Trauma Case Reports 57 (2025) 101182

Contents lists available at ScienceDirect

Trauma Case Reports

journal homepage: www.elsevier.com/locate/tcr

Case Report

Watch out your pins! Periprosthetic femoral fracture at tracking pin site early after robotic-assisted knee arthroplasty treated with dual nail-plate fixation

Jaime Sánchez del Saz [a,*], Jaime Coderch Carretero [a], Javier García Coiradas [a], Rodrigo García Crespo [b]

[a] Trauma Surgery Unit, Hospital Universitario Clínico San Carlos, Calle Profesor Martín Lagos, s/n, Madrid 28040, Spain
[b] Knee Surgery Unit, Hospital Universitario Clínico San Carlos, Calle Profesor Martín Lagos, s/n, Madrid 28040, Spain

A R T I C L E I N F O

Keywords:
Periprosthetic femoral fracture
Femur
Robotic-assisted arthroplasty
Knee
Tracking pin
Nail-plate osteosynthesis

A B S T R A C T

Robotic-assisted orthopedic surgeries are gaining popularity due to several factors such as its potential for enhanced precision and alignment in prosthetic implant placement, as well as its better pain control and reduction in hospital stay time. However, complications such as pin-related periprosthetic fractures, though rare, highlight the importance of technical precision during pin placement and adequate postoperative monitoring.

We present the case of a 76-year-old obese female patient who presented to the Emergency Department with severe pain and deformity around the knee two months after robotic-assisted total knee arthroplasty following a fall from standing height. Radiographs revealed a displaced femoral periprosthetic fracture at tracking pin sites without associated implant instability. Surgical management involved combined nail-plate fixation, which promoted both early weight-bearing and functional recovery. At one year postoperatively, the patient achieved satisfactory fracture healing and functional outcomes, with a Knee Society Score of 92 and an EuroQol-5D index value of 0.78.

Combined nail-plate osteosynthesis, though more invasive compared to other fixation methods, could be an effective strategy for managing distal femoral fractures following robotic-assisted arthroplasty, especially in obese and elderly patients, due to its biomechanical advantages, supporting early mobilization and weight-bearing with reliable fracture healing.

Background

In recent decades, there has been a growing worldwide interest in developing technology aimed at upgrading precision in the placement of prosthetic implants and limb alignment in orthopaedics, especially in cases of hip and knee primary arthroplasty. This technology is described to improve short-term outcomes and reduce hospital stays for patients, with an apparently short learning curve for orthopedic surgeons. However, the theoretical main goal of this technology, which has yet to be corroborated, is to enhance long-term functional outcomes, increase implant survival and reduce revision rates in prosthetic surgery, thereby lowering the overall costs of these procedures in a context of steadily increasing volumes of joint replacement surgery worldwide [1–3]. This process began

* Corresponding author at: Hospital Virgen de Altagracia, Avenida Emiliano García Roldán, s/n, Manzanares 13200, Spain.
E-mail address: jsdelsaz@gmail.com (J. Sánchez del Saz).

https://doi.org/10.1016/j.tcr.2025.101182
Accepted 14 April 2025
Available online 15 April 2025

decades ago with navigation assistance systems and is currently experiencing another period of prominence with robotic-assisted surgery. This type of surgery introduces specific complications in addition to the usual ones of arthroplasty due to temporary tracking pin placement required by the robotic system, such as periprosthetic fractures, which can further question the cost-effectiveness of this technology. In knee arthroplasty cases, two pins are placed in the femur and another two in the tibia temporarily during surgery, either within the operative field or percutaneously using separate stab incisions. However, there is little conclusive information available concerning the placement of pin trackers in the distal femur during robotic-assisted knee arthroplasty [4–11].

The estimated incidence of these fractures varies between 0.06 % and 4.8 %, although the vast majority of studies report rates below 2 %. This complication usually occurs early after primary knee arthroplasty (at a mean of 9.5 weeks after index surgery) and most commonly affects the femoral diaphysis (60 %). Despite being usually atraumatic in nature or resulting from low-energy trauma, these fractures are often displaced (40–60 %) and, therefore, require surgical management [4,10]. There is a limited number of cases published in the literature about periprosthetic fractures associated with tracking pins in robotic-assisted surgery due to its rarity, making this one of the few cases described to our knowledge. In our case, we introduce a periprosthetic femoral metaphyso-diaphyseal fracture, treated with a combined osteosynthesis implant (nail-plate) in the same surgical procedure.

