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CASE REPORT

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A Case of Primary Total Knee Arthroplasty Revision Using CORI System

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Abstract

Total knee arthroplasty (TKA) is a highly successful surgical procedure used to treat end-stage osteoarthritis of the knee. The increasing adoption of computer-assisted and robotic-assisted techniques in total joint arthroplasty has been found to enhance the accuracy of component placement. Short-term studies have indicated improved survival rates in unicompartmental knee arthroplasty with the use of robotic assistance. While robotic technology has proven beneficial in revising procedures like converting unicompartmental knee arthroplasty to TKA, there is limited information on its application in revising primary TKA.This case report details the utilization of robotic-assisted technology with CORI system in the revision of TKA. The incorporation of robotic assistance during TKA revision surgeries may contribute to better alignment of components and potentially increase the longevity of the prosthetic implant. However, further research is essential to explore the impact of robotic assistance on the overall survival rates and cost-effectiveness of revision TKA procedures.

Keywords: Revision Total Knee Arthroplasty; CORI; Robotic-Assisted; Computer-Assisted; Total Knee Replacement

Introduction

The use of robotic arm assistance is increasingly popular in total joint arthroplasty [1]. Revision total knee arthroplasty (rTKA) often addresses issues such as septic and aseptic loosening as well as periprosthetic fractures, especially among elderly individuals [2]. At our medical center, we employ the robotic arm-assisted CORI (Core of Real Intelligence) technology developed by Smith & Nephew. This advanced system utilizes image-free smart mapping, eliminating the necessity for pre-operative CT scans and minimizing image distortion from previous procedures. With this technology, surgeons can create patient-specific 3D joint models that accurately depict the anatomy profile and bony defects following component extraction. Furthermore, the system facilitates immediate intra-operative gap balancing and precise component placement. We opted for the CORI system over Mako (Stryker, Mahwah, NJ) due to the latter's reliance on preoperative CT scans and off-label indications for primary joint replacement [3].

Revision total knee arthroplasty (rTKA) poses significant challenges due to bone loss, scarred soft tissue, and infection risks. Precise component placement is crucial for restoring proper alignment, biomechanics, and stability, reducing complications, and achieving optimal patient outcomes.

This case represents the inaugural use of the CORI system for robotic arm assistance in a rTKA procedure, necessitated by the failure of the primary TKA.

Case Report

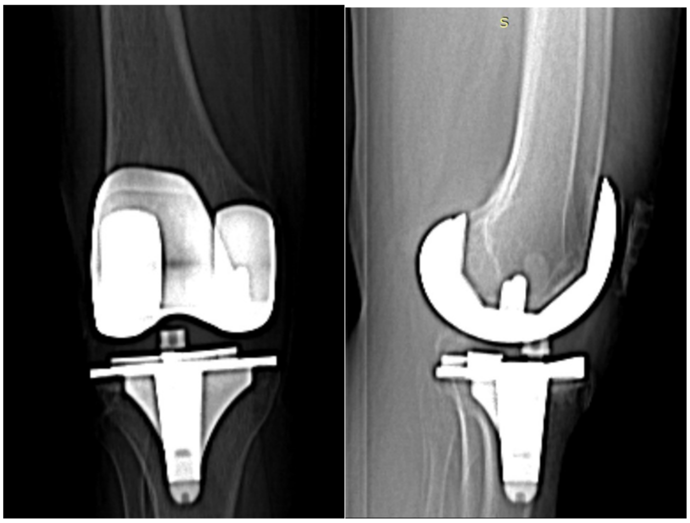
In 2019, a 67-year-old woman underwent total knee arthroplasty (TKA) with mechanical alignment technique at another medical facility due to right knee pain stemming from arthrosis, diagnosed through clinical examination and X-ray imaging (grade 4, Kellgren and Lawrence classification). Post-surgery, she faced challenges with intensive rehabilitation due to persistent anterior knee pain during both active and passive mobilization, resulting in a loss of 35 degrees of extension, swelling, and difficulty in walking. A Knee Society Score (KSS) was administered to her resulting in 20/100.

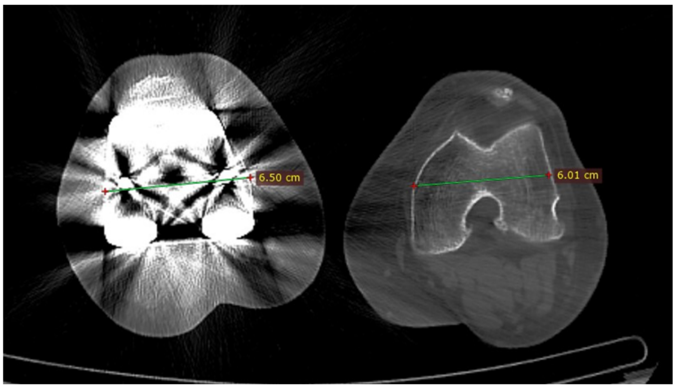
In 2021, she was diagnosed with patellofemoral malalignment and subsequently underwent patellofemoral arthroplasty to address patellar tracking issues. Unfortunately, she continued to experience discomfort postoperatively, impeding her physiotherapy efforts. The KSS was still 20/100.

