National University Hospital

All-Intra-Incisional-Pins in Robotic Total Knee Arthroplasty (TKA) as a New Standard of Care – A Practical Technique Guide

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Faculty Disclosure Information

We have nothing to declare

Introduction

- Major robotic systems utilize array pins in the tibia and femur for robot registration and calibration[1,2,3,4,5]
- These are often placed extra-incisionally and can potentially lead to **intraoperative soft tissue injuries**, such as peroneal nerve damage and periprosthetic fractures. This occurs secondary to **weakening of the diaphysis by the pins, which act as stress risers**[6,7,8]
- We have developed an **all-intra-incisional pin method** with a low complication rate - the pins remain securely with minimal obstruction to bone cuts, trial implants, tibial keel preparation, and final implants.
- This paper aims to **describe our technique and analyse the proximity of the pins to the implants**. Our hypothesis is that we can place the pins close to the final implants without causing any collisions.

Technique

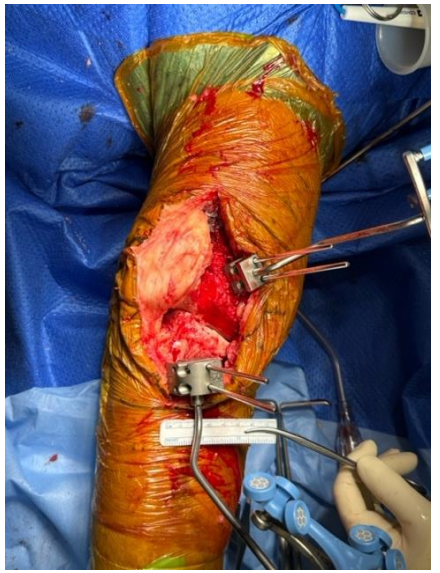
Femoral Pin Placement

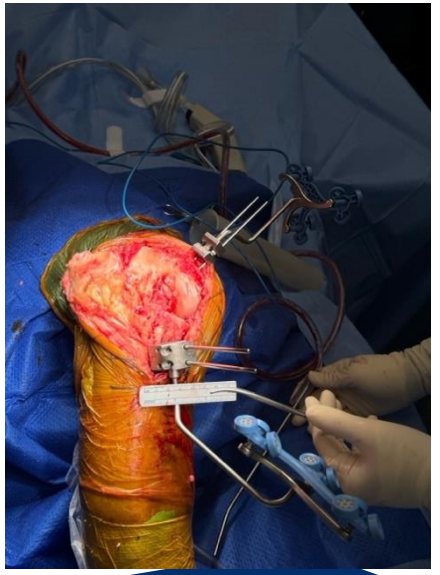
- The knee is positioned in **90 degrees of flexion** prior to placement of the femoral pins.
- For placement of the first pin in the distal femur, the starting point is determined by referencing the **inflection of the articular border on the medial aspect of the trochlear, before it flares out to form the medial articular condyle**, known as the Liau-inflection point.
- From this reference point, the pin is positioned **20mm medially and 20mm proximally**. The pin is aimed **10mm deep to the apex of the intercondylar notch**.
- The placement of the second pin in the proximal femur is **system-specific**, as some systems have their arrays arranged longitudinally, while others have them arranged perpendicularly.
- This second pin is designed to **work in conjunction with the first pin**, serving the functional purpose of retracting the medial soft tissues to aid in exposure.
- The pins are **inserted in a trajectory and depth that does not impede** the placement of trial femur component nor actual implant.
- Typically, the pins are placed to **engage double cortices for maximal stability**.

Technique

Tibial Pin Placement

- The knee is positioned in **full extension** prior to placement of the tibial pins.
- For the placement of the first pin in the distal tibia, the assistant retracts the medial soft tissues using two Langenbeck retractors.
- The distal Langenbeck is positioned to **retract the soft tissues distal to the apex of the deep medial collateral ligament (MCL) without retracting the ligament** itself.
- The proximal Langenbeck **retracts the medial soft tissues, including the deep MCL**, to ensure proper exposure.
- The starting point for the distal tibial pin is determined by **referencing the proximal jig hole at the level of the tibial tuberosity**, and is placed **intra-incisionally but extra-capsularly** to avoid unnecessary tenting or release of the deep MCL/medial sleeve, which could impact subsequent medial gap balancing assessments.
- The **distal pin is placed first through the distal tracker jig hole**, approximately **30mm from the tibial crest**. The pin is **aimed 10 degrees** distally towards the foot.
- For the placement of the second pin in the proximal tibia, the starting point is referenced from the **apex of the tibial tuberosity**. The pin is **placed proximally, about 15mm away from the tibial tuberosity**. The trajectory involves a **10-degree rotation, resulting in an internally rotated** tibial tracker jig.





Methodology

- A retrospective study was conducted, recruiting **102 rTKAs**, performed between February 2023 to May 2024, at two tertiary hospitals, using the **ROSA (Zimmer), MAKO (Stryker) and CORI (Smith & Nephew) systems**.
- **53 rTKAs were in the Intra-incisional group**, and the remaining **49 in the extra-incisional group**.
- The patient's **post-operative day zero (POD 0) Antero-Posterior and Lateral radiographs** of the operated knee were used for measurements, with adjustment for X-Ray magnifications.
- A priori power analysis was conducted to achieve 80% power at a significance criterion of $\alpha = 0.05$, which was determined to be 67.