Case report

A 76-year-old female patient who underwent primary knee arthroplasty assisted by a robotic arm 2 months earlier due to knee osteoarthritis with a varus deformity of the lower limb (Figs. 1 and 2) presented to our emergency department with severe pain, swelling, and deformity around the intervened knee after a fall from her own height. Her medical history was notable for grade 2 obesity, with a body mass index (BMI) of 36, without other relevant personal history. Two 3.2 mm tracking pins were placed at the metaphyso-diaphyseal zone in the femur and another two in the proximal tibia during the index surgery. The surgery and the

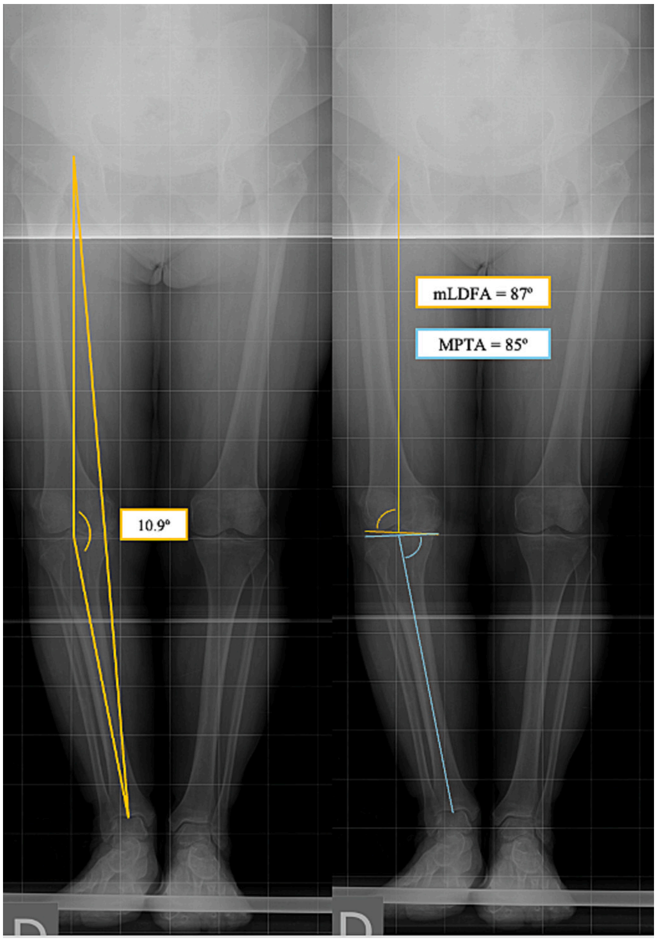

Fig. 1. Preoperative radiographs of the entire lower limb showing advanced osteoarthritis in the right knee with varus mechanical alignment (10.9°) in the right lower limb. The mechanical axis line traverses the knee joint line within Stevens' zone +2. The varus deformity is primarily due to the tibial side, as indicated by the abnormal medial proximal tibial angle (MPTA).

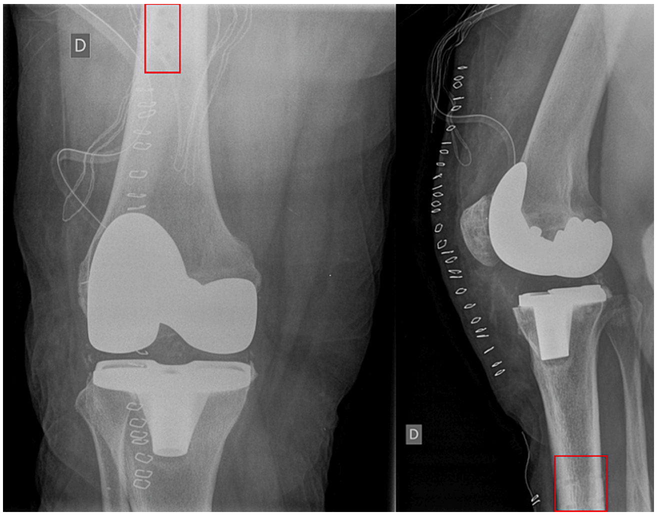

Fig. 2. Radiographic image taken on the first postoperative day following robotic-assisted total knee arthroplasty. The red highlights indicate the locations of the femoral and tibial tracking pinholes used temporarily during surgery. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

postoperative period up to that point had lapsed uneventfully. The patient was discharged 2 days after surgery, completely independent and being able to walk properly with the assistance of two canes, which abandoned one month after surgery.