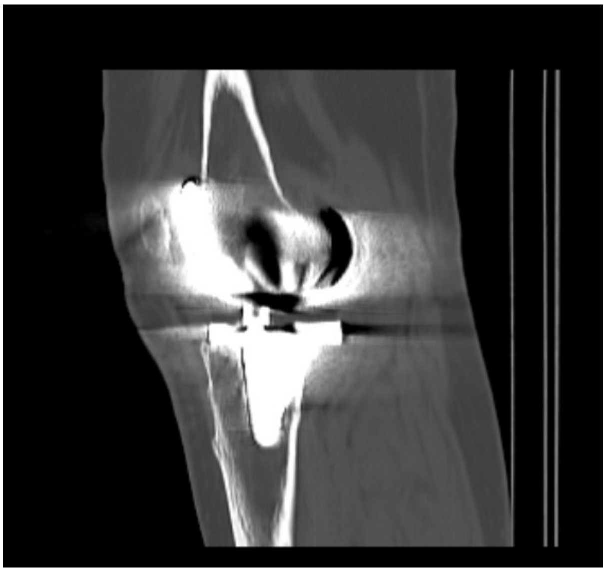
In September 2023, the patient presented to our institution with stiffness and severe knee pain, significantly limiting her daily activities. She reported a Visual Analogue Score (VAS) pain rating of 8/10 and was taking anti-inflammatory medication. Her knee range of motion (ROM) was restricted to 35°-85° due to mechanical blockage, indicating potential issues with the implant.

To rule out a prosthetic joint infection, we conducted laboratory tests based on the 2018 MSIS criteria, including erythrocyte sedimentation rate, C-reactive protein, procalcitonin, blood count with formula and joint aspiration, all of which yielded negative results [4].

The CT scan (Figure 1 and Figure 2) showed no signs of loosening but there was evidence of an oversized femoral component in both mediolateral and anteroposterior planes leading to a patellofemoral overstuffing, according to methods of quantifying patello-femoral joint (PFJ) overstuffing produced by Kemp et al [5]. PFJ overstuffing has been shown to potentially affect the lever arm provided by the quadriceps mechanism in the knee stretching the patellar tendon, altering the contact forces between the implants and thus leading to a decreased strength, limitated range of motion and giving pain. The anteroposterior PFJ size is given by a combination of parameters such as anterior patellar displacement (APD), anterior-posterior femur diameter (APFD), anterior femoral offset (AFO), and posterior femoral offset (PFO) and consequently a modification of these parameters alters the patello-femoral tracking. In facts, restoring the anatomic dimensions of the PFJ is recommended, keeping the surgeon within a safe margin of error [6]. Furthermore, mediolateral oversizing is a factor considered to be predictable of poor results in TKA despite it is difficult to obtain optimal fit between the implant and bone [7]. Revising the patella alone might not have been sufficient to address the patient's symptoms. While the primary symptoms were pain and restricted flexion, which could be due to overstuffing, these symptoms may also stem from other issues such as improper component alignment, ligament tension or joint instability. By using the robot for a more comprehensive revision approach, we can address the patella and simultaneously ensure that other potential causes are identified and corrected, leading to a more complete and effective treatment of the patient's symptoms.







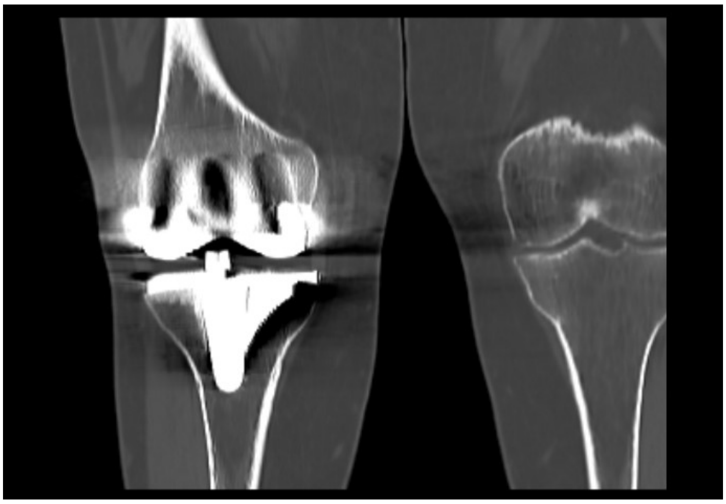


Figure 1and 2: Pre-operative implants XR and CT scan

After a lengthy discussion, we decided to proceed in right rTKA with CORI robotic assistance using Smith & Nephew revision knee system.

