Pin- Site Complications Compared to NAVIO[®] Surgical System

Reference:

Desai SS, Shah, RP*, Cooper HJ*. A comparison of pin site complications between large and small pin diameters in robotic-assisted total knee arthroplasty. J Exp Orthop. 2023 Mar 10;10(1):22. doi: 10.1186/s40634-023-00584-1

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01 Study Design

A single center retrospective analysis comparing overall and pin-site complications between small pin diameters with the ROSA[®] Knee System and large pin diameters with the NAVIO[®] Surgical System in robotic-assisted total knee arthroplasty (raTKA).

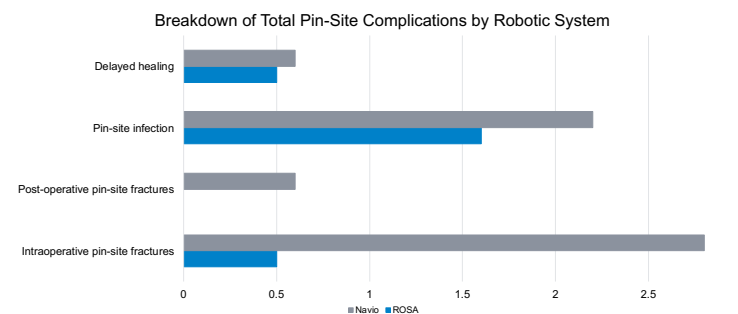
Small diameter pins (3.2 mm): n=190
Large diameter pins (4.5 mm): n=177

Three-month post-operative medical records were reviewed for:

- Pin-site infections, pin-site fracture, and delayed wound healing
- Non-pin-site complications
- Reoperations

02 Key Findings

- Total pin-site complications (2.6% vs. 5.6%), non-pin-site complications (7.4% vs. 10.2%), and reoperations (3.2% vs. 4.0%) were all lower with small compared to large diameter pins, however, the differences were not statistically significant.
- 86.7% of pin-site complications were on the tibia, most presented either intra-operatively or in the first-month post-operative, and there were zero pin or drill breakages.



03 Clinical Significance

Pin-site complications are uncommon following raTKA. Their occurrence seems to be less frequent when smaller diameter pins are used, highlighting a potentially lower risk of pin-site fractures with the ROSA Knee System.

The ROSA® Knee System: Faster Post-Operative Improvements in Pain and Function

Reference:

Khan IA, Vaile JR, DeSimone CA, et al. Image-free robotic-assisted total knee arthroplasty results in quicker recovery but equivalent one-year outcomes compared to conventional total knee arthroplasty. *The Journal of Arthroplasty*. 2023;38(6). doi:10.1016/j.arth.2023.02.023

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01 Study Design

A multicenter, propensity score-matched, retrospective study evaluating the functional outcomes of robotic-assisted Total Knee Arthroplasty (raTKA) compared to conventional Total Knee Arthroplasty (cTKA)

- Participants: 254 raTKA and 762 cTKA patients
- Follow-up: 14 months average (12-20 months range)
- Criteria: Patients with primary unilateral TKA, pre/post-operative KOOS-JR data
- Outcomes: Minimal Clinical Important Difference (MCID) and PASS for KOOS-JR

02 Key Findings

- The ROSA Knee group had significantly higher KOOS-JR than the conventional group at 4-6 weeks post-operative (61.3 vs. 59.0)
 - The change in KOOS-JR scores between pre-operative and 4-6 weeks post-operative were also significantly greater in the ROSA Knee group (19.9 vs. 14.0)
- The ROSA Knee group had significantly higher KOOS-JR than the conventional group at one-year post-operative (77.8 vs. 74.3)
 - However, there were no differences between groups in the number of patients who achieved a minimal clinical important difference in KOOS-JR scores (84.0 vs. 80.9%)

03 Clinical Significance

“[Imageless] robotic-assisted TKA with ROSA Knee reduces pain and improves early functional recovery compared to conventional TKA at 4-6 weeks, but functional outcomes at one year are equivalent based on the MCID for KOOS-JR.”

The ROSA[®] Knee System: Faster Recovery of Range of Motion Compared to Manual Total Knee Replacement

Reference:

Fary C, Cholewa J*, Ren AN*, Abshagen S*, Anderson MB*, Tripuraneni K. Multicenter, prospective cohort study: Immediate postoperative gains in active range of motion following robotic-assisted total knee replacement compared to a propensity-matched control using manual instrumentation. *Arthroplasty*. 2023;5(1). doi:10.1186/s42836-023-00216-0

Study funded by Zimmer Biomet.
*Zimmer Biomet employee

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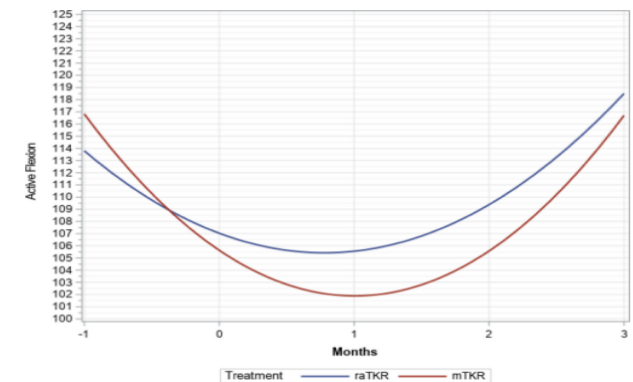
01 Study Design

A multicenter, propensity-matched, prospective study evaluating active range of motion (aROM) changes following total knee replacement (TKR) between robotic-assisted Total Knee Replacement (raTKR) and manual Total Knee Replacement (mTKR)

- aROM measured pre-operative and at one- and three-months post-operative
- raTKR: n=216
- mTKR: n=216

02 Key Findings

- aROM increased by 6.9° and 4.9° more in raTKR compared to mTKR at one- and three-months post-operative, respectively
- raTKR had 2.15 higher odds of achieving 90° of active flexion at one-month compared to mTKR
- Opioid use was significantly less (31.2% vs. 42.6%) in raTKR compared to mTKR



03 Clinical Significance

raTKR is associated with a lower loss of aROM in the immediate post-operative period and higher odds of achieving 90° of flexion within one-month. Unlike mTKR patients, raTKR patients also exceeded their pre-operative aROM by three-months post-operative.

Robotic-Assisted TKA isn't Associated with Increased Satisfaction: Study Limitations

Reference:

Hoveidaei AH, Esmaeili S, Ghaseminejad-Raeini A, Pirahesh K, Fallahi MS, Sandiford NA, Citak M. Robotic assisted Total Knee Arthroplasty (TKA) is not associated with increased patient satisfaction: a systematic review and meta-analysis. *Int Orthop.* 2024 May 6. doi: 10.1007/s00264-024-06206-4

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01 Study Design

A systematic review and meta-analysis of studies reporting satisfaction outcomes between robotic-assisted (rTKA) and conventional total knee arthroplasty (cTKA)

- Studies published prior to August 2023 were included
- There were 9 studies included that compared satisfaction outcomes between rTKA to cTKA
- 8 single cohort studies that involved only rTKA were also included
- Only one of the 17 studies used the ROSA® Knee System

1. Kahlenberg CA, Nwachukwu BU, McLawhorn AS, Cross MB, Cornell CN, Padgett DE. Patient Satisfaction After Total Knee Replacement: A Systematic Review. *Hss j* 14(2): 192, 2018

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02 Key Findings

- In the meta-analysis the rates of satisfaction were 95% and 91% for rTKA and cTKA, respectively, but the odds ratio for greater satisfaction with rTKA was not statistically significant.
- The study was limited by the following:
 - The authors excluded 6 studies from the meta-analysis without justification.
 - Satisfaction was statistically higher in 3 of the excluded studies.
 - Two of the excluded studies reported no statistical difference.
 - One study did not statistically analyze satisfaction.
 - Satisfaction was collected at different time points, and was not standardized in the meta-analysis.
 - Satisfaction may change from 6 months to 2 years.
- The rate of satisfaction following rTKA across 11 studies was 94% (95% Confidence Interval of 92% to 96%).

03 Clinical Significance

The systematic review found approximately 92% to 96% of patients are satisfied with their rTKA procedure, a value greater than the 80-90% reported in the literature for TKA.¹ Because 66% of the comparative studies were excluded from the meta-analysis, the finding that rTKA is not associated with increased patient satisfaction should be interpreted with caution.

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Robotic-Assisted TKA is Not Associated With Decreased Odds of Early Revision

Reference:

Kirchner GJ, Stambough JB, Jimenez E, Nikkel LE. Robotic-assisted TKA is not associated with decreased odds of early revision: An analysis of the American Joint Replacement Registry. *Clinical Orthopaedics & Related Research*. 2023;482(2):303-310. doi: 10.1097/corr.0000000000002783

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01 Study Design

A retrospective analysis of the American Joint Replacement Registry (AJRR) of Medicare patients undergoing total knee arthroplasty (TKA) between 2017 and 2022 with at least two years of follow-up.

- (This limits the inclusion of ROSA® Knee System in the analysis)

The revision rate and indications for revision were compared between conventional (cTKA) and robotic-assisted (raTKA) TKA

- cTKA: n=128,334
- raTKA: n=14,126

All reasons for revision were included in the analysis, thus some patients were counted more than once as they may have had both pain and instability.

02 Key Findings

- The rate of revision was 1.2% in each technique and not different between cTKA and raTKA
- When controlling for other variables, the odds of revision were significantly greater in raTKA for:
 - Instability: Odds ratio 1.6 (95% Confidence Interval: 1.0 to 2.4)
 - Pain: Odds ratio 2.1 (95% Confidence Interval: 1.4 to 3.0)

Limitations of the analysis:

- There were 1578 cTKA and 172 raTKA revisions
- There were 1844 cTKA and 216 raTKA indications for revision
- The primary reason for revision was not isolated, meaning one patient could have several diagnoses evaluated
 - This essentially resulted in more raTKA patients counted multiple times in the analysis on reasons for revision

03 Clinical Significance

Based on data from the AJRR, there does not appear to be a difference in the risk of two-year revision between cTKA and raTKA.

The primary indication for revision was not isolated, the higher odds of revision due to instability and pain should be interpreted with caution as raTKA cases were more likely to be counted multiple times.

The ROSA® Knee System: Improved Recovery with Anatomo-Functional Implant Positioning

Reference:

Parratte S, Van Overschelde P, Bandi M, Ozturk BY, Batailler C. An anatomo-functional implant positioning technique with robotic assistance for primary TKA allows the restoration of the native knee alignment and a natural functional ligament pattern, with a faster recovery at 6 months compared to an adjusted mechanical technique. *Knee Surgery, Sports Traumatology, Arthroscopy.* 2022;31(4):1334-1346. doi:10.1007/s00167-022-06995-4

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01 Study Design

Retrospective case control series assessing clinical outcomes of anatomo-functional implant positioning (AFIP) technique with robotic-assisted Total Knee Arthroplasty (raTKA) compared to adjusted mechanical alignment (aMA) with conventional Total Knee Arthroplasty (cTKA) instrumentation in Total Knee Arthroplasty (TKA)

- n=40 (AFIP)
- n=40 (aMA)
- 12-month follow-up

02 Key Findings

- The lateral gap was significantly more lax in flexion and no soft tissue release were required with AFIP raTKA
- Native femoral anatomy was retained with AFIP raTKA, while the femoral component was implanted significantly more varus in aMA cTKA
- Improvement of Knee and Function KSS at six months was better in the raTKA AFIP group vs. cTKA aMA group, with no peri-operative complications
- KSS Function PASS scores were only achieved in raTKA AFIP

03 Clinical Significance

“The AFIP concept allowed the restoration of the native knee anatomy and alignment with a natural ligament pattern.”

