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ROBOTIC-ASSISTED TOTAL KNEE ARTHROPLASTY USING THE CUVIS JOINT ROBOT

Orthopaedics

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ABSTRACT

Background: Robotic-assisted Total Knee Arthroplasty (RA-TKA) is a transformative approach offering unmatched precision in bone resections and component alignment. We report our initial experience with 30 robotic-assisted TKA procedures using the Cuvis Joint Robot developed by Meril Life Sciences, India. **Objective:** To assess perioperative metrics, radiological alignment, functional outcomes, complications, and the integration of the Cuvis system into routine surgical practice. **Methods:** A prospective observational case series of 30 patients (both primary osteoarthritis and inflammatory arthritis) was studied. All underwent CT-based preoperative planning followed by autonomous robotic execution. **Results:** Excellent mechanical alignment (<3°) was achieved in 93.3% of patients. Functional scores significantly improved postoperatively, and complications were minimal. A noticeable reduction in operative time was observed, indicating a short learning curve. **Conclusion:** Cuvis robotic TKA is safe, accurate, and reliable, and can be smoothly integrated even in a high-volume orthopedic practice.

KEYWORDS

Robotic-Assisted Total Knee Arthroplasty, Cuvis Joint Robot, Implant Alignment Accuracy

INTRODUCTION

Total Knee Arthroplasty (TKA) remains the gold standard for end-stage degenerative and inflammatory arthritis of the knee. Proper alignment, balanced gaps, and component positioning are key to ensuring implant longevity and patient satisfaction. Robotic systems have evolved to address the limitations of conventional jig-based techniques. The Cuvis Joint Robot is a fully autonomous robotic system that offers:

- CT-based 3D planning
- Real-time visualization of bone resections
- Autonomous cutting without manual interference
- No requirement for optical trackers or pins

This study presents a single-surgeon experience with the first 30 robotic TKA cases using Cuvis, focusing on:

- Workflow integration
- Surgical precision
- Functional and radiological outcomes
- learning curve

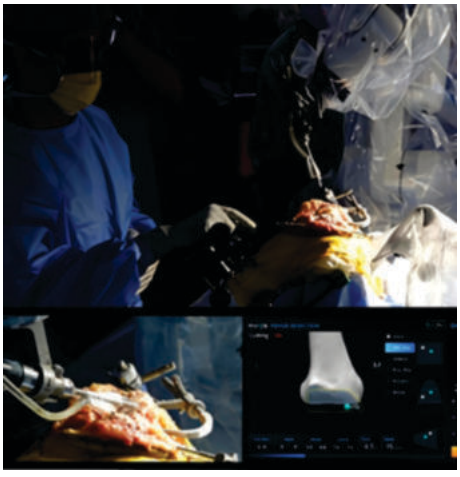

Figure 1 – Cuvis System Setup in the Operating Room with Surgeon Console and Robotic Arm

MATERIALS AND METHODS

Study Design

- Prospective case series conducted at a single tertiary-care orthopedic center
- Duration: [January 2024 – May 2025]
- Ethics clearance obtained, and all patients provided informed consent

Inclusion Criteria

- Symptomatic primary osteoarthritis
- Inflammatory arthritis (RA, PsA, AS)
- Failed non-operative management
- Flexion contracture <20°, varus/valgus <25°
- CT scan availability for robotic planning
- Age between 50–85 years

Exclusion Criteria

- Revision arthroplasty
- Fixed deformity >25°
- Active or prior infection
- Severe osteoporosis with risk of fracture
- Refusal for robotic procedure

Robotic System

- Cuvis Joint Robot (Meril Life Sciences)
- CT-based patient-specific 3D model
- Autonomous execution without surgeon-held tools

Surgical Protocol

- Spinal ± epidural anaesthesia
- Standard medial parapatellar approach
- Patient-specific planning based on CT scan
- Femoral and tibial registration
- Autonomous bone resection by Cuvis robot
- Cemented implants in all cases
- Tourniquet used throughout