The robotic system provides precise measurements and real-time feedback, allowing us to identify any inconsistencies in the joint alignment or gaps. If there was a gap mismatch, we were able to adjust the components or modify the bone cuts to achieve optimal alignment and balance. Even though these assessments can be done manually in a conventional total knee replacement (TKR), the robot offers greater accuracy and precision, ensuring a more consistent outcome.

The patient underwent spinal anesthesia and a tourniquet was applied. A midline incision over the previous scar was made, followed by a medial arthrotomy. On inspection, the femoral component was oversized, but well-aligned. The patellofemoral button was of appropriate size, but the patellar thickness was inadequate, potentially explaining the knee pain and extensor mechanism stiffness.

The knee was tight in flexion and somewhat loose in extension. After removing the 9 mm polyethylene, femoral and tibial checkpoints, along with CORI array pins, were secured. Real-time intra-operative gap balance and a 3D model of the rTKA were planned (Figure 3).

Figure 3: Intra-operative mapping directly on the current implants.

The femoral and tibial components were carefully removed, without significant bone loss. The patellar button was well-fixed and left intact.

Using the operative plan, the CORI robotic arm with a saw attachment made minimal fresh cuts to the femur and tibia. Trial components were implanted, resulting in a well-balanced knee with a 13 mm trial polyethylene insert (Figure 4). Osteophytes around the patella were removed and the joint was irrigated. Femoral and tibial components were cemented and implanted with a 13 mm polyethylene PS insert (Figure 5). Intra-operative tests showed smooth and centered patellar tracking. The operative time was 172 min, a significant increase as compared with our standard (96 ± 23 minutes).

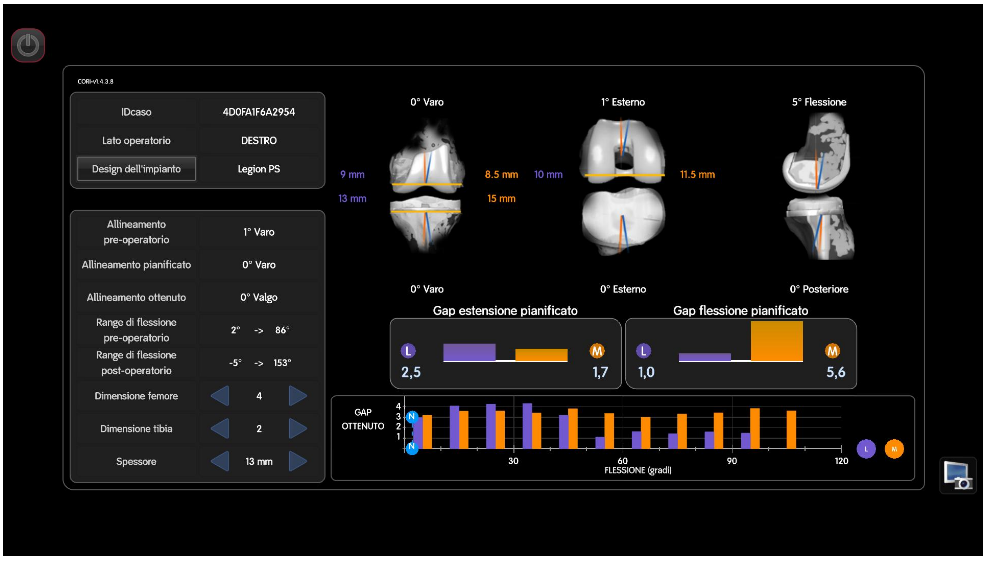


Figure 4: Post-operative mapping directly on the current implants.