Radiographs taken at the emergency department showed a displaced metaphyso-diaphyseal femoral periprosthetic fracture through femoral tracking pin holes. No radiographic signs of prosthetic implant instability were identified. This corresponded to a type 2 fracture in the Lewis-Rorabeck classification system, amenable to fixation. The patient was provisionally immobilized with a

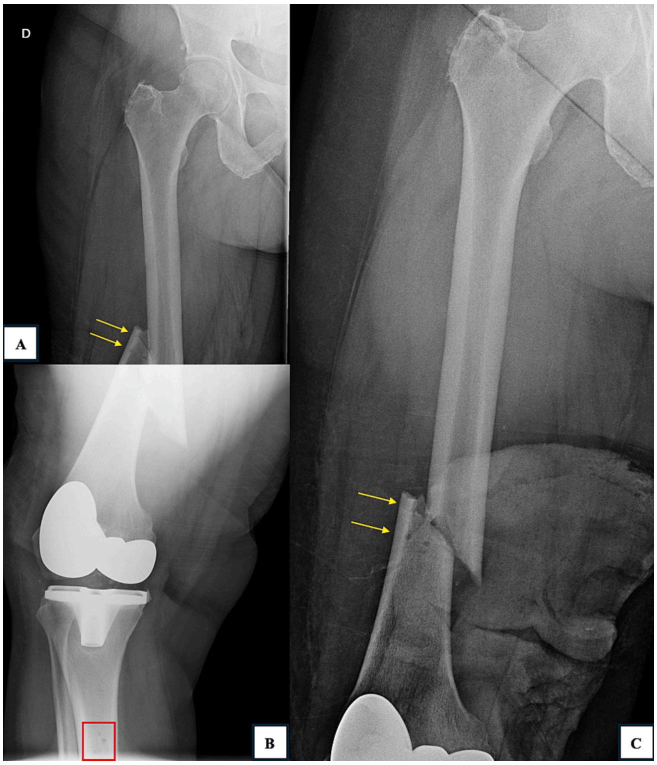

Fig. 3. Radiographs illustrating the periprosthetic femoral fracture. Yellow arrows (A and C) indicate the femoral tracking pinholes through which the fracture occurred. The red highlight (B) marks the intact tibial tracking pinholes used temporarily during surgery. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

posterior splint (Fig. 3).

Due to the patient's obesity and to allow early weight bearing, we decided to proceed with a combined osteosynthesis consisting of a long cephalomedullary femoral anterograde nail, in order to protect the femoral neck from further peri-implant injuries, and lateral femoral plating in the same surgical procedure the day after the injury occurred. First, closed reduction under fluoroscopic control and osteosynthesis with an 11 × 320 mm diameter femoral nail and an 85 mm long cephalic screw were performed, followed by a minimally invasive lateral approach to the femur and complementary fixation with a 14-hole variable-angle locking compression plate (LCP) with distal and proximal (unicortical) locking screws and one screw securing the plate to the nail in an interlocking configuration (Fig. 4).

In the immediate postoperative period, post-surgical anemia was treated with a single dose of intravenous iron and transfusion of one red blood cell concentrate with an adequate response. No other medical complications occurred. Weight bearing as tolerated with the help of two crutches was authorized from the first postoperative day. The early rehabilitation protocol emphasized improving knee range of motion, muscle strengthening of the operated limb, and re-education of gait. The patient was discharged home five days after surgery due to satisfactory evolution, walking with two crutches and with a satisfactory knee range of motion (90° of flexion and full extension).

One month after surgery, the surgical sites were completely healed, and no signs of infection or other local complications were identified. Three months after surgery, the patient achieved complete extension of the knee and reached 110° of flexion, thanks to the rehabilitation program, and was able to remove one of the crutches for walking assistance. Radiographic control started to show some bony callus at this point, but the fracture was still in the process of healing (Fig. 5).

Six months after surgery, control radiographs showed a healed fracture and no signs of loosening of prosthetic implants were identified, though slight residual varus was identified (Fig. 6). The patient reported no pain at the fracture site, and the range of motion of the knee improved to 120° of flexion and full extension, though she was still walking with the assistance of a cane.