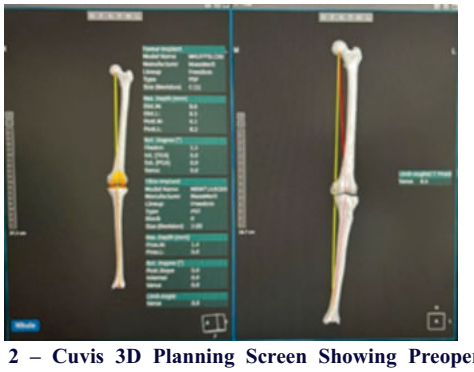

Figure 2 – Cuvis 3D Planning Screen Showing Preoperative Alignment Plan

RESULTS

Demographics

Parameter	Value
Total Patients	30
Gender (M:F)	12:18
Mean Age	64.2 years (range: 53–79)
Diagnoses	23 OA, 5 RA, 2 PsA

Laterality	Right (16), Left (14)
Mean BMI	27.8 ± 3.1

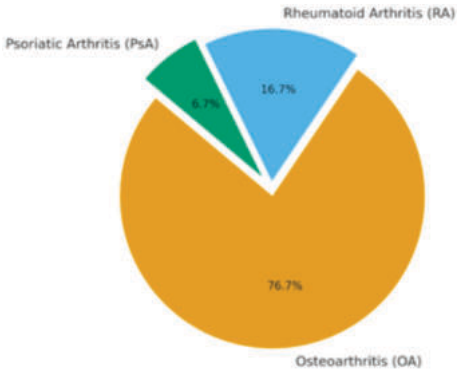

Figure 3 – Pie chart of Diagnosis Distribution (OA vs RA vs PsA)

Operative and Perioperative Metrics

Metric	Value
Mean operative time	92 mins (range: 75–118 mins)
Mean blood loss	220 ml
Tourniquet time	65 mins
Hospital stay	3.5 days (range: 2–6)
Time to ambulation	2.5 days
Time to full weight bearing	1.1 days

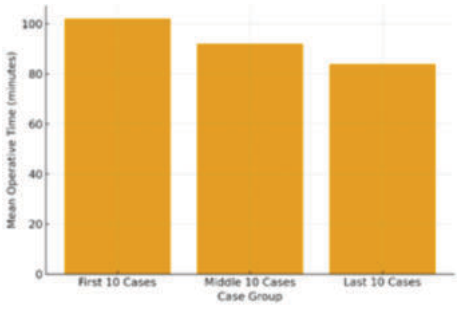

Figure 4 – Bar Graph Comparing Operative Time Across First vs Last 10 Cases

Functional Outcomes

Outcome	Pre-op	6 Weeks	3 Months
KSS (mean ± SD)	42.1 ± 5.6	69.8 ± 7.1	84.6 ± 6.3
VAS Score (mean)	8.3	3.2	1.7
ROM (average flexion)	90°	110°	120°
Patient Satisfaction Rate	—	—	96.6%

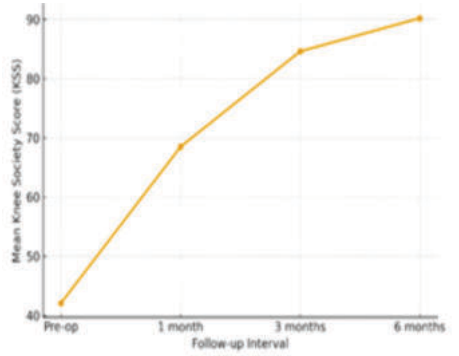

Figure 5 – Line Graph Showing KSS Progression at Different Follow-up Points

Radiological Outcomes

Alignment Parameter	Result
Mechanical axis within ±3°	28/30 (93.3%)
Femoral component accuracy	<1.5° deviation in 29/30 cases
Tibial slope accuracy	±2° in 100% of cases
Post-op HKA axis (mean)	179.1° ± 1.2°
Outliers (>3° deviation)	2 patients

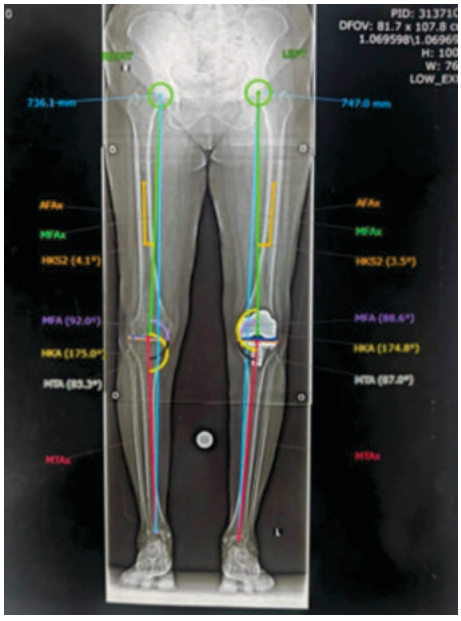

Figure 6 – Post-operative Full-length X-ray (standing scanogram)