“With a more physiological target for ligament balancing, [robotically assisted] AFIP technique had equivalent clinical outcomes at 12 months compared to aMA, with a faster recovery.”

The ROSA® Knee System: Less deviations in post-operative gait compared to manual Total Knee Arthroplasty

Reference:

A. G. Salvi; P. Valpiana; B. Innocenti; S. Ghirardelli; M. Bernardi; G. Petralia; G. Aloisi; K. Zepeda; C. Schaller; P. F. Indelli. (2024). **The Restoration of the Prearthritic Joint Line Does Not Guarantee the Natural Knee Kinematics: A Gait Analysis Evaluation Following Primary Total Knee Arthroplasty.** Arthroplasty Today, 30:101586. doi: [10.1016/j.artd.2024.101586](https://doi.org/10.1016/j.artd.2024.101586)

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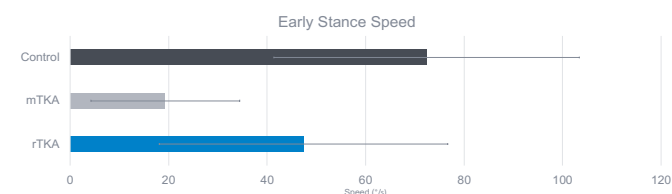
01 Study Design

A retrospective, gait analysis study of patients who received either robotic total knee arthroplasty (rTKA) or manual instrumented TKA (mTKA).

- rTKA: n=12
 - Surgical technique: Restricted kinematic alignment.
 - Implant: cemented Persona® Medial Congruent (Persona MC) Knee System.
- mTKA: n=12
 - Surgical technique: unrestricted kinematic alignment.
 - Implant: medial pivot (GMK® Sphere, Medacta International).
- Healthy Control: n=12
 - Compared to the rTKA and mTKA cohorts, the control group was younger, predominantly female, and tended to have a lower BMI.
- Gait analysis was conducted at minimum nine months post-operative.

02 Key Findings

- The presence of weight acceptance, as a measure of the load response, during the stance phase was more prevalent in controls (54.5%) and rTKA patients (36.4%) compared to mTKA patients (9.1%).
- rTKA patients were less likely to lose the natural knee flexion pattern compared to mTKA patients, though the difference did not reach statistical significance.
- Early stance speed was greater in the rTKA compared to mTKA cohort.
- rTKA patients displayed a more efficient transition between double support and single stance phase compared to mTKA patients.
- There were no differences between rTKA and mTKA for knee Range of Motion (ROM) during stance or swing phase, walking speed, step length, trunk lean or center of gravity.



03 Clinical Significance

Restricted kinematic alignment with ROSA Knee is associated with less deviation in knee kinematics during the loading and early stance phases of gait compared with an unrestricted manual TKA in the early post-operative period.

The ROSA® Knee: Personalized Alignment Surgical Technique

Reference:

Massé V*, Cholewa J** and Shahin M (2023) **Personalized alignment™ for total knee arthroplasty using the ROSA® Knee and Persona® knee systems: Surgical technique.** *Front. Surg.* 9:1098504. doi: 10.3389/fsurg.2022.1098504

A Zimmer Biomet funded study.

*Zimmer Biomet paid consultant

**Zimmer Biomet employee

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01 Study Design

Dr. Vincent Massé describes how to perform a personalized technique with restricted kinematic alignment (rKA) using ROSA® Knee and the Persona® Knee systems.

This surgical technique paper covered the following topics:

- Differences between rKA and mechanical alignment.
- rKA boundaries.
- Image-based and imageless pre-operative planning.
- Anatomic landmarking.
- Intra-operative evaluation, planning and adjustment, and validation.
- Laxity assessments.
- Expected outcomes.

02 Key Findings

- The purpose of rKA is to recreate pre-arthritis anatomy by maintaining a patient's individual native soft tissue tensions.
- The boundaries for rKA are:
 - Arithmetic hip-knee-ankle angle: 0 ± 3
 - Distal femoral coronal angle: $0 \pm 5^\circ$
 - Proximal tibial coronal angle: $0 \pm 5^\circ$
- ROSA Knee allows the surgeon to perform valgus and varus stress tests at 10° and 90° to assess native ligament laxity and maximal deformity correction.
- Robotic validation is performed after the femoral and tibial resections, and allows the surgeon to adjust the pre-operative plan and obtain final information on the accuracy of the resections. The Personalized Alignment technique minimizes soft tissue release, however, anatomical corrections in excess of $2-3^\circ$ will often necessitate ligament releases.

03 Clinical Significance

The ROSA® Knee System allows for a personalized approach using a restricted kinematic alignment philosophy in primary total knee arthroplasty.

Common Functional Alignment Resections with the ROSA® Knee System

Reference:

Braathen DL, Clapp IM, et al. **Common adjustments made in robotic total knee arthroplasty to achieve functional alignment and minimize soft tissue releases.** J Orthop. Published online August 25, 2025. doi:10.1016/j.jor.2025.08.051.

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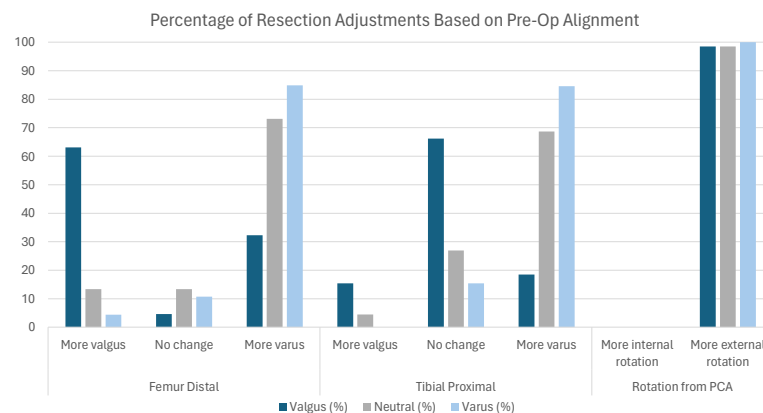
01 Study Design

A single institution, retrospective analysis evaluating the femoral and tibial resection adjustments needed to balance the knee in flexion and extension with the ROSA Knee System assisted total knee arthroplasty (TKA) based on pre-operative alignment.

- N=292
- Patients were categorized into two groups based on hip-knee-ankle alignment (HKA):
 - Pre-operative varus: > 3° varus HKA: n=160 (58.4%)
 - Pre-operative valgus: > -3° valgus HKA: n=65 (22.3%)
 - Pre-operative neutral: -3° to 3°: n=67 (22.9%)
- All patients were implanted with a functional alignment technique, aiming to minimize soft tissue manipulations.

02 Key Findings

Patients with pre-operative varus or neutral knee alignment are typically balanced with tibial varus resections. In contrast, valgus alignment are usually balanced with femoral valgus resections.



03 Clinical Significance

Consistent patterns in resections based on pre-operative deformity were observed in functional alignment. The ROSA Knee System demonstrates the potential to accommodate soft tissue variability and support achieving balanced functional alignment.

The ROSA[®] Knee System: Eight steps for performing Inverse Kinematic Alignment

Reference:

Eijking, H.M., Dorling, I., van Haaren, E. et al. **Image-based robotic (ROSA[®] knee system) total knee arthroplasty with inverse kinematic alignment compared to conventional total knee arthroplasty.** J Orthop Surg Res 20, 47 (2025).

<https://doi.org/10.1186/s13018-024-05427-y>

Study was funded by Zimmer Biomet

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01 Study Design

A randomized, controlled trial protocol investigating patient-reported outcomes, adverse events, and implant survival between the ROSA[®] Knee System (raTKA) and conventional total knee arthroplasty (cTKA).

- cTKA patients will receive mechanically aligned TKAs.
- Alignment in raTKA patients will be performed with Inverse Kinematic Alignment (iKA).
- The iKA strategy involves an eight-step technique that prioritizes:
 - Gap balancing in both knee flexion and extension, with slight lateral laxity in flexion
 - Mid-flexion stability
 - Functional knee alignment
 - Restoration of the joint-line orientation and posterior condylar offset
 - Preservation of patella height
 - Minimal soft tissue releases, with consideration for necessary adjustments during surgery

02 Key Findings

The eight steps for iKA include:

1. Setting the tibial slope with a goal of replicating the native slope, with specific limits (e.g., 0-10 degrees), depending on implant used.
2. Aligning the tibia in varus/valgus, matching the Medial Proximal Tibial Angle (MPTA) and allowing for varus deviation within set limits, while limiting valgus deviation in knees with correctable valgus deformities.
3. Determining femoral rotation with a maximum of 5 degrees external rotation.
4. Matching medial posterior resection to the total component thickness, aiming for 9 mm resection. Aligning tibia resection level to accommodate total implant thickness.
5. Refining femur alignment in varus/valgus to achieve balanced gap extension and adjusting the distal femur resection level for uniform gap balance. Then fine-tuning the tension of the medial collateral ligament (MCL), especially in extension, to achieve optimal soft tissue balance.
6. Limiting distal femur resection to 9 mm, with special considerations for extensions deficits or hyperextensions.
7. Adjusting femur size to a stylus height between 0 and 0.5 mm, while limiting femoral flexion between 2-4°.

03 Clinical Significance

This study protocol presents a detailed algorithm to perform Inverse Kinematic Alignment with the assistance of the ROSA Knee System with minimal alterations to standard surgical workflow.

The ROSA® Knee System: Accurate Distal Femoral Resurfacing

Reference:

Claudel S, Ollivier M, Fabre-Aubrespy M, et al. **Robotic anatomic-functional alignment total knee arthroplasty accurately resurfaces the distal femur and preserves joint line obliquity: A prospective 3D modelling study.** Knee Surg Sports Traumatol Arthrosc. Published online July 7, 2025. doi:10.1002/ksa.12772

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01 Study Design

A prospective, observational study evaluating metrics of anatomic-functional alignment with the ROSA® Knee System.

- N=100
- **Objective 1:** Achieve symmetrical (1-3 mm of laxity) medial and lateral gaps in extension, and asymmetrical (an additional 1.5 mm lateral laxity) gaps in flexion.
- **Objective 2:** Maintain joint line obliquity (JLO) by restoring the lateral distal femoral angle (LDFA) to 3° of varus or valgus.
- **Objective 3:** Restore the hip-knee-ankle angle (HKA) between 176° to 182°.
 - JLO and HKA were assessed with post-operative radiographs.
 - Femoral resurfacing was assessed with post-operative CT.

02 Key Findings

- The distal femoral articular surface was restored within 2.27 ± 1.60 mm.
- JLO was restored in 91% of cases.
- The mean absolute difference between targeted and post-operative HKA was $2.1^\circ \pm 1.8^\circ$.
- Slight laxity of the lateral joint in flexion was achieved in 85% of knees.
- Full gap balance in extension and flexion were achieved in 78% of varus knees and 69% of valgus knees.

03 Clinical Significance

The ROSA Knee System is a reliable tool for achieving the objectives of anatomic-functional alignment in total knee arthroplasty.