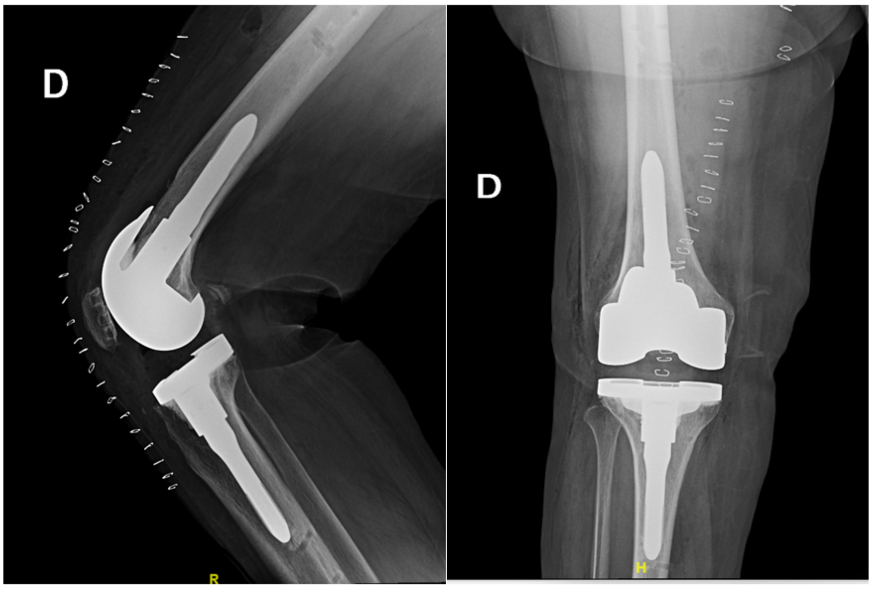


Figure 5: Post-operative implants XR

Results

The femoral and tibial components were cemented (femur size 4 PS, femoral stem 12mm X 120mm, tibial size 2, tibial stem 10mm X 120mm). We used a 13 mm polyethylene PS insert. Intra-operative tests showed smooth and centered patellar tracking, with knee ROM ranging from -5 to 110 degrees.

Following the surgery, she embarked on a three-week rehabilitation program at our institution's Rehabilitation Department, commencing five days post-surgery, and achieved a ROM of 0-95°.

The patient followed up at 2 weeks, 1, 3 and 6 months, participating in 3 months of outpatient physical therapy to improve ROM and strength.

Her VAS pain scores decreased at each visit, reaching 2/10 at 6 weeks, with no pain medication. The patient displayed excellent clinical progress, reporting no knee pain, instability, or stiffness.

At the latest follow-up, she could ambulate without assistance, with knee ROM of 0-100 degrees and slightly less strength compared to the other leg.

Discussion

The field of revision total knee arthroplasty has seen continual advancements aimed at enhancing bone cutting precision, improving component placement accuracy, and ensuring surgical safety [8]. Research suggests that these advancements contribute to reduced complications, preservation of soft tissues [9], increased patient satisfaction, and improved clinical outcomes [10, 11].

Despite the considerable focus on robotic-assisted total knee arthroplasty (RATKA), there is a scarcity of literature regarding the use of robotics in revision knee arthroplasty, particularly in converting unicompartmental knee arthroplasty (UKA) to total knee arthroplasty (TKA).

One notable case report describes the off-label use of the MAKO robot for revising a failed primary TKA due to aseptic loosening, which resulted in acceptable radiographic outcomes and excellent clinical results [12]. The success of such cases prompts speculation about potential future approvals for similar applications and the surgical planning interface displayed on screens can be intricate, demanding experience for precise and efficient operation. [13]

The CORI System, announced in 2022, has been identified as suitable for revision knee replacement, combining robotics technology with the Legion Revision Knee System. This case report marks the first documented instance of utilizing the CORI System for revising a failed primary TKA.

The patient exhibited satisfactory radiographic outcomes as evaluated by postoperative X-rays.

The robot plays a crucial role in the planning phase of a robotic knee replacement, especially in a revision scenario. It allows for highly detailed preoperative planning using 3D imaging, enabling the surgeon to visualize the anatomical structure and identify existing implants or anatomical abnormalities. This level of planning helps in accurately aligning the new components and avoiding any complications with previous implants or bone structures. Compared to conventional revision, the robot provides enhanced precision, reduces the risk of human error and allows for a more personalized approach to the revision surgery.

With continuous advancements in robotic technology and software capabilities, there is promise for improved surgical outcomes and the expansion of robotic applications across various orthopedic procedures.

Conclusion

The incorporation of robotic technology in revision TKA after a failed primary procedure represents an innovative approach deserving further exploration. Nonetheless, this system is accompanied by several limitations. Firstly, its use in revision procedures entails significant costs, limiting accessibility to many surgeons, prolongation of operative time and requiring a steep learning curve. Secondly, despite anticipated advantages, there exists insufficient evidence substantiating substantial enhancements in functional outcomes. It is crucial to recognize that conclusive evidence demonstrating significant improvements in the functional outcomes of patients through the utilization of robotic systems has yet to be established.

Clinical Message

The robotic technology in revision TKA need to be evaluated as well as improved so that can be easily performed in much more cases and by the majority of orthopedic surgeon. Currently, it demonstrates significant improvements in the functional outcomes of patients.

Funding

None

Consent

Consent of the patient has been taken that his photo and detail can be published in case report

Competing Interests

Authors declare that there is no any competing interest.

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None

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