Complications

Complication	Number of Cases
Superficial wound infection	2
Transient peroneal neuropraxia	1
DVT, PE, deep infection, mortality	0

Figure 7 – Flowchart of Postoperative Rehabilitation Protocol

Learning Curve Analysis

- First 10 cases: Average operative time = 102 min
- Last 10 cases: Average time = 84 min
- Registration and planning time reduced by 35%
- Improved coordination among surgical team led to faster turnover
- No increase in complications during early learning phase

DISCUSSION

1. Precision and Component Alignment

The goal of TKA is to restore mechanical alignment within ±3°, which correlates with improved implant longevity and reduced polyethylene wear (1,2). In our study, 28 out of 30 cases achieved this target. Such accuracy is consistent with other robotic systems like MAKO and ROSA (3,4).

The Cuvis robot uses CT-based planning and autonomous bone resection, which eliminates intraoperative manual variability. Studies have shown that robotic TKA systems offer more consistent component alignment and rotational accuracy compared to conventional techniques (5,6).

In particular, Kayani et al. found that robotic-arm-assisted TKA improved limb alignment and implant positioning with fewer outliers (3). Our data align with these findings.

2. Performance in Inflammatory Arthritis

Inflammatory arthritic knees are often more challenging due to soft

bone, joint deformities, and tissue contractures. However, our study included 7 patients with inflammatory arthritis (5 RA, 2 PsA), all of whom achieved alignment and functional results similar to the primary OA group.

Kim et al. compared robotic and conventional TKA in bilateral cases and found superior outcomes with the robotic side, including better pain scores and ROM, even in complex knees (6). Similarly, Song et al. demonstrated accuracy and soft tissue protection benefits in robotic TKA across various diagnoses (7).

This suggests Cuvis can be safely used in inflammatory pathology, expanding its utility beyond straightforward OA.

3. Early Functional Recovery
The mean KSS improved from 42.1 to 84.6 at 3 months, and mean VAS score dropped from 8.3 to 1.7. These improvements mirror findings by Marchand et al., who noted better pain relief and patient satisfaction in the robotic group versus manual TKA at 1-year follow-up (4).

Several biomechanical advantages may contribute:
- Less soft tissue dissection due to planned cuts
- Better preservation of ligament tension
- Balanced flexion-extension gaps before bone cuts

These promote faster rehabilitation and earlier return to activity (8,9).

4. Learning Curve and Workflow Integration
Despite being our first experience with Cuvis, a sharp decline in operative time (from 102 to 84 minutes) was observed after the first 10 cases. This matches the learning curve reported in other robotic systems, where plateauing occurs within 15–20 cases (3,8).

The autonomous nature of Cuvis reduces physical effort and allows the surgeon to focus on soft tissue handling and final positioning. The lack of pin-based trackers — used in other systems — also reduces pin-related complications such as fractures or infections (10).

5. Safety and Complications
Our complication rate was low: two superficial infections and one case of transient peroneal neuropraxia. No deep infections, DVT, or implant-related failures occurred. These rates are comparable to or better than those seen in conventional TKA cohorts (5,10).

Furthermore, Khlopas et al. observed reduced iatrogenic soft tissue trauma in robotic-assisted procedures, which might contribute to the low complication profile (9).

CONCLUSION

Robotic-assisted TKA using the Cuvis Joint Robot provides high precision, reproducibility, and safe outcomes even in inflammatory knees. Our series of 30 patients confirms:
- Superior alignment and implant positioning
- Rapid early functional recovery
- Minimal complications
- Modest learning curve and seamless workflow adaptation

Cuvis is a robust, autonomous robotic system well-suited for modern TKA demands and applicable to a wider range of patient profiles than traditionally considered.

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