Outcomes

Primary Outcomes

- Distances **between the array pins and the tibial and femoral implant** when pins were placed intra-incisionally, compared to when extra-incisionally.
- Specifically, the distances (mm) measured and defined in the present study are:
  - **(a) Distance between the closest Tibia Pin and Tibial Implant in AP view;**
  - **(b) Distance between the closest Tibia Pin and Tibial Implant in Lateral view**
  - **(c) Distance between the closest Tibia Pin and Tibial Implant in Lateral view;**
  - **(d) Distance between closest Femur Pin to the Femoral Implant on AP view**

Secondary Outcomes

- Secondary outcomes of interests were the **complications rates** in both groups such as infections and fractures.

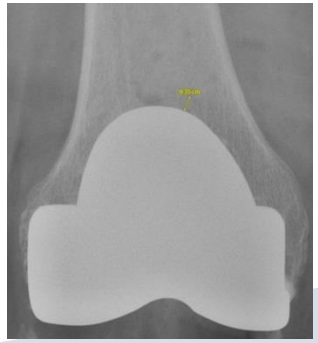
Statistical Analysis

- **Shapiro-Wilks Test** for normality was performed, followed by **ANOVA and Post-Hoc T-testing** if data was normally distributed, or **Mann-Whitney U Testing**, **Kruskal-Wallis Testing** and **Post-Hoc Dunn Testing** if data was non-normally distributed

Distance (a)

Distance (b)

Distance (c)



Distance (d)

Results

	Age			Male %		Race				
	Mean (95% CI)	S.D	P-Val	Mean (95% CI)	P-Val	Chinese	Malay	Indian	Other	P-Val
Intra-incisional (n=53)	69.6 (68, 71.3)	7.6	0.30	40.5%	0.72	66.7	9.5	23.8	0	0.27
Extra-incisional (n=49)	68.1 (65.8, 70.5)	6.4		35%		80	3.3	15	1.7	

	BMI			Robot System		
	Mean (95% CI)	S.D.	P-Val	ROSA	MAKO	CORI
Intra-incisional (n=53)	28.1 (26.8, 29.3)	4	0.9	81	11.9	7.1
Extra-incisional (n=49)	28 (26.5, 29.4)	5.4		40	56.7	3.3

Results

Parameter		Mean Distance (mm)	95% CI	Standard Deviation	P-Value	Multivariate Analysis
						Adjusted P-Value
Tibia Pin to Tibial Implant on AP View	Intra-Incisional Pins	**8.99**	7.78, 10.2	3.9	< 0.001	< 0.001
	Extra-Incisional Pins	**58.6**	52.8, 64.4	21.1		
Tibia Pin to Tibial Implant on Lateral View	Intra-Incisional Pins	**9.40**	7.97, 10.8	4.2	< 0.001	< 0.001
	Extra-Incisional Pins	**57.5**	51.2, 63.7	20.8		
Tibia Pin to Tibial Reamed Surface on AP View	Intra-Incisional Pins	**5.93**	4.64, 7.22	3.7	< 0.001	< 0.001
	Extra-Incisional Pins	**47.0**	38.5, 55.5	22		
Femur Pin to Femoral Implant on AP View	Intra-Incisional Pins	**6.01**	4.64, 7.37	2	0.002	< 0.001
	Extra-Incisional Pins	**28.2**	21.3, 35.1	21.7		

	Intra-incisional, n (%)	Extra-incisional, n (%)
Complications*	0	1 (2.04)

Discussion

- This is the **first paper** to describe an all-intra-incisional pin technique in the placement of robotic tracker pins in a total knee arthroplasty, regardless of the robotic system used.
- Our study demonstrates that **intra-incisional pins can be placed 6.52 times closer** compared to extra-incisional pins – 8.99mm (95% CI 7.78, 10.2) versus 58.6mm (95% CI 52.8, 62.4).
- Employing our techniques, we observed **no immediate intra-operative complications**, and there was **no need to reposition any pins** during the procedures when utilizing intra-incisional pins. In the group with extra-incisional pins, there was one instance of a potential pin-site related tibia fracture (2.04%), whereas there was none for the intra-incisional group, suggesting intra-incisional pins might reduce pin-related complications.
- It has been shown that pins in diaphysis are more likely to cause stress risers which may lead to pin site fractures[7,8]. This is hypothesized by diaphysis having a smaller surface area and pins passing through non-cancellous bone.
- Our technique allows pins to go through the metaphyseal region of both femur and tibia which have a larger surface area and cancellous bone. In the authors' opinion, this is a safer technique to employ when inserting robotic TKA tracker pins.

Conclusions

- Our study has demonstrated that our technique is consistent and easily reproducible in achieving precision.
- This technique may result in a reduced incidence of pin-site fracture complications, as the pins are inserted into the cancellous bone of the metaphyses which has a wider surface area, instead of cortical diaphyseal bone with a narrower surface area.
- Importantly, this outcome is not influenced by patient demographics.

Limitations

- The all-intra-incisional pin method can potentially interfere with sawing, reaming, and the placement of both trial and actual implants. Nevertheless, once the initial learning curve is overcome, such instances have become infrequent.
- Intra-incisional femur pin holes were mostly not visible on the lateral X-rays. Consequently, we were unable to assess the pin-to-femur implant distances for some rTKAs..
- The all-intra-incisional-pins technique was performed by only a single surgeon, and reproducibility of this technique by other surgeons needs to be evaluated.

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