The ROSA® Knee System: Successful One-Year Outcomes in Terms of Functional Results

Reference:

Selvanathan N, Ayena F, Sorial R. Incidence of soft tissue releases in robotic assisted cementless TKA with mechanical alignment and gap balancing. *Arthroplasty*, 2023, 5:8. doi:10.1186/s42836-023-00188-1

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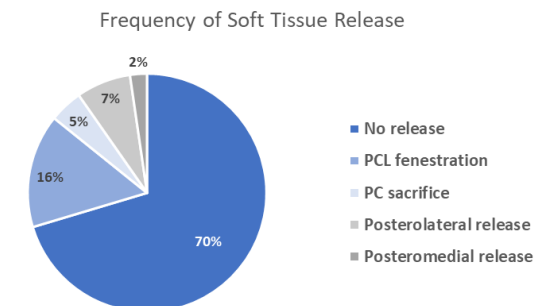
01 Study Design

A single center prospective and retrospective evaluation of the soft tissue releases required for ligament balance with the ROSA Knee System.

- n=175 robotic-assisted total knee arthroplasty patients
- Minimum follow-up of 6 months
- Medial releases were recorded for varus knees, posterolateral fenestrated release and retinacular release for valgus knees, and any posterior cruciate ligament (PCL) fenestration or sacrifice was documented

02 Key Findings

- 97.8% of initial bone resections were within 1.5 mm accuracy
- Soft tissue releases were performed in 29.7% of patients
- Only 9.7% of patients required a soft tissue release for coronal plane correction
- Valgus knees had a higher rate of soft tissue release than varus knees (53% vs. 29%)
- There were no revisions and only 2 patients (1.1%) required manipulation under anesthesia



03 Clinical Significance

Robotic-assisted total knee arthroplasty with the ROSA Knee System may reduce the need for unnecessary soft tissue releases to achieve coronal alignment to the mechanical axis in total knee arthroplasty.

Six-month post-operative outcomes with a contemporary knee system challenges the 80% satisfaction rate

Reference:

Zhang E, Yeo W, Liu E, Chen J, Pang H, Yeo S, Liow L. (2025) **Does robotic surgical assistant (ROSA) functionally aligned TKA lead to higher satisfaction than conventional mechanically aligned TKA: A propensity-matched pair analysis**, Journal of Orthopaedics, 63: 93-97. [doi: 10.1016/j.jor.2024.10.039](https://doi.org/10.1016/j.jor.2024.10.039).

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01 Study Design

A retrospective, propensity-matched cohort study of patients who received the cemented Persona® The Personalized Knee® comparing the ROSA® Knee System total knee arthroplasty (rTKA) using functional alignment to a manual mechanically aligned technique (mTKA).

- Patient Reported Outcome Measures (PROMs) were measured pre-operatively and post-operatively at six months:
 - Knee Society Knee Score (KSS)
 - Knee Society Function Score (KSFS)
 - Oxford Knee Score
 - Short-Form 36 questionnaire (SF36)
 - Satisfaction
- Cohorts were matched for age and sex:
 - rTKA: n=46
 - mTKA: n=46

02 Key Findings

- At six-months follow-up, both groups demonstrated excellent clinical and satisfaction outcomes.
- There were no significant differences between rTKA and mTKA for post-operative KSS (80.9 vs. 85.1), KSFS (76.3 vs. 68.2), OKS (19.1 vs. 20.1) SF36-Physical Component (46.6 vs 46.3), or rate of satisfaction (100% vs. 98.1%).
- This study was limited by differences in physical function between the groups pre-operatively and a small sample size.
 - The rTKA group had significantly ($p=0.04$) higher SF36-general health and trended toward a higher SF36-Physical Component ($p=0.06$) and KSS ($p=0.07$) pre-operatively.
 - This data suggests the rTKA group had higher pre-operative function and thus, less potential room for improvements.
 - The sample size was too small to detect a difference in patient-reported outcomes.
 - A post-hoc power analysis revealed each cohort required 86 patients to be adequately powered.

03 Clinical Significance

rTKA patients had equivalent outcomes and satisfaction levels compared to mTKA patients when measured post-operatively. All patients were **highly satisfied** at six months post-operative (>98%), suggesting that contemporary knee replacements are challenging the 20% dissatisfaction rate often reported.

The ROSA® Knee System: Improved Outcomes Compared to Imageless Navigation

Reference:

Mancino F, Rossi SM, Sangaletti R, Lucenti L, Terragnoli F, Benazzo F. A new robotically assisted technique can improve outcomes of total knee arthroplasty comparing to an imageless navigation system. Archives of Orthopaedic and Trauma Surgery. 2022;143(5):2701-2711. doi:10.1007/s00402-022-04560-9

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01 Study Design

Retrospective analysis of prospectively collected data comparing 1-year clinical outcomes of robotic-assisted total knee arthroplasty (rTKA) with an imageless navigated procedure (nTKA)

- n=50 rTKA
- n=47 nTKA
- 1-year follow-up

02 Key Findings

- Robotic-assisted, imageless TKA had better range of motion (ROM) (119.4° vs. 107.1°; $p < 0.001$)
- Significantly better ROM gains (23.02° v. 11.36°, $p < 0.001$)
- Significantly better KOOS pain scores ($p = 0.028$)
 - ROSA Knee: 85 ± 11.4 (44–100)
 - iAssist® Knee: 79.1 ± 14.7 (33–100)
- Significantly better KSS Knee and Function scores ($p < 0.001$)
- Cautionary Note: “the overall number of postoperative outliers was higher in the rTKA group (30.00% vs. 17.02%; $p = 0.1570$)”
 - This is based on $\pm 3^\circ$ of neutral mechanical alignment. However, the ROSA Knee with Personalized Alignment technique aimed for 2° varus

03 Clinical Significance

“Imageless rTKA was associated with longer surgical time, **better pain perception and improved ROM at 12-month follow-up** compared with nTKA. No significant differences were reported on other PROMs, complication rates and radiographic outcomes.”

The ROSA® Knee System: Successful Joint Restoration and Early Outcomes in Severe Deformities

Reference:

Rossi SM, Sangaletti R, Andriollo L, Matascioli L, Benazzo F. The use of a modern robotic system for the treatment of severe knee deformity. *Technology and Healthcare*. January, 2024; published online ahead of print. doi:10.3233/THC-231261

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01 Study Design

A single center evaluation of clinical and radiological outcomes in patients with severe varus or valgus deformity treated with the ROSA Knee System.

- Valgus deformity ($>10^\circ$)
 - n=10
- Varus deformity ($>15^\circ$ fixed intra-articular deformity)
 - n=20
- PROMs assessed at minimum six-months follow-up
 - Mean follow-up was 18 (range: 6 to 30) months post-operative
- Radiographs assessed at 3 months post-operative for mechanical coronal alignment

02 Key Findings

- Significant ($p<0.0001$) improvements in range of motion, Knee Society (KSS), Hospital for Special Surgery (HSS), Oxford Knee Score (OKS), and Western Ontario and McMaster University Osteoarthritis Index (WOMAC) Scores
 - ROM increased by 19.5°
 - Improvements in KSS (+53.4), HSS (+35.2), OKS (+23), and WOMAC* pain (-16.7), stiffness (-4.3) and function (-39.4) all exceed the minimal clinical important differences
- Post-operative hip-knee-ankle angle was restored to $179.5\pm 2.1^\circ$ and all implants were determined to be in mechanical alignment
- There were no revisions through 30 months of follow-up

*Lower WOMAC scores represent better outcomes

03 Clinical Significance

Robotic-assisted total knee arthroplasty with the ROSA Knee System is successful in restoring a neutral alignment and improving clinical outcomes even in severely deformed knees.

The ROSA® Knee System: Excellent Knee Function in Patients with Severe Extra-articular Deformities

Reference:

Eu WC, Yuik Ho JP, Kunalan G. **Functional alignment is a feasible alignment strategy in robotic assisted total knee arthroplasty for knee osteoarthritis with extra-articular deformity - A case series.** SICOT J. 2025;11:2.

doi: [10.1051/sicotj/2024059](https://doi.org/10.1051/sicotj/2024059).

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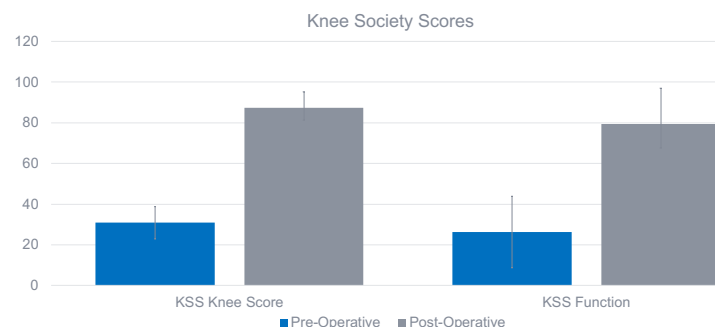
01 Study Design

A retrospective, single cohort analysis of osteoarthritic patients with extra-articular deformities secondary to fracture malunion who received ROSA® Knee total knee replacement (rTKA) and a functional alignment technique.

- **N = 8.**
- Mean pre-operative coronal femur and tibial deformities were 18.8° and 11.2° varus, respectively.
 - One patient presented with a 15° valgus femoral deformity.
 - A second presented with an 8.3° valgus tibial deformity.
- Mean pre-operative sagittal femur and tibial deformities were 12.3° and 6.7° varus procurvatum, respectively.
- Radiographic, range of motion (ROM), and Knee Society Scores were collected pre-operatively through one-year follow-up.

02 Key Findings

- The hip-knee-ankle angle (HKA) was corrected from 17.6° varus to 5.2° varus post-operative.
 - Patients with valgus deformity HKA were corrected from 21° pre-operative to 2.5° valgus post-operative.
- Flexion and extension ROM significantly improved by approximately 20° and 10°, respectively.



03 Clinical Significance

Functional alignment with ROSA Knee can restore lower limb alignment approaching the native knee and producing satisfactory outcomes in TKA patients with extra-articular deformities.

The ROSA® Knee System: Significantly Shorter Operative Time Compared to Mako®

Reference:

Zhou, G., Wang, X., Geng, X., Li, Z. and Tian, H. (2024), Comparison of Alignment Accuracy and Clinical Outcomes between a CT-Based, Saw Cutting Robotic System and a CT-Free, Jig-guided Robotic System for Total Knee Arthroplasty. Orthop Surg. <https://doi.org/10.1111/os.14055>

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01 Study Design

A retrospective analysis comparing accuracy and one-year clinical outcomes between the ROSA® Knee System and Mako, each performed by a single surgeon using mechanical alignment.

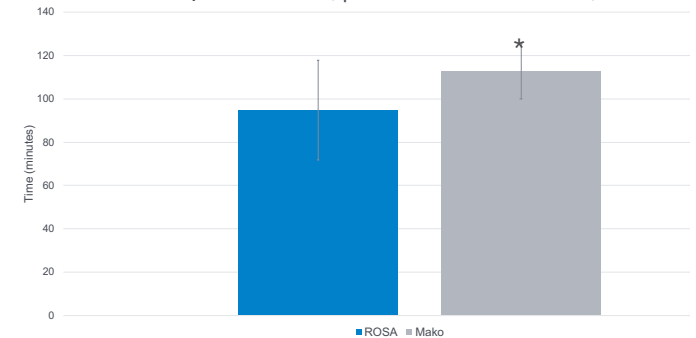
Accuracy was compared between the pre-operative plan and post-operative radiographs at three-months and one-year in the coronal tibial and femoral angles and sagittal tibial angle (tibial slope).

- ROSA Knee: n=20
- Mako Knee: n=20

02 Key Findings

- Operative time was significantly less in the ROSA Knee System compared to Mako by approximately 18 minutes.
- Both platforms produced similarly good accuracy for alignment and component position.
- Mean deviations for component positioning were all less than 2° for ROSA Knee and 2.5° for Mako at three-months and one-year post operative.
- There were no significant differences in patient-reported outcome measures or satisfaction at one-year post-operative.

Mean Operative Time (95% Confidence Intervals¹)



03 Clinical Significance

Robotic-assisted total knee arthroplasty with the ROSA Knee System provides comparable component positioning to the Mako knee system, but with significantly shorter operative times.

1. Confidence intervals 1.96 were calculated using the mean, standard deviation, and sample size: $\text{Mean} \pm Z \times (\text{standard deviation} / \sqrt{n})$, whereby Z denotes a confidence level of 1.96 corresponding to 95%.

The ROSA® Knee System: Significantly Less Radiation Exposure Than Mako®

Reference:

Saad A, Mayne A, Pagkalos J, Ollivier M, Botchu R, Davis E, Sharma A. Comparative analysis of radiation exposure in robot-assisted total knee arthroplasty using popular robotic systems. *J Robot Surg.* 2024;18(1):120. doi: 10.1007/s11701-024-01896-9

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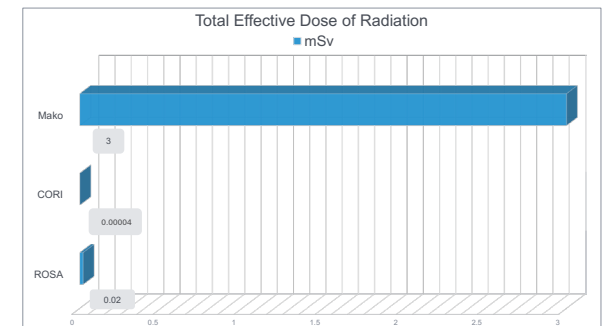
01 Study Design

A retrospective analysis comparing radiation exposure from three robotic-assisted total knee arthroplasty (raTKA) systems at a single institution. The systems used were Mako®, ROSA® Knee and CORI.

- Mako (n=43): Pre-operative CT image-based scanning of hip, knee, and ankle regions
- ROSA Knee (n=47): Antero-posterior long leg alignment radiographs
- CORI (n=50): standard antero-posterior, lateral, and skyline knee radiographs

02 Key Findings

- Significant differences in radiation were found between all three systems.
- Patients undergoing Mako raTKA were exposed to significantly more radiation compared to ROSA Knee raTKA.



03 Clinical Significance

Imageless raTKA with ROSA Knee System had significantly less radiation exposure than a CT-based system (Mako), though clinical safety limits were not exceeded by any group. This information may help surgeons inform the consenting process for patients.

Robotic-Assisted TKA: Similar Operative Times to Conventional TKA After 30 Cases

Reference:

Ejnisman L, Antonioli E, Cintra L, de Oliveira Souza PG, Costa LAV, Lenza M. Robot-assisted knee arthroplasty: Analyzing the learning curve and initial institutional experience. *Comput Struct Biotechnol J*. 2024 Apr 12;24:343-349. doi: 10.1016/j.csbj.2024.04.013.

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01 Study Design

A single center, retrospective review of robotic-assisted (rTKA) and conventional (cTKA) cases using either the ROSA® Knee System or Mako®.

- 617 cases of rTKA and cTKA were performed by 80 surgeons.
 - rTKA: n=321
 - cTKA: n=296
- Surgeons who had performed more than 10 rTKA cases were classified as “proficiency stage surgeons”.
- Surgeons with less than 10 rTKA cases were classified as “initial stage surgeons”.
- Operative time was defined as the time between initial skin incision to final wound closure.

02 Key Findings

- Significant differences in operative times were found between the first and last 10 rTKA cases (177.5 vs. 145 minutes) for five surgeons who had reached the proficiency stage.
- There were no differences in operative times between the surgeon’s last 10 rTKA and cTKA cases (145 vs. 150 minutes).
- 30 rTKA cases were required by proficiency-stage surgeons to reach an rTKA operative time less than that of cTKA.
- The number of cases necessary to reach the proficiency stage was highly variable, depending on the level of surgeon experience, ranging from 12 to 41 cases.
- There was no difference in clinical outcome measures between the groups pre- or 90 days post-operatively.

03 Clinical Significance

Robotic-assisted TKA is associated with a learning curve of 12 to 40 cases, depending on individual skill. Surgeons may expect their rTKA operative times to be equal to or less than their cTKA operative times after approximately 30 rTKA cases.

The ROSA® Knee System: Similar Component Positioning Accuracy to Mako®

Reference:

Rajgor H, Mayne A, Munasinghe C, Pagkalos J, Agrawal Y, Davis E, Sharma A. Mako versus ROSA: Comparing Surgical Accuracy in Robotic Total Knee Arthroplasty. *Journal of Robotic Surgery*, 2024; 18(33):1-5. doi:110.1007/s11701-023-01786-6

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01 Study Design

A single center retrospective evaluation of accuracy between the ROSA Knee System and Mako robotic arm-assisted surgery.

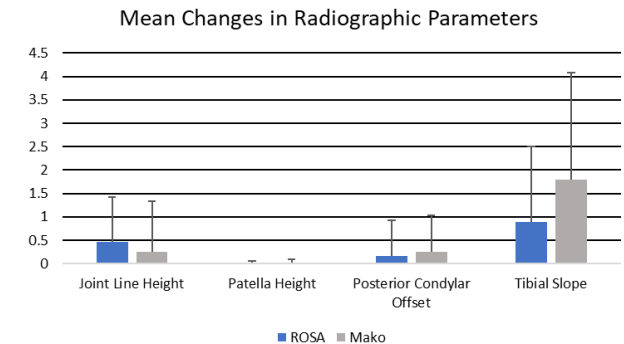
- ROSA Knee: n=50
- Mako Knee: n=50

Accuracy was measured as the pre- to post-operative restoration of radiographic parameters:

- Joint line height
- Patella height
- Tibial slope
- Posterior condylar offset

02 Key Findings

- There were no significant differences between ROSA Knee and Mako for joint line height (0.47 vs. 0.26 mm), patella height (0.01 vs. 0.03 Insal-Salvati ratio), tibial slope (0.9° vs. 1.8°) or posterior condylar offset (0.16 vs. 0.26 mm)
- No pin-site fractures occurred in either ROSA Knee or Mako groups



03 Clinical Significance

Robotic-assisted total knee arthroplasty with the ROSA Knee System is highly accurate and provides comparable component positioning to the Mako knee system in both sagittal and transverse planes.

The ROSA® Knee System: Similar Learning Curve Between ROSA Knee and Mako Knee

Reference:

Kang LB, Jeong S, Lee JW, et al. **Comparison of learning curves and short-term outcomes: ROSA versus MAKO robotic-assisted total knee arthroplasty.** *Curr Orthop Pract.* 2025;36(2):e1285.

[doi:10.1097/BCO.0000000000001285.](https://doi.org/10.1097/BCO.0000000000001285)

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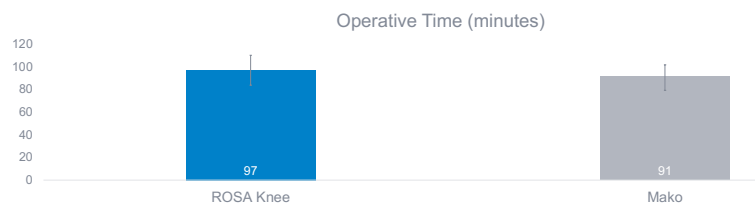
01 Study Design

A single-surgeon, retrospective review comparing learning curves and clinical outcomes between the ROSA® Knee System and Mako Total Knee.

- ROSA Knee System (n=95).
- Mako Total Knee (n=115).
- Patient demographics, operative data, and post-operative complications were collected.
- The following patient-reported outcomes (PROs) were assessed and collected pre-operatively and at six months and one-year post-operatively:
 - Oxford Knee Score
 - SF-12 Version 1
 - Knee Injury and Osteoarthritis Outcome Score for Joint Replacement
- Steady state is the average manual total knee arthroplasty (TKA) operative time of the surgeon.

02 Key Findings

- Steady state was reached at nine cases in the ROSA Knee System and six cases with the Mako robotic-arm.
- Operative time was significantly longer in the ROSA Knee compared to Mako cohort.
 - Variations in operative time may be due to the location of the surgeries, with longer times observed in ambulatory surgery centers (ASCs) compared to hospitals; 35% of ROSA Knee cases were performed in ASCs, while all Mako cases took place in hospitals.



- There were no significant differences in PROs, 90-day complications or all-cause revisions.
- Significantly more ROSA Knee patients were discharged to homes compared to Mako (66.3% vs. 22%).

03 Clinical Significance

Both the ROSA Knee System and Mako Total Knee exhibit minimal learning curves of nine and six cases, respectively, with no significant differences in post-operative outcomes at one-year post-surgery.

The ROSA[®] Knee System: Assessing the Dynamic HKA During Passive ROM Evaluations

Reference:

Qordja F, Valpiana P, Andriollo L, Rossi SMP, Salvi AG, Bocchino G, Zepeda K, Benazzo F, Indelli PF. **The HKA axis varies significantly with knee motion: A robot-assisted intraoperative evaluation during total knee arthroplasty supports the use of dynamic, not static, alignment classifications.** J Exp Orthop. 2025 Jul 18;12(3):e70370. doi: 10.1002/jeo2.70370.

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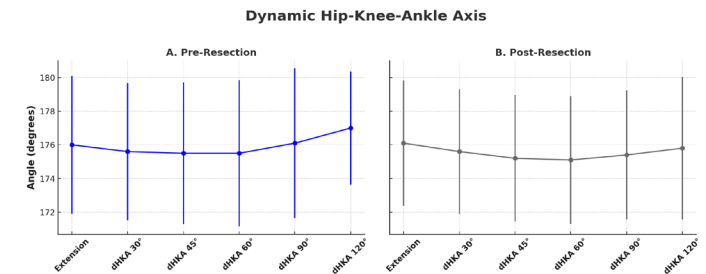
01 Study Design

A prospective, two-center study evaluating the relationship between radiographic static hip-knee-ankle axis (sHKA) and dynamic (dHKA) during flexion using the ROSA[®] Knee System.

- N=107
- Long leg coronal X-rays were taken pre-operatively and at six-weeks post-operative.
- dHKA was assessed with ROSA Knee at full extension and at 30°, 45°, 60°, 90°, and 120° of flexion pre-resection and post-resection during component trialing.
 - dHKA was compared between positions.
- Outliers were defined as pre- and post-resection dHKA >3° compared to the respective sHKA.

02 Key Findings

- Pre- and post-resection, the dHKA tended to decrease as flexion ROM increased through 60°.
- Pre-resection knees displayed a more pronounced trend for an increase in dHKA with flexion ROM exceeding 60° compared to post-resected knees.
- The frequency of dHKA outliers increased with increasing ROM through 120° in pre-resected knees and leveled off at 90° in post-resected knees.



03 Clinical Significance

The HKA varies from the standing, radiographic HKA throughout the intra-operative arc of ROM. The ROSA Knee system can detect dynamic HKAs intra-operatively.

The ROSA® Knee System: Addressing Flawed Research Methods and Measurement Validity in Sagittal Accuracy

Reference:

Eggermont, E., Janssens, R., Ulrix, M. et al. **Sagittal accuracy and functional impact of tibial slope in imageless robotic-assisted Total Knee Arthroplasty.** International Orthopaedics (SICOT) (2025). <https://doi.org/10.1007/s00264-025-06472-w>

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01 Study Design

A single-center comparative study evaluating accuracy in applying tibial slope (TS) with the ROSA® Knee System (rTKA) vs manual techniques (mTKA).

- n= 82 (rTKA)
- n=110 (mTKA)
- Tibial slope was evaluated using a short lateral knee X-ray, measured relative to the posterior tibial cortex, with a target angle of 3°.

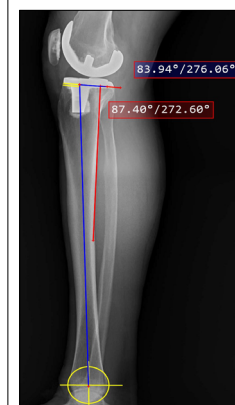
1. Zaidi F, Goplen CM, Fitz-Gerald C, Bolam SM, Hanlon M, Munro JT, Monk AP (2024). High in-vivo accuracy of a novel robotic-arm-assisted system for total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc.*
2. Yoo, Jae Ho et al. (2008). Anatomical References to Assess the Posterior Tibial Slope in Total Knee Arthroplasty: A Comparison of 5 Anatomical Axes. *The Journal of Arthroplasty*, Volume 23, Issue 4, 586 - 592
3. Ishii Y, Noguchi H, Sato J, Takahashi I, Ishii H, Ishii R et al (2022) Comparison of the tibial posterior slope angle between the tibial mechanical Axis and various diaphyseal tibial axes after total knee arthroplasty. *Arthroplasty Today* 17:137-141

02 Key Findings

- mTKA achieved a mean post-operative TS of $3.11^\circ \pm 2.12^\circ$, with 92.87% within 3° of the target. rTKA had a TS of $-0.11^\circ \pm 1.93^\circ$, with 56.63% within 3°.

Limitations

- The measurements used to assess slope do not match the methods used by the ROSA Knee System:
- Eggermont et al. assessed TS using the posterior tibial cortex (PTC).
 - Post-operative short lateral films limit the ability to identify the mechanical axis (MA).
 - Zaidi et al.¹ recognized this limitation and requested outliers return for long-leg films.
 - TS measurements can be off by a couple of degrees dependent upon the axis selected:
 - Yoo et al.² reported variations between the MA and the PTC of $2.9^\circ \pm 1.1^\circ$.
 - Ishii et al.³ found differences of more than 2° between different axes, the greatest difference being the PTC.
 - TS measures are more reliable when using the MA².



Mechanical Axis (Slope = 83.94°)
(consistent with the ROSA Knee System)

Posterior Tibial Cortex (Slope = 87.4°)
(consistent with standard short sagittal films by Eggermont et al.)

03 Clinical Significance

The use of short lateral knee X-rays and the PTC axis are inconsistent with the measure of tibial slope using the mechanical axis. Long-leg X-rays and assessing TS with the MA are necessary to accurately assess the precision of the ROSA Knee System in the sagittal plane.

The ROSA® Knee System: Addressing Flawed Research Methods and Measurement Validity

Reference:

Shin C, Crovetto C, Huo E, Lionberger D. Unsatisfactory accuracy of recent robotic assisting system Rosa for total knee arthroplasty. *Journal of Experimental Orthopaedics*. 2022;9(1). doi:10.1186/s40634-022-00522-7

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01 Study Design

A single center comparative study to evaluate the accuracy of the ROSA Knee System for Total Knee Arthroplasty (TKA)

- n=37 patients
- TKA performed using ROSA Knee by the same surgical team over 3 months
- Intra-operative mechanical axis (alpha, beta, gamma, delta angles, hip-knee-ankle angle) calculated by ROSA Knee
- Mechanical implant angles from post-op films, comparing with ROSA Knee's intra-operative plan for accuracy within 2° and 3°

02 Key Findings

- **Exceptional accuracy** between ROSA Knee's intra-operative planned axes and "post-operative mechanical angles" for the coronal, but not sagittal angles
- **Substantial measurement error and bias concerns** have been raised over the **sagittal measurements** (Gamma and Delta angles)
 - The measurement methods used by the authors **do not match the methods used by the robotics system**
 - The post-operative interrater reliability was moderate and **faulty sagittal images were included in the analysis**
 - **Measurement and subject selection biases** are evident in the study
- Despite the inflammatory title and above errors, the authors reported individual mean errors of ≤ 2.04 degrees with standard deviations ≤ 1.55 degrees for all four angles assessed, indicative of **accurate and precise resections**.
 - Alpha: 0.88 ± 0.71
 - Beta: 1.24 ± 1.06
 - Gamma: 1.93 ± 1.03
 - Delta: 2.04 ± 1.55

03 Clinical Significance

The ROSA Knee System is accurate and precise in both the coronal and sagittal planes according to the raw values reported.

The ROSA® Knee System: Addressing Flawed Radiographic Methods Assessing Sagittal Accuracy

Reference:

Aflatooni J., Winger A., Sullivan T., Brown T., Park, K. (2025). **Accuracy of Sagittal Plane Component Alignment in Robotic-Assisted Total Knee Arthroplasty**. *Arthroplasty Today*, Volume 34, 101774. doi.org/10.1016/j.artd.2025.101774

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01 Study Design

A retrospective, two-surgeon, single-institution study evaluating the sagittal tibial and femoral accuracy of two different robotic-assisted total knee arthroplasty systems.

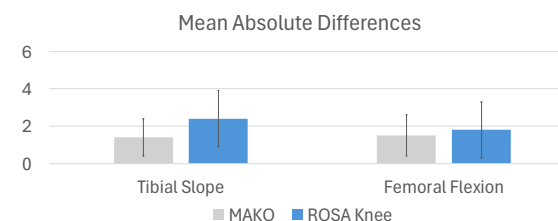
- MAKO®, N=73
- ROSA® Knee, N=96
- The sagittal femoral (femoral flexion) and tibial (tibial slope) angles were assessed with post-operative short lateral radiographs and compared to intra-operative planned alignments.
- No statistical comparisons were made between systems.

1. Yoo, Jae Ho et al. Anatomical References to Assess the Posterior Tibial Slope in Total Knee Arthroplasty: A Comparison of 5 Anatomical Axes. *The Journal of Arthroplasty*, Volume 23, Issue 4, 586 - 592
2. Ishii Y, Noguchi H, Sato J, Takahashi I, Ishii H, Ishii R et al (2022) Comparison of the tibial posterior slope angle between the tibial mechanical Axis and various diaphyseal tibial axes after total knee arthroplasty. *Arthroplasty Today* 17:137–141

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02 Key Findings

- According to post-operative X-rays, both systems tended to align the tibial component with less tibial slope (TS) compared to the intra-operative plan.
- Limitations:
 - The measurements used to assess slope do not match the mechanical axis (MA) methods used by the ROSA Knee System.
 - Short lateral films limit the ability to identify the MA.
 - Aflatooni et al. appears to measure TS with the central anatomical axis (CAA).
 - TS measures may be off by a couple of degrees dependent upon the axis selected:
 - Yoo et al.¹ reported variations between MA and CAA of $-2.2^\circ \pm 0.7^\circ$
 - Ishii et al.² reported variations between MA and CAA of $-1.6^\circ \pm 2.0^\circ$



03 Clinical Significance

The use of short lateral knee X-rays and the CAA axis are inconsistent with the measure of tibial slope using the mechanical axis. Long-leg X-rays and assessing TS with the MA are necessary to accurately assess the sagittal plane precision of the ROSA Knee System.

The ROSA® Knee System: Addressing Flawed Research Methods and Measurement Validity

Reference:

Shin C, Crovetto C, Huo E, Lionberger D. Unsatisfactory accuracy of recent robotic assisting system Rosa for total knee arthroplasty. *Journal of Experimental Orthopaedics*. 2022;9(1). doi:10.1186/s40634-022-00522-7

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01 Study Design

A single center comparative study to evaluate the accuracy of the ROSA Knee System for Total Knee Arthroplasty (TKA)

- n=37 patients
- TKA performed using ROSA Knee by the same surgical team over 3 months
- Intra-operative mechanical axis (alpha, beta, gamma, delta angles, hip-knee-ankle angle) calculated by ROSA Knee
- Mechanical implant angles from post-op films, comparing with ROSA Knee's intra-operative plan for accuracy within 2° and 3°

02 Key Findings

- **Exceptional accuracy** between ROSA Knee's intra-operative planned axes and "post-operative mechanical angles" for the coronal, but not sagittal angles
- **Substantial measurement error and bias concerns** have been raised over the **sagittal measurements** (Gamma and Delta angles)
 - The measurement methods used by the authors **do not match the methods used by the robotics system**
 - The post-operative interrater reliability was moderate and **faulty sagittal images were included in the analysis**
 - **Measurement and subject selection biases** are evident in the study
- Despite the inflammatory title and above errors, the authors reported individual mean errors of ≤ 2.04 degrees with standard deviations ≤ 1.55 degrees for all four angles assessed, indicative of **accurate and precise resections**.
 - Alpha: 0.88 ± 0.71
 - Beta: 1.24 ± 1.06
 - Gamma: 1.93 ± 1.03
 - Delta: 2.04 ± 1.55

03 Clinical Significance

The ROSA Knee System is accurate and precise in both the coronal and sagittal planes according to the raw values reported.

The ROSA® Knee System: Correcting Methodological Flaws and Validating Measurements in Sagittal Plane

Reference:

Petrillo S, Migliorini F, Moretti G, Romagnoli S. **Accuracy of ROSA Knee System in Bone Cuts Orientation During Total Knee Arthroplasty: An Observational Study.** Journal of Clinical Medicine. 2025; 14(15):5205. <https://doi.org/10.3390/jcm14155205>

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01 Study Design

A single-surgeon, retrospective analysis evaluating the accuracy of the ROSA® Knee System.

- N=55
- Medial proximal tibial angle (MPTA), lateral distal femoral angle (LDFA), tibial slope (TS), and distal femoral flexion (DFF) were evaluated with three-month post-operative radiographs
- Long-leg antero-posterior radiographs were used for the MPTA and LDFA
- Short-leg lateral radiographs were used for the TS and DFF
- Outliers were defined as mean absolute errors greater than 3°



Scan or click for further discussion

1. Yoo, Jae Ho et al. (2008). Anatomical References to Assess the Posterior Tibial Slope in Total Knee Arthroplasty: A Comparison of 5 Anatomical Axes. The Journal of Arthroplasty, Volume 23, Issue 4, 586 - 592
2. Ishii Y, Noguchi H, Sato J, Takahashi I, Ishii H, Ishii R et al (2022) Comparison of the tibial posterior slope angle between the tibial mechanical Axis and various diaphyseal tibial axes after total knee arthroplasty. Arthroplasty Today 17:137-141

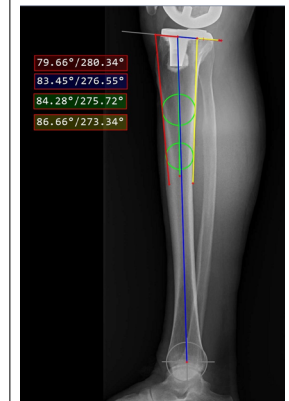
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02 Key Findings

- The outlier rate was zero for LDFA and 5.7% for MPTA
- Post-operative tibial slope was significantly different than the planned angle ($6.46 \pm 1.2^\circ$ vs. $7.0 \pm 0.0^\circ$, respectively)

Limitations

1. The measurements used to assess slope do not match the methods used by the ROSA Knee System.
 - Petrillo et al. assessed TS using the anterior tibial cortex (ATC)
 - Post-operative short lateral films limit the ability to identify the mechanical axis (MA)
 - TS measurements can be off by a couple of degrees dependent upon the axis selected:
 - Yoo et al.¹ reported variations between the MA and the ATC of $3.2^\circ \pm 1.3^\circ$
 - Ishii et al.² found differences of more than 3° between the ATC and MA
 - TS measures are more reliable when using the MA¹



Mechanical Axis (Slope = 83.94°)
(consistent with the ROSA Knee System)

Posterior Tibial Cortex (Slope = 79.7°)
(consistent with standard short sagittal films by Petrillo et al.)
* Image courtesy of Nathan Cafferky, MD

03 Clinical Significance

The use of short-leg lateral knee X-rays and the ATC axis are inconsistent with the measure of tibial slope using the mechanical axis. Long-leg X-rays and assessing TS with the MA are necessary to more accurately assess the precision of the ROSA Knee System in the sagittal plane.