One year after the injury, the patient showed a good functionality level according to the literature [5], despite still requiring assistance of a cane for walking outside home. The Knee Society Score (KSS) was 89 points, and the EuroQol-5D index score value was 0.78. Mild medial opening (+/+++) with valgus stress of the knee in 90° of flexion was identified but not in extension, and this did not result in a clinical complaint from the patient, who was globally satisfied with the clinical result after the surgery.

Discussion

Although robotic-assisted prosthetic surgery offers certain advantages, it still has a considerable way to go before surpassing the outcomes and cost-effectiveness of conventional primary prosthetic surgery. In addition, it is necessary to consider the specific complications arising from these modern procedures, which can also result in extra costs and increased morbidity for patients if not managed properly.

Several risk factors have been described for periprosthetic fractures through tracking pin sites after robotic-assisted total knee arthroplasty, and some of them are modifiable, making this complication preventable to some extent. Patient-related risk factors include gender (females appear to have the greatest incidence, probably due to decreased bone mineral density after menopause), body

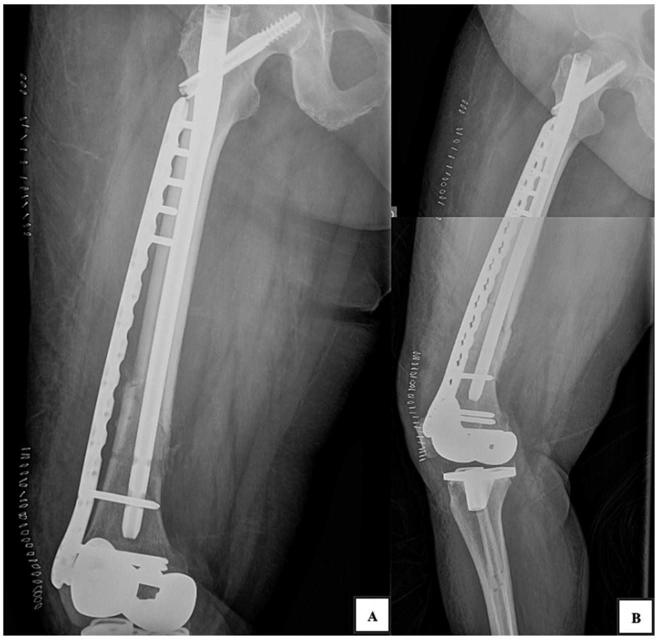

Fig. 4. Radiographic anteroposterior (A) and lateral oblique (B) images from the first postoperative day after femoral fixation using a nail-plate.

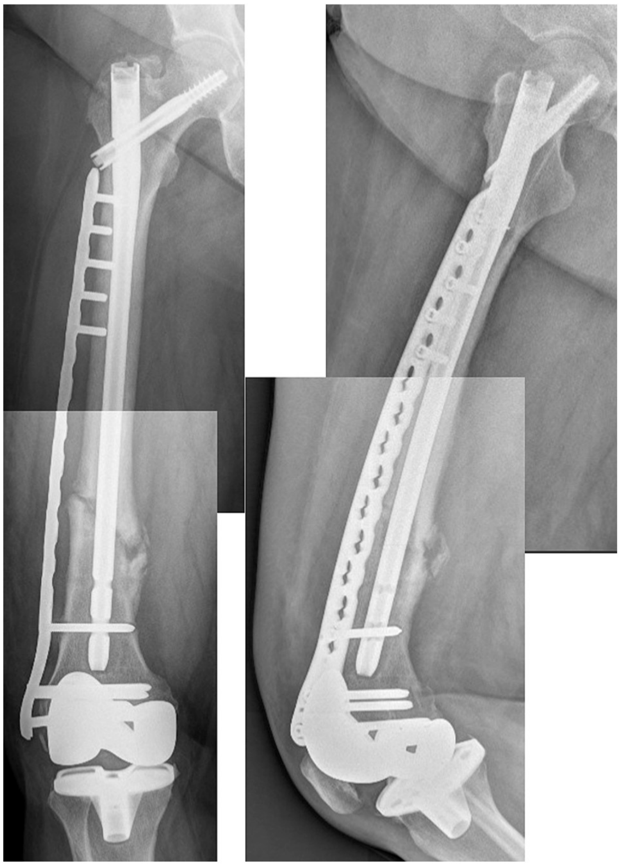

Fig. 5. Radiographic image taken 3 months post-femoral nail-plate fixation, showing robust bone callus formation around the fracture site.

