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Novel application of an imageless robotic system in simultaneous unicompartmental knee arthroplasty and anterior cruciate ligament reconstruction

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A R T I C L E I N F O

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A B S T R A C T

This technical note explores the novel use of an imageless robotic surgical system for simultaneous unicompartmental knee arthroplasty (UKA) and anterior cruciate ligament reconstruction (ACLR). Knee osteoarthritis (OA) and anterior cruciate ligament (ACL) insufficiency are common conditions that traditionally require separate management. The integration of robotic assistance offers enhanced precision in surgical procedures, addressing both medial compartment OA and ACL insufficiency in a single operation.

We present a case involving a 47-year-old patient with medial compartment osteoarthritis and complete ACL rupture. The patient underwent a simultaneous robotic-assisted UKA and ACLR using the CORI Surgical System (Smith&Nephew, London, UK). This approach enables accurate tibial tunnel placement and precise soft tissue balancing. The robotic system facilitates real-time gap assessment and balancing, reducing the risk of over- or under-constraint during ACL graft tensioning.

The procedure was performed with a standard medial parapatellar approach. Key steps included hamstring autograft harvesting, femoral and tibial tunnel creation, and robotic-assisted implant positioning. Post-operative rehabilitation allowed full weight-bearing by the third week.

This case represents the first reported instance of using an imageless robotic system for simultaneous UKA and ACLR, highlighting its potential to standardize and improve results in complex knee surgeries.

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1. Introduction

Knee osteoarthritis (OA) is a common condition[1,2] that involves the deterioration of the articular cartilage. Increased wear and tear can be attributed to the thinner nature of the medial cartilage compared to the lateral cartilage and the internal rotation of the femur during the extension of the knee, where the malalignment of the lower limb contributes to the development of OA.[3]

Another common cause of knee degeneration is anterior cruciate ligament (ACL) insufficiency. The lack of functional ACL contributes to the knee joint instability which results in intra-articular pathology such as meniscal tearsand cartilage thinning.[4,5] Evidence towards the management of concomitant medial knee OA and ACL insufficiency is lacking with no consensus on the appropriate treatment options. Newer techniques have been developed to simultaneously treat both diseases through drilling an ACL tunnel and ensuring adequate exposure for the

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Fig. 1. Pre-operative MRI showing an ACL-deficient knee (A) and standing radiographs of the left knee (B-D).

Fig. 3. Intra-op photo of robotic UKA after passage of ACL graft. Final gap assessment is performed before tibial fixation.

unicompartmental knee arthroplasty (UKA), which is especially important for young and more active patients.[4,6]

Imageless robotic systems do not rely on preoperative imaging and planning to execute accurate bone resections.[7] A virtual 3D model is created intraoperatively via surface mapping, and soft tissue tension can be obtained from applying varus and valgus stress through full range of motion of the knee.[8] This allows the surgeon to accurately plan, adjust component position and soft tissue tension according to the surgeon's preferences, and to precisely execute the plan.

The use of imageless robotic surgical system has shown consistent and significant improvements in UKAs[9] but have not been known to be used for a simultaneous UKA and ACL reconstruction (ACLR). Here we report on a novel usage of an imageless robotic surgical system (CORI Surgical System, Smith&Nephew, London, UK) in a patient with underlying medial compartment osteoarthritis and ACL insufficiency undergoing simultaneous UKA and ACLR.

2. technical note

A 47-year-old lady with history of left knee sprain 3 years prior presented to us with complete ACL rupture on magnetic resonance imaging (MRI) imaging; her condition was initially managed conservatively with physiotherapy in view of minimal instability symptoms. Upon subsequent visits to our clinic, she complained of progressive medial-sided knee pain in the past year. Physical examination showed varus deformity of the knee, with range of motion of 0–130°. Lachman and anterior drawer tests were grade II, and pivot shift test showed revealed grade II laxity. Varus and valgus stress tests were negative. Standing radiograph of the left knee revealed isolated medial compartment osteoarthritis of Kellgren-Lawrence grade 2 (Fig. 1). Scannogram showed varus alignment with hip-knee-ankle angle of 6°. In view of persistent medial knee pain with instability symptoms, she was consