ISAKOS CONGRESS 2025 | MUNICH GERMANY June 8–11

Joint Line Convergence Angle After Total Knee Arthroplasty: A Head-to-Head Comparison of Mechanical v/s Patient-Specific Alignment in Robotic-Assisted Surgery

David Figueroa Poblete, Waldo Gonzalez Duque, Jorge Isla Villanueva, Loreto Figueroa Berrios, Rodrigo Guiloff Krauss

Department of Traumatology, Knee and Arthroscopy Unit, Clinica Alemana, Universidad del Desarrollo, Santiago, Chile.

Faculty Disclosure Information

- Nothing to disclosure.
- All the authors contributed to the design, analyses and reporting for this manuscript. Both authors read and approved the final submitted manuscript.
- No funding was required for this study.

INTRODUCTION

- The concept of performing bone cuts at right angles—known as mechanical alignment (MA)—, with the goal of creating parallel and equal flexion and extension spaces, was introduced in the early stages of Total Knee Arthroplasty (TKA) development.

- In the past, this led many surgeons to view TKA as a soft tissue surgery aimed at balancing bone cuts. However, in most TKA procedures, soft tissues are rarely adjusted.

- On the other hand, it has been shown that restoring native soft tissue laxity in TKA is more easily achieved when implants are positioned closer to the patient's constitutional alignment. For many surgeons, this has led to a philosophical shift in the approach to TKA, moving from MA to a more patient-specific (PS) approach.

- Robotic assistance (RA), guided by 3D CT imaging, has proven highly effective precision.

INTRODUCTION

- The joint line convergence angle (JLCA)—a key component of knee kinematics—has recently gained attention as a clinically relevant parameter. It is a well-recognized surrogate measure for estimating the degree of intra-articular deformity.

- The JLCA is influenced by intra-articular deformity and lateral soft tissue laxity. For this reason, if JLCA is influenced by soft tissue laxity, performing RA-TKA should result in less disruption of soft tissues, thereby having a greater impact on JLCA.

- This study aimed to evaluate the joint line convergence angle following robotic-assisted TKA using two different alignment strategies.

- We hypothesized that a patient-specific alignment (PSA) strategy would result in a higher proportion of JLCA values within the normal range (0–2°).

METHODS

- A prospective review was conducted on a cohort of patients who underwent RA-TKA (Mako, Stryker, Mahwah, NJ) between January 2023 and January 2024.
- The indication for surgery was advanced knee osteoarthritis, classified as Kellgren-Lawrence stages 3 and 4, affecting at least two of the three knee compartments.
- A standard radiographic evaluation was performed using preoperative and postoperative weight-bearing X-rays, including anteroposterior, Rosenberg, lateral, axial patellar (skyline), and full-length lower limb radiographs.
- The joint line convergence angle was measured by two independent observers on both preoperative and postoperative radiographs.

METHODS

- **Mechanical Alignment:** The MA technique aims to restore a neutral axis (0°) or, at a minimum, correct coronal deformity within a ±3° limit.
    - This approach ensures that the HKA angle remains within a safe range of 177–183°.
- **Patient-Specific Alignment (PSA):** The goal was to restore the pre-arthritic medial proximal tibial angle (MPTA) within a safe range of 84° (varus) to 92° (valgus), which represents the knee's native alignment.
    - This approach ensures that the HKA angle remains within a safe range of 174–183°.
- Demographic data and the Knee Injury and Osteoarthritis Outcome Score Junior (KOOS JR) were collected preoperatively and at 12 months postoperatively. Demographic data included age, sex, body mass index (BMI), and postoperative complications.

RESULTS

- A total of 110 patients underwent RA-TKA between January 2023 and January 2024.
- All patients were contacted between November 2024 and January 2025 for a review.
- At follow-up, 98 patients (100 knees) were available, giving a follow-up rate of 89% at a minimun follow-up time of 12 months after surgery.

Group	Obs	Mean	Std. err.	Std. dev.	[95% conf.	interval]
1	50	2.336	.2105728	1.488974	1.912838	2.759162
2	50	2.428	.2437637	1.72367	1.938139	2.917861
Combined	100	2.382	.1603114	1.603114	2.063907	2.700093
diff		-.092	.3221205		-.7312377	.5472377

diff = mean(1) - mean(2) t = -0.2856
H0: diff = 0 Degrees of freedom = 98

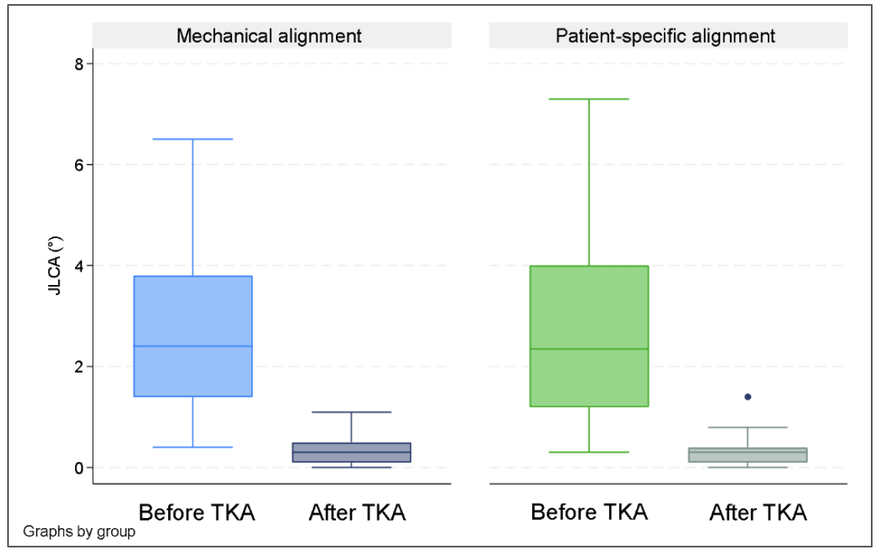
Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.3879 Pr(|T| > |t|) = 0.7758 Pr(T > t) = 0.6121

Statistical Analysis: Group 1 (MA) vs. Group 2 (PS).

RESULTS

- The mean preoperative KOOS JR score was 45.9 (SD: 10.7), while the postoperative KOOS JR score was 78.2 (SD: 12.1), with an average total improvement of 32.2 points (SD: 16.1).

- No significant differences were observed between the groups in terms of sex, age, BMI, preoperative KOOS JR or postoperative KOOS JR between the two groups at 1-year follow-up.



Statistical results. Comparison between both groups of the preoperative versus postoperative JLCA change.

Characteristics	Mean (SD)
Female sex, %	60 (61.2)
Age	70.0 (8.2)
BMI	28.1 (4.2)
Preoperative KOOS	45.9 (10.7)
Postoperative KOOS	78.2 (12.1)

Univariate Analysis

DISCUSSION

- The most important finding of our study is that, despite not being explicitly planned, both MA and PS alignment strategies optimized through robotic assistance effectively improved the postoperative JLCA, bringing it close to 0° in both cases.

- At the beginning of our robotic-assisted surgery experience, our group exclusively employed mechanical alignment in all joint replacement procedures, with few outliers.

- However, as we transitioned to a more patient-specific alignment approach, the boundaries of our planning expanded, leading us to consider implant positioning with varus angles of up to 5° or even 6° in certain patients.

- Interestingly, despite these variations, we observed that postoperative JLCA values remained largely unchanged, suggesting that individualized alignment strategies may still achieve comparable joint balance.

DISCUSSION

- Interestingly, despite advocating for a neutral MA (HKA = 180°), more than 60% of patients had an alignment outside the 178°–182° range.
- This highlights that planned bone cuts often do not translate perfectly into the achieved alignment, reinforcing the complexity of achieving precise MA in TKA.
- It is interesting to observe how our group has obtained similar results unintentionally, demonstrating that certain MA concepts are reproducible using the MAKO 2.0 software for more PSA philosophy.
- This system emphasizes prosthetic balance based on the ligamentous condition and the medial and lateral laxities throughout the entire range of flexion-extension.

CONCLUSION

- Postoperative JLCA improved in both mechanical and patient-specific alignment strategies following robot-assisted TKA, with no significant differences between the two approaches.

- Further studies with larger sample sizes, more long term outcomes and the inclusion of more functional outcomes are needed to validate these findings.

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