No Increased Risk of Distal Femur Fractures with Robotic-Assisted versus Manual Primary Total Knee Arthroplasty

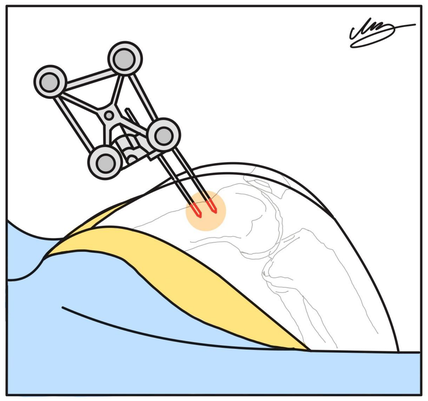
Maxim Bukhbinder, BS[1], Martinus Megalla, MD[2], Jordan Bauer, MD[2], Nicholas Lee, BS[1], Matthew Grosso, MD[3]

[1]Frank H. Netter MD School of Medicine, Quinnipiac University, North Haven, CT , [2]Department of Orthopaedic Surgery, University of Connecticut, Farmington, CT, [3]Connecticut Joint Replacement Institute, Saint Francis Hospital, Hartford, CT

1. BACKGROUND

- Total Knee Arthroplasty (TKA) volume in the United States is projected to rise steeply through 2030.
- Robotic-assisted TKA (RA-TKA) has demonstrated improved alignment and component positioning.
  - However, its bone-anchored tracking pins may create bony defects that act as stress risers versus manual total knee replacement.
- Case reports and reviews describe fractures at these sites (incidence ranging from 0.06% to 4.8%), but no series included a manual arm, so risk attributable to the pins has never been measured.

Objective: measure the two-year incidence of ipsilateral distal femur fracture after robotic versus manual TKA, and quantify how much excess risk the pins could still carry.



Tracking array pins pass through both femoral cortices. The resulting defects are the postulated stress risers. (Original illustration by Maxim Bukhbinder)

2. METHODS

- Design - retrospective cohort, 15,555 consecutive TKAs at one institution, April 2014 to December 2025.
- Cohort - non-primary surgeries and knees without a two-year follow-up window were excluded; 14,240 remained.
- Exposure - Robotic-Assisted TKA (bone-anchored pins) vs manual TKA. Navigated knees also use pins and are reported separately.
- Outcome - ipsilateral distal femur fracture within two years; contralateral and femoral shaft fractures not counted.
- Ascertainment - ICD-10 diagnosis, procedure codes, and institutional fracture flags applied identically to both arms.
- Analysis - exact proportions and risk ratios, Fisher exact tests, a one-sided 95% upper bound on excess risk, and 1:1 propensity matching on nine covariates.

3. STUDY FLOW

15,555 consecutive TKAs
CJRI registry · April 2014 - December 2025

Excluded n = 1,328
58 non-primary (UKA, patellar, tumor)
1,270 without a closed two-year window

14,240 eligible primary TKAs
two-year follow-up complete

4,621 robotic	1,016 navigated	8,603 manual
MAKO · tracking pins	pins · reported separately	no tracking pins

Primary comparison: 4,621 robotic vs 8,603 manual
n = 13,224 knees · navigated arm reported separately

4. KEY FINDING

Ipsilateral distal femur fracture within two years

0.043%	0.116%	0.37
robotic	manual	risk ratio
2 fractures / 4,621 knees	10 fractures / 8,603 knees	95% CI 0.08-1.70

Risk difference -0.073 percentage points (95% CI -0.18 to +0.05); p = 0.236

Exact binomial 95% CIs. Median time to fracture 67 vs 88 days; two-year mortality 0.65% vs 0.58% (p = 0.64).

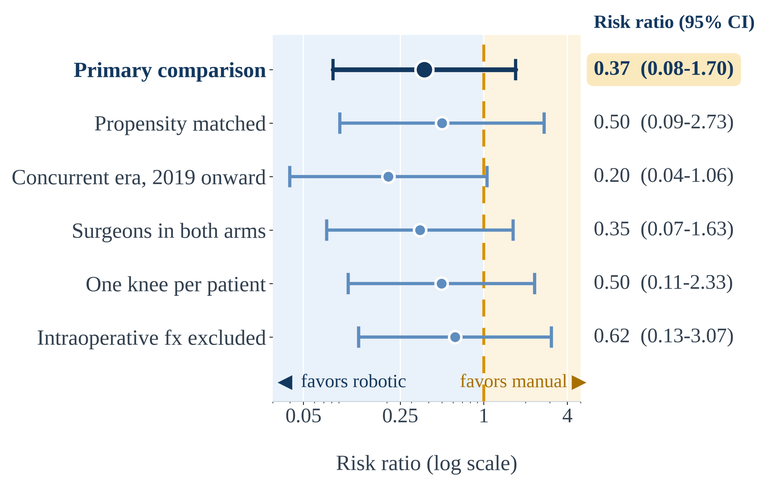
5. ADJUSTED AND SUBGROUP ANALYSES

Robotic patients were older (68.8 vs 66.9 years)with more comorbidities(cardiac disease 42.7% vs 29.2%). Propensity matching on nine covariates gave 3,130 pairs balanced across all nine (all |SMD| 0.018 or less), and the result held: 2 vs 4 events, RR 0.50 (0.09-2.73), p = 0.687.

Navigation uses the same pins as robotic TKA. No fractures occurred in 1,016 navigated knees (95% upper bound 0.362%). Pooling navigated with robotic gives 2 of 5,637, RR 0.31 (0.07-1.39).

Propensity model c-statistic 0.611.
A Firth-penalized model keeping all 13,224 knees gives OR 0.44 (0.09-1.52).

6. SENSITIVITY ANALYSES



Direction of effect is unchanged across every definition of exposure and outcome tested.

7. CONCLUSIONS & LIMITATIONS

- RA-TKA was not associated with increased risk of periprosthetic distal femur fracture.
- Incidence was low in both arms: about one fracture per 2,300 robotic and one per 860 manual knees.
- Any excess risk attributable to the pins is bounded at one extra fracture per 3,800 robotic knees.
- To our knowledge, this is the first direct comparison of pin-exposed knees against a concurrent manual cohort.

LIMITATIONS

- Retrospective, single institution, not randomized.
- Events came from codes and fracture flags - chart review of additional candidates is ongoing.
- The manual arm spans 2014 onward while robotic cases begin only in 2019, so the arms are not fully contemporaneous. Restricted to the shared era, the risk ratio falls to 0.20.

ACKNOWLEDGEMENTS & REFERENCES

Thanks to the CJRI clinical database team at Saint Francis Hospital for data extraction, and to the Frank H. Netter MD School of Medicine for supporting this project.

Disclosures: None.

Full reference list can be viewed by scanning QR code.