mass index (high mean BMI values have been described among patients with these complications, as in our case, with a mean value of 31–33 kg/m^2), and other comorbidities causing osteopenia and osteoporosis, such as chronic corticosteroid therapy, chronic kidney disease, and systemic inflammatory diseases like rheumatoid arthritis. Pin-related issues must also be considered, including pin location (diaphyseal placement), pin diameter (>4–4.5 mm, although peri-prosthetic fracture cases using pins as small as 1.5 mm in diameter have been reported), and pin path (non-perpendicular to bone path, multiple drilling attempts, close drilling to other pins, and transcortical location due to its associated larger cortical bone removal and increased risk of thermal bone necrosis). It remains unclear whether there is a higher fracture rate associated with bicortical vs unicortical placement, although there is a trend towards unicortical and metaphyseal (which may be more resistant to torsional and bending stresses) pin placement [4–10].

This case resulted in a change in surgical practice at our institution, modifying the placement of the femoral pins more distally through the same surgical incision (Fig. 7), without registering any complication of this kind again. This location has been described as safe, with very low pin-related infection and periprosthetic fracture rates after index robotic-assisted surgery [9,12,13].

Distal femoral fracture fixation strategy (nailing, plating, or both) is challenging for the orthopedic surgeon due to their significant morbidity, 1-year mortality rates, and high non-union risk, and no consensus on the best method of treatment for this fracture cohort has been reached to date. Single plates have a higher non-union and implant failure incidence, particularly in the elderly, and usually involve a period of several weeks of weight-bearing restriction. Meanwhile, intramedullary nailing alone often results in less-than-optimal reduction and fixation, especially in comminuted fractures. We believe that the nail-plate combination in distal femoral fractures, despite being more technically demanding for the surgeon and more aggressive for the patient, could reflect “the best of both worlds,” providing a biomechanically advantageous fixation that allows early weight-bearing while reducing postoperative morbidity and non-union risk. This is especially relevant in obese and elderly patients, who are less prone to comply with restricted weight-bearing protocols due to baseline mobility deficits. Numerous studies support this strategy, with promising results regarding fracture healing and functional outcomes not only in native distal femoral fractures but also in periprosthetic fractures, as in our case, without assuming a significant increase in intraoperative morbidity [14–20].

Glossary

- Robotic-Assisted Arthroplasty: joint replacement surgery performed with the assistance of robotic systems, providing enhanced precision and control.

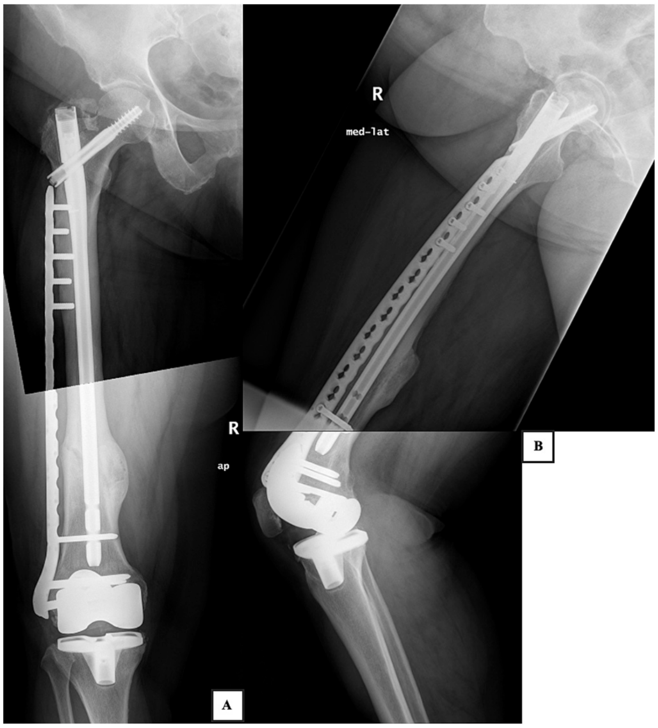

Fig. 6. Radiographic anteroposterior (A) and lateral oblique (B) images taken 6 months post-femoral nail-plate fixation, showing complete fracture healing.