ROSA Hip Topics



Jump To:

Accurate

- Improved Cup Accuracy
- Accuracy in a matched-pair cadaveric study
- Accuracy in Restoring Leg Length Discrepancy and Offset

Cost Effectiveness

- Compared to Manual Total Hip Arthroplasty Over Time

Efficient

- Compared to CT-based System

Initial Learning Curve

- Learning Curve of 12 Cases

Outcomes

- Leads to greater improvements in Patient Reported Outcome Measures at one year
- Shows Less Early Pain Outcomes and Low Complication Rate
- High Accuracy in Cup Placement and Excellent Outcomes at 1 year

Radiation Exposure

- Compared to Manual C-arm Imaging

Versus Mako®

- Better Outcomes at One-Year
- More Time Efficient than Mako

Workflow Standardisation

- Cup Placement for Obese Patients
- Cup Placement

The ROSA® Hip System: Shows Similar Total Operative Room Time and Improved Cup Accuracy

Reference:

Buchan GB, Hecht II CJ, Liu D*, Mokete L*, Kendoff D, Kamath AF*. Improved accuracy of a novel fluoroscopy-based robotically assisted THA System compared to Manual THA. *Journal of Robotic Surgery*. 2023;17(5):2073-2079. doi: 10.1007/s11701-023-01623-w

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01 Study Design

A single center retrospective analysis of consecutive patients who received conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA)

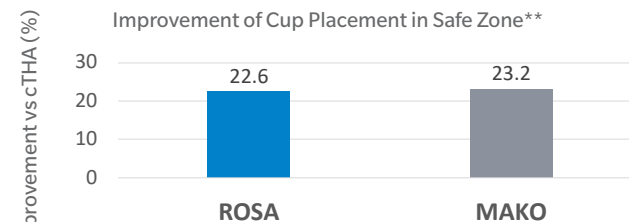
- cTHA: n=100
- rTHA: n=98

For all patients, an acetabular cup anteversion angle of 15° and inclination angle of 40° were targeted.

Differences in cup inclination, anteversion, percentage of cups positioned in the Lewinnek safe zone, operative and overall room time were compared between study groups.

02 Key Findings

- The ROSA Hip group had a significantly:
 - Higher accuracy for acetabular anteversion than the manual THA cohort (18.5° vs. 21.7°). Cup inclination was not different between the two groups ($p=0.976$)
 - Lower variance for both acetabular anteversion (26.0 vs. 44.5) and inclination (26.8 vs. 46.7)
 - Greater proportion of acetabular cups placed within the Lewinnek safe zone compared to manual THA (81.6% vs. 59%)
- The ROSA Hip group had a slightly longer operative time (39.0 vs. 35.3 min); however, total operating room time was similar between groups



**Domb BG et al (2020) Minimum 5-year outcomes of robotic-assisted primary total hip arthroplasty with a nested comparison against manual primary total hip arthroplasty: a propensity score-matched study. *J Am Acad Orthop Surg* 28:847-856

03 Clinical Significance

The ROSA Hip System increases the accuracy of acetabular cup placement and the percentage of cups within the safe zone with no increase in overall case time.

The ROSA® Hip System: Improved Accuracy and Reproducibility Compared to Manual Instrumentation

Reference:

Kamath AF*, Durbhakula SM*, Pickering T*, Cafferky NL*, Murray TG*, Wind MA Jr*, Méthot S.** **Improved Accuracy and Fewer Outliers with a Novel CT-free Robotic THA System in Matched-pair Analysis with Manual THA.** Journal of Robotic Surgery. 2022;16(4):905-913.

[doi: 10.1007/s11701-021-01315-3](https://doi.org/10.1007/s11701-021-01315-3)

Study funded by Zimmer Biomet

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01 Study Design

A matched-pair cadaveric study comparing the accuracy of ROSA® Hip (rTHA) with conventional instrumentation (cTHA). Fluoroscopic guidance was used in both groups:

- rTHA: N = 33
- cTHA: N = 33

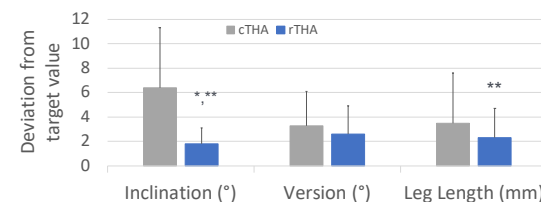
Surgeries were conducted by 14 high-volume surgeons.

For all cases, an acetabular cup anteversion angle of 15°, inclination angle of 40° and leg length discrepancy of 0 mm were targeted.

Differences in leg length, cup inclination, anteversion, and percentage of cups positioned in the Lewinnek/Callanan safe zone were compared between study groups.

02 Key Findings

- Compared to conventional instrumentation, ROSA Hip demonstrated a lower mean absolute error and a lower variance (fewer outliers) for:
 - Acetabular Component Orientation
 - Acetabular component inclination was significantly more accurate and more reproducible (fewer outliers) than conventional instrumentation. The version was similar between groups.
 - Leg Length Discrepancy (LLD)
 - LLD was significantly more reproducible than conventional instrumentation (fewer outliers)
- ROSA Hip resulted in significantly more cases within the safe zones (fewer outliers) for the acetabular component orientation.
 - 100% of robotic cases vs. 73% for conventional instrumentation.



* Mean absolute error, t-test $p < 0.05$

** Variance, F Test, $p < 0.05$

03 Clinical Significance

The ROSA Hip System reduces the leg length discrepancy and increases the reproducibility of the the accuracy of acetabular cup placement and the percentage of cups within the safe zone. The data supports the clinical use of the system for primary total hip arthroplasty.

The ROSA® Hip System: High Accuracy in Restoring Leg Length Discrepancy and Offset

Reference:

Buchan GBJ, Hecht II CJ, Nugent M, Heckmann ND, Kanaji A, Kamath AF*. **Efficacy of a novel, fluoroscopy-based robotic-assisted total hip arthroplasty system in restoring limb length and offset.** Arch Orthop Trauma Surg. 2025 Mar 5; 145(1): 175

[doi: 10.1007/s00402-024-05648-0](https://doi.org/10.1007/s00402-024-05648-0)

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01 Study Design

A single-center retrospective analysis of consecutive patients who received fluoroscopy-based, robotic-assisted Total Hip Arthroplasty (rTHA) via the direct anterior approach.

- rTHA: n = 98

For all patients, an acetabular cup anteversion angle of 15° and inclination angle of 40° were targeted.

Accuracy was calculated between the pre-operative templated* parameters and:

- Intra-operative values (robotic logs)
- Post-operative X-ray (6 weeks)

* ONE Planner® Hip was used for pre-operative planning

Please refer to Table 4 of the manuscript for a detailed overview.

Definitions:

LLD = leg length discrepancy; FO = femoral offset; GO = global offset.

02 Key Findings

- Versus pre-operative templated values:
 - Compared to the intra-operative robotic logs:
 - All parameters for LLD and offset were within 3.5 mm.
 - The proportion of patients that achieved less than 10 mm difference was 89% for LLD, 90% for FO and 79% for GO.
 - Both version and inclination of the acetabular cup were within 1.5°.
 - Compared to the 6-week post-operative radiographs:
 - All parameters for LLD and offset were within 1.5 mm.
 - The proportion of patients that achieved less than 10 mm difference was 92% for LLD, 93% for FO and 91% for GO.
- Femoral head size or femoral neck geometry target plans were adjusted intra-operatively for 44% of the patients.
- Accuracy levels for LLD and offset are comparable with CT-based robotic systems for THA (literature review).#

03 Clinical Significance

The ROSA® Hip System can restore templated LLD and offset parameters with high accuracy. This offers a degree of intra-operative flexibility, a key parameter of hip biomechanics.

The ROSA® Hip System: More Cost Effective than Manual THA Over Time

Reference:

Ong CB, Buchan GBJ, Acuña AJ, Hecht II CJ, Homma Y, Shah RP*, Kamath AF*. Cost-effectiveness of a novel, fluoroscopy-based robotic-assisted total hip arthroplasty system: a Markov analysis. Int J Med Robot. 2023; e2582 doi: 10.1010.1002/rcs.258202/

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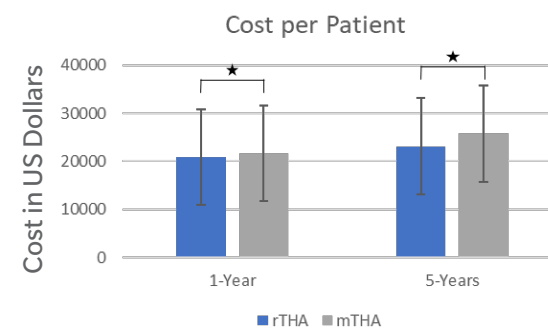
01 Study Design

A Markov analysis comparing the cost-effectiveness of robotic-assisted THA (rTHA) vs manual THA (mTHA)

- Quality-adjusted life years (QALY) were calculated for 1- and 5-years post-operative
- Cost-effectiveness was calculated by dividing the difference in cost between treatments by the difference in utility
- Input data was extracted from the literature and combined with available institutional rTHA data

02 Key Findings

- rTHA had significantly lower costs with an average savings of \$795 at 1-year and \$2631 at 5-years
- rTHA gained significantly more QALYS at 1- and 5-years
 - rTHA was significantly more cost effective per QALY at 1- and 5-years
- Probability sensitivity analysis revealed rTHA was more cost effective in 67.1% to 75.2% of cases at 5-years
 - The largest driver of cost-effectiveness was a lower probability of no complication revision with rTHA



03 Clinical Significance

Robotic-assisted total hip arthroplasty with the ROSA Hip System leads to lower treatment costs and improved utility through at least 5-years post-operative.

The ROSA® Hip System is More Time Efficient when Compared with a CT-based Robotic Platform for THA

Reference:

Ong CB, Buchan GBJ, Hecht II CJ, Lawrie CM*, DeCook CA, Sculco PK*, Kamath AF*. Robotic-assisted total hip arthroplasty utilizing a fluoroscopy-guided system resulted in improved intra-operative efficiency relative to a computerized tomography-based platform. J Robot Surg 2023 Dec; 17(6): 2841:2847 doi: [10.1007/s11701-023-01723-7](https://doi.org/10.1007/s11701-023-01723-7)

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01 Study Design

Retrospective data analysis from patients who underwent RTHA via the direct anterior approach using two different robotic platforms fluoroscopy-based (ROSA® Hip System) vs. CT-based (Mako® Total Hip replacement)

- fRTHA, n=107
- ctRTHA, n=159

Abbreviation	Definition
THA	Total Hip Arthroplasty
RTHA	Robotic Total Hip Arthroplasty
fRTHA	Fluoroscopy-based Robotic Total Hip Arthroplasty
ctRTHA	CT-based Robotic Total Hip Arthroplasty

02 Key Findings

- Average surgical and operating room (OR) times were shorter in fRTHA ($p<0.001$)
- Surgical and OR times were also more consistent (less variance, $p<0.001$)
- Mean ROSA Hip total active time was 24.43 ± 6.30 min:
 - Cup impaction time: 5.16 ± 1.63 min
 - Cup verification time: 2.37 ± 1.68 min
 - Trial and validation time: 16.9 ± 5.7 min

System	Surgical Times	
	Skin-Skin	Wheels-in – Wheels-out
fRTHA	38.7 ± 7.0	101.4 ± 12.2
ctRTHA	75.3 ± 11.4	156.74 ± 17.79

03 Clinical Significance

The ROSA Hip System leads to time savings when compared to a robotic CT-based system. The reduction in variance for surgical and total OR time allows for more efficient management of hospital resources.