- Tracking pin or tracker: a small pin used in robotic-assisted surgery to track bone position for accurate placement of prosthetic implants.
- Cephalomedullary nail: a type of implant used to stabilize long bone fractures, particularly in the femur, by inserting a nail into the bone with a cephalic screw that protects also the femoral neck.
- Locking Compression Plate (LCP): a type of plate used for fracture fixation, which allows screws to lock into the plate for increased stability.
- BMI (Body Mass Index): a measurement used to assess whether a person is underweight, normal weight, overweight, or obese based exclusively on height and weight parameters.
- Osteopenia: a condition where bone mineral density is lower than normal, but not low enough to be considered osteoporosis.
- Osteoporosis: a condition where bone mineral density is lower than normal and bones become weak and brittle, making them more susceptible to fractures.
- Peri-implant injuries: injuries occurring around a prosthetic implant, often due to stress or complications from the implant.
- Knee Society Score (KSS): a scoring system used to assess the functional outcome of knee replacement surgery.
- EuroQol-5D: a standardized instrument used to measure health-related quality of life.

CRediT authorship contribution statement

Jaime Sánchez del Saz: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Jaime Coderch Carretero:** Data curation, Investigation, Resources, Writing – original draft. **Javier García Coiradas:** Investigation, Supervision, Validation, Visualization, Writing – review & editing. **Rodrigo García Crespo:** Supervision, Validation, Writing – review & editing.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

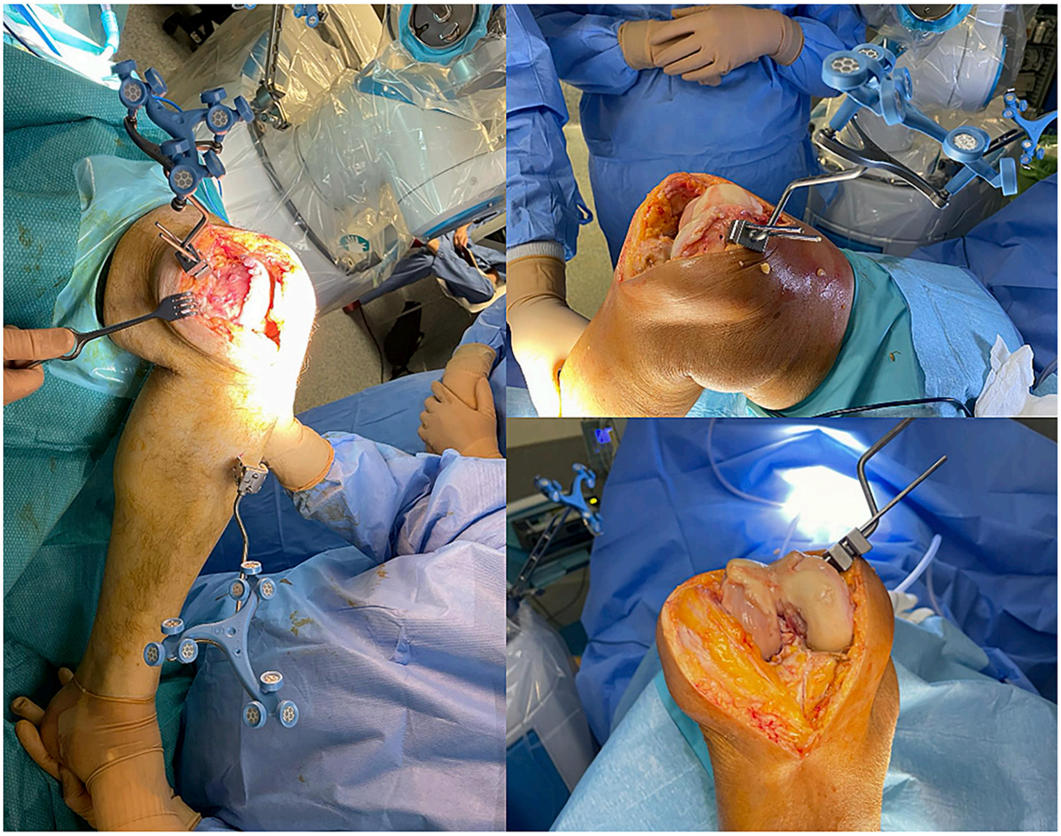

Fig. 7. Current configuration for placing 3.2 mm tracking pins in the femur (intra-incisional in the epiphyseal region) and tibia during robot-assisted total knee arthroplasty.

Acknowledgements

We would like to express our profound gratitude to Professor Fernando Marco for his invaluable guidance and insightful feedback during the preparation of this manuscript. Professor Marco's dedication to advancing clinical knowledge and fostering academic growth has greatly inspired our team, and we are deeply appreciative of his contributions to this work.

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