The ROSA® Hip System: Operative Times Show a Learning Curve of 12 Cases

Reference:

Buchan GBJ, Hecht II CJ, Lawrie CM*, Sculco PK*, Kamath AF*. The learning curve for a novel, fluoroscopy-based robotic-assisted total hip arthroplasty system. The International Journal of Medical Robotics and Computer Assisted Surgery 2023;19(4). doi: 10.1002/rcs.2518

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01 Study Design

A single center retrospective analysis of consecutive patients who received robotic Total Hip Arthroplasty (rTHA)

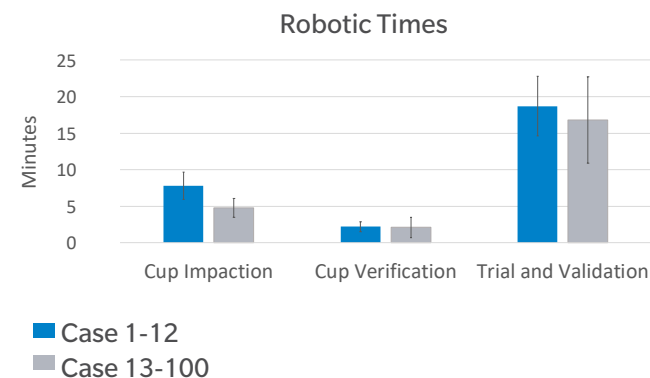
- rTHA: n=100

Analyzed parameters included:

- Operative times
- Duration of specific steps of the surgical workflow when the robot was active
- Acetabular cup orientation
- Radiographic outcomes
- Complication rate

02 Key Findings

- The ROSA Hip System had a learning curve of 12 cases with an operative time of 44.3 ± 4.4 min in the learning phase vs. 38.0 ± 7.1 min in the proficiency phase
- Cup impaction time was significantly longer in the learning phase: 7.8 ± 1.9 vs. 4.8 ± 1.3 min
- No significant differences in acetabular cup anteversion and inclination between the two different learning phases
- No complications reported for up to six months follow-up in the learning phase group



03 Clinical Significance

The ROSA Hip System is associated with a brief learning curve of 12 cases, with the most significant improvements in surgical efficiency realized during acetabular cup placement.

The ROSA® Hip System: Leads to greater improvements in PROMs at one year

Reference:

Buchan GBJ, Ong CB, Hecht CJ II, DeCook CA*, Spencer-Gardner LS, Kamath AF*. Use of a fluoroscopy-based robotic-assisted total hip arthroplasty system produced greater improvements in patient-reported outcomes at one year compared to manual, fluoroscopic-assisted technique. Archives of Orthopaedic and Trauma Surgery; Feb 2024 doi: <https://doi.org/10.1007/s00402-024-05230-8>

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01 Study Design

A single-center retrospective analysis of consecutive patients who received conventional (cTHA) or robotic Total Hip Arthroplasty (rTHA) via the direct anterior approach.

- cTHA: n=91
- rTHA: n=85

Pre- to post-operative differences in several patient-reported outcomes (VR12, HOOS and UCLA scores) were compared between study groups.

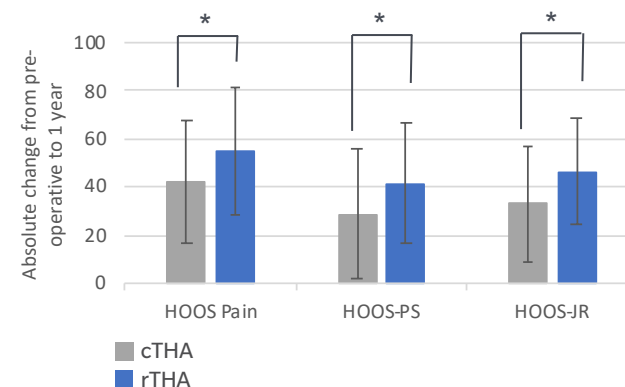
Sub-group analysis was performed for patients with cup placement in and outside the Lewinnek safe zone in both conventional and robotic cohorts.

Pre-operative evaluation, surgical technique and post-operative workflow were identical between the study cohorts.

02 Key Findings

- The rTHA group experienced significant improvements between pre- and post-operative HOOS sub-scores compared to the cTHA cohort (mean absolute values).
- A similar effect was also observed in the robotic group for patients with cup placement outside the Lewinnek safe zone.
- There was no difference in post-operative values for VR-12, HOOS and UCLA Activity scores between the two study cohorts.

HOOS sub-Scores



03 Clinical Significance

The ROSA® Hip System leads to greater improvements in pain, physical function and joint replacement HOOS sub-scores compared to fluoroscopy based-manual technique one year after surgery.

The ROSA® Hip System: Shows Less Early Pain Outcomes and Low Complication Rate

Reference:

Buchan, GB*, Hecht II CJ*, Sculco PK*, Chen JB*, Kamath AF*. Improved short-term outcomes for a novel, fluoroscopy-based robotic-assisted total hip arthroplasty system compared to manual technique with fluoroscopic assistance. Archives of Orthopaedic and Trauma Surgery. Published online 2023. doi: 10.1007/s00402-023-05061-z

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01 Study Design

A single-center retrospective analysis of consecutive patients who received conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA)

- cTHA: n= 105
- rTHA: n= 107

Rates of complications within 90 days post-surgery, length of hospital stay (LOS), and visual analog scale (VAS) pain scores were compared between the study groups.

02 Key Findings

- Versus manual THA, the ROSA Hip group had significantly:
 - Lower pain scores at 2 weeks post-operative (3.3 vs. 2.5; $p=0.048$), with both groups achieving similar pain scores at 6 weeks
 - Greater proportion of patients undergoing outpatient surgeries (3.8% vs. 37.4%; $p < 0.001$)
 - Shorter hospital length of stay (39.5h vs. 26h; $p < 0.001$)
 - Lower complication rate (6.7% vs. 0.9%; $p=0.029$)

Complications

Type	cTHA (n)	rTHA (n)
Reoperations	2	0
DVT* without PE**	3	1
Delirium	1	0
Hematoma	1	0

*DVT: Deep Venous Thrombosis

**PE: Pulmonary Embolism

03 Clinical Significance

The ROSA Hip System leads to an earlier reduction in pain levels and a decrease in length of stay by 34.2%, allowing a greater proportion of outpatient cases with no increase in complication rate or inpatient rehabilitation compared to a manual technique.

The ROSA® Hip System: High Accuracy in Cup Placement and Excellent Functional Outcomes at 1 year

Reference:

Liu D *, Kamath AF *, Cholewa J **, Stoenica L **, Anderson MB **, Lennox H. **Cup accuracy and early-term clinical outcomes of a novel, pinless, robotic-assisted total hip arthroplasty system: A first-in-human pilot study.** Arthroplasty. 2025;7(1):20. Published 2025 Mar 20.

[doi:10.1186/s42836-025-00299-x](https://doi.org/10.1186/s42836-025-00299-x)

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01 Study Design

A pre-market pilot study (first in human), two-surgeon/single site, prospective analysis of consecutive patients who received fluoroscopy-based robotic-assisted Total Hip Arthroplasty (rTHA) via the direct anterior approach

- rTHA: n = 19

Accuracy was calculated between the intra-operative plan and:

- Intra-operative values (robotic validation)
- Post-operative X-Ray (4 weeks)

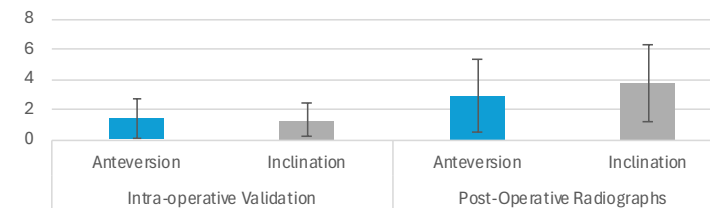
Patient reported outcome measures (PROMs) were assessed pre-operatively and at four weeks, three months and one-year post-operative.

- OHS = Oxford Hip Score
- NRPS = Numeric Pain Rating Scale
- HOOS-12 = Hip Osteoarthritis Outcome Score-12

02 Key Findings

- Versus intra-operative planning:
 - Analysis of the 4 weeks post-operative radiographs showed:
 - 77.8% of cases were within 5° of the targeted angles for both anteversion and inclination
 - In 88.9% of cases, the cup was within the Lewinnek and in 61.1% of cases within the Callanan safe zone
- At the one-year follow up:
 - There were no revisions, complications, or radiolucencies greater than 2 mm
 - All PROMs (OHS, NRPS, HOOS-12) significantly improved
 - 100% of patients were satisfied or very satisfied

Mean Absolute Errors (degrees)



03 Clinical Significance

ROSA® Hip leads to accurate acetabular cup placement, improvement in PROMs and excellent patient satisfaction as early as 4 weeks post-surgery.

The ROSA® Hip System: Shows Similar Radiation Exposure Compared to Manual C-arm Imaging

Reference:

Buchan GBJ, Ong CB, Hecht II CJ, Tanous TJ, Peterson B*, Hasegawa A, Kamath AF*. Equivalent radiation exposure with robotic total hip replacement using a novel, fluoroscopic-guided (CT-free) system: case –control study versus manual technique. *Journal of Robotic Surgery*. 2023;17(4):1561-1567. doi: 10.1007/s11701-023-01554-6

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01 Study Design

A single-center retrospective analysis of consecutive patients who received conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA)

- cTHA: n=100
- rTHA: n=100

Differences in number of fluoroscopic images, radiation dose, and duration of radiation exposure per procedure were compared between study groups.

02 Key Findings

- Statistically greater radiation (1.0+0.8 vs. 3.0+1.4 mGy) and fluoroscopic images (4.3 vs. 7.5) were recorded in the ROSA Hip group, however:
 - The difference between groups was not clinically significant
 - The amount of radiation recorded for the ROSA Hip group was similar to the normal range of radiation (0.3 to 2.97 mGy) reported for conventional procedures
- No learning curve was present. The first 20 and last 80 cases both required the same number of images (7.2 vs. 7.6)

03 Clinical Significance

The ROSA Hip System shows no clinically significant increase in radiation exposure to the patient compared to manual approaches.

The ROSA® Hip System: shows similar PROMs at 1 year when compared with a CT-based robotic platform for THA

Reference:

Ong CB, Buchan GBJ, Hecht II CJ, Liu D*, Petterwood J, Kamath AF*. Use of a fluoroscopy-based robotic-assisted total hip arthroplasty system resulted in greater improvements in hip-specific outcome measures at one-year compared to a CT-based robotic-assisted system. Int J Med Robot. 2024;e2650. doi: <https://doi.org/10.1002/rcs.2650>

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01 Study Design

A single-center retrospective analysis of consecutive patients who received THA via the direct anterior approach using two different robotic platforms (fluoroscopy-based (ROSA Hip System) vs. CT-based (Mako® Total Hip replacement))

- fTHA: n=85
- ctTHA: n=125

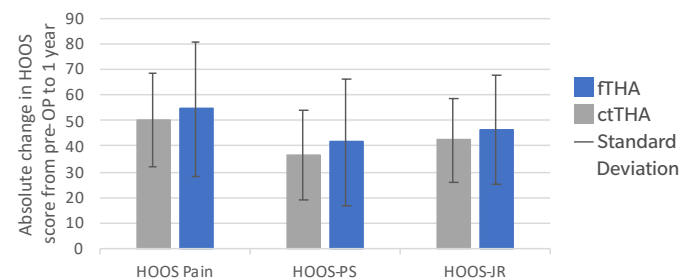
PROMs analysis: Pre- to one-year post-operative differences in several patient-reported outcomes (VR12, HOOS and UCLA scores) were compared between study groups.

Abbreviation	Definition
fTHA	Fluoroscopy-based robotic Total Hip Arthroplasty
ctTHA	CT-based robotic Total Hip Arthroplasty

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02 Key Findings

- The fTHA group experienced a significantly greater improvement of 4.99 points between pre- and post-operative HOOS-PS compared to the ctTHA cohort
 - All other PROMs were similar between the two groups.
- There were no differences in major complication rate, radiographic outcomes at six weeks post-operative and percentage of cups within the Lewinnek safe zone between the two study cohorts.
- Surgical time was significantly shorter in the fTHA group (38.7 vs 75.5 min)



03 Clinical Significance

The ROSA® Hip System leads to a greater improvement in HOOS-PS score one-year post-operatively when compared to a CT-based robotic technique. This finding needs to be interpreted with care given that the reported difference did not reach the minimal clinically important difference of 10.01*.

The ROSA® Hip System is More Time Efficient when Compared with a CT-based Robotic Platform for THA

Reference:

Ong CB, Buchan GBJ, Hecht II CJ, Lawrie CM*, DeCook CA, Sculco PK*, Kamath AF*. Robotic-assisted total hip arthroplasty utilizing a fluoroscopy-guided system resulted in improved intra-operative efficiency relative to a computerized tomography-based platform. J Robot Surg 2023 Dec; 17(6): 2841:2847 doi: [10.1007/s11701-023-01723-7](https://doi.org/10.1007/s11701-023-01723-7)

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01 Study Design

Retrospective data analysis from patients who underwent RTHA via the direct anterior approach using two different robotic platforms fluoroscopy-based (ROSA® Hip System) vs. CT-based (Mako® Total Hip replacement)

- fRTHA, n=107
- ctRTHA, n=159

Abbreviation	Definition
THA	Total Hip Arthroplasty
RTHA	Robotic Total Hip Arthroplasty
fRTHA	Fluoroscopy-based Robotic Total Hip Arthroplasty
ctRTHA	CT-based Robotic Total Hip Arthroplasty

02 Key Findings

- Average surgical and operating room (OR) times were shorter in fRTHA ($p<0.001$)
- Surgical and OR times were also more consistent (less variance, $p<0.001$)
- Mean ROSA Hip total active time was 24.43 ± 6.30 min:
 - Cup impaction time: 5.16 ± 1.63 min
 - Cup verification time: 2.37 ± 1.68 min
 - Trial and validation time: 16.9 ± 5.7 min

System	Surgical Times	
	Skin-Skin	Wheels-in – Wheels-out
fRTHA	38.7 ± 7.0	101.4 ± 12.2
ctRTHA	75.3 ± 11.4	156.74 ± 17.79

03 Clinical Significance

The ROSA Hip System leads to time savings when compared to a robotic CT-based system. The reduction in variance for surgical and total OR time allows for more efficient management of hospital resources.

The ROSA® Hip System: Improves Acetabular Cup Placement for Obese Patients

Reference:

Ong CB, Buchan GBJ, Hecht II CJ, Kendoff DO, Homma Y, Kamath AF*. Fluoroscopy-based robotic assistance for total hip arthroplasty improves acetabular cup placement accuracy for obese patients compared to the manual, fluoroscopic-assisted technique. Technol Health Care. 2023 Nov 9. doi: 10.3233/THC-231127

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01 Study Design

A single center retrospective analysis of obese and non-obese consecutive patients who received conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA) performed by one surgeon.

For all patients, an acetabular cup anteversion angle of 15° and inclination angle of 40° were targeted.

Differences in cup inclination, anteversion, placement consistency** and percentage of cup positioning in the Lewinnek safe zone were compared between study groups.

- cTHA: n=105
 - Obese, n=47
 - Non-Obese, n=58
- rTHA: n=102
 - Obese, n=50
 - Non-Obese, n=52

** Cup placement consistency/variances were calculated using the square of standard deviation for cup placement angle.

02 Key Findings

- The obese vs non-obese population in the cTHA cohort had:
 - Significant larger cup inclination angle ($44.8^{\circ} \pm 6.5^{\circ}$ vs. $41.4^{\circ} \pm 6.8^{\circ}$, $p=0.009$) in obese patients
 - Significantly smaller proportion of cup within the Lewinnek safe zone (48% vs. 67%, $p=0.027$) in obese patients
 - Similar angles for cup anteversion and no differences in cup placement consistency for both inclination and anteversion measurements
- There were no differences between obese and non-obese patients in the rTHA group for any of the measured accuracy or consistency parameters

Accuracy of Cup Placement with ROSA

Measurement	Obese	Non-Obese
Inclination	$6^{\circ} \pm 6.2^{\circ}$	$5.2^{\circ} \pm 4.1^{\circ}$
Anteversion	$4.7^{\circ} \pm 5^{\circ}$	$4.8^{\circ} \pm 4.5^{\circ}$

03 Clinical Significance

The ROSA Hip System allows for accurate cup placement independent of obesity status, minimizing the risk of over-abducted “open” cups when using a minimally invasive direct anterior approach for THA.

The ROSA[®] Hip System: Minimizes the Difference Between Left and Right Cup Placement

Reference:

Ong CB, Buchan GBJ, Hecht II CJ, Homma Y, Harmon DJ, Kendoff DO, Petterwood J, Kamath AF*. Fluoroscopy-based robotics in total hip arthroplasty mitigates laterality-based differences in acetabular cup placement when compared to the manual, fluoroscopic- assisted technique Technol Health Care. 2023 Nov 9. doi: 10.3233/THC-231126

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01 Study Design

A single center retrospective analysis of consecutive patients who received unilateral (left or right) conventional (cTHA) or robotic-assisted Total Hip Arthroplasty (rTHA) performed by one right-hand-dominant surgeon.

For all patients, an acetabular cup anteversion angle of 15° and inclination angle of 40° were targeted.

Differences in cup inclination, anteversion and percentage of cup positioning in the Lewinnek safe zone were compared between study groups.

- cTHA: n=106
 - Left, n=40
 - Right, n=66
- rTHA: n=102
 - Left, n=48
 - Right, n=54

02 Key Findings

- In the cTHA cohort, the left operated hip had a significantly smaller cup inclination angle when compared with the right one ($41.1^\circ \pm 7.4^\circ$ vs. $44^\circ \pm 6.3^\circ$, $p=0.04$)
- The anteversion cup angle and the proportion of left and right cups placed within the Lewinnek safe zone were similar for cTHA
- In rTHA, all measured parameters were similar between the left and right hips
- The rTHA had a higher proportion of right cups placed within the safe zone when compared with the cTHA (80% vs. 59%, $p=0.03$)
- When combining the left and right hips, there was a significantly larger proportion of hips placed with the Lewinnek safe zone in the rTHA group (78% vs. 59%, $p=0.003$)

03 Clinical Significance

The ROSA Hip System standardizes the THA procedure by reducing differences in placement of left or right acetabular cups, which may lead to more homogenous outcomes across different surgical scenarios.

mymobility Topics

Jump To:

Satisfaction

- Easy to use
- Shows Positive Impact

Compliance

- Better Completion of PROMs

Passive Data Collection

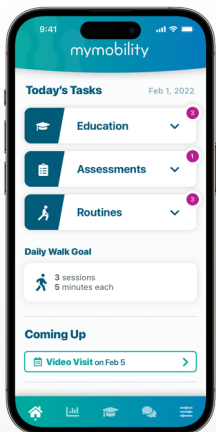
- On Recovering Total Hip Arthroplasty Patients
- On Recovering TKA Patients
- Integrating Data

Outcomes

- Fewer Emergency Visits Post-Operatively
- Lessened Need for Physical Therapy Visits
- Similar Outcomes to Traditional Standard of Care

Post-operative costs

- mymobility Can Help Reduce Post-Operative Costs After TKA



Efficiency as Part of the Joint Replacement Journey



Why Rapid Recovery®:

Healthcare costs are rising globally. There is greater demand for joint replacements due to increasing life expectancies⁵.

The Enhanced Recovery After Surgery (ERAS®) Society outlines recommendations for the perioperative care pathway for patients undergoing hip and knee replacement surgery.^{1,2} Rapid Recovery is an evidence-based programme like ERAS that combines fast-track surgery principles, process optimisation and patient engagement aiming to improve patient outcomes, have better care team and patient experiences^{3,4} and drive faster and more efficient care.⁴⁻⁷

Rapid Recovery is available for:

- ✓ Hip and Knee
- ✓ Fragility Fracture (Hip)
- ✓ Shoulder (Shoulder and Trauma)
- ✓ Outpatient (Hip, Knee, Shoulder)

Programs Similar to Rapid Recovery Have Been Shown to Deliver:

- ✓ Rapid and safe recovery after surgery^{1,2,5}
- ✓ Lower treatment costs^{6,7}
- ✓ Increased patient and employee satisfaction through information transparency³
- ✓ Improved interdisciplinary collaboration with standardized and improved treatment pathways for pre-, peri- and post-operative care⁴
- ✓ Fast Track protocols aligned with latest evidence²
- ✓ Reduced readmission and complication rates^{1,5}

Zimmer Biomet's Rapid Recovery:

- ✓ In a survey, 97% recommendation rate among Rapid Recovery users³
- ✓ Rapid Recovery Specialists for >25 years >250 Implementations in Europe
- ✓ >250 Implementations in Europe.

References

1. Sauro KM et al. Enhanced Recovery After Surgery Guidelines and Hospital Length of Stay, Readmission, Complications, and Mortality: A Meta-Analysis of Randomized Clinical Trials. *JAMA Netw Open*. 2024 Jun 3;7(6):e2417310.
2. Wainwright TW et al. Consensus statement for perioperative care in total hip replacement and total knee replacement surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. *Acta Orthop*. 2020 Feb;91(1):3-19.
3. Results of a 2023 employee satisfaction survey among employees from 33 Rapid Recovery clinics (n=63) who implement Rapid Recovery principles in their daily work. Data available upon request.
4. Noeth U et al. Fast-Track-Strategien in der Hüftendoprothetik [Fast track strategies in hip arthroplasty]. *Der Orthopaede*. 2019 Apr;48(4):330-336.
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7. Restelli U et al. Health Technology Assessment for Fast-Track Elective Knee and Hip Arthroplasty in a High-Volume Orthopaedic Hospital in Italy. *Clinicoecon Outcomes Res*. 2024 Aug 5;16:537-545. doi: 10.2147/CEOR.S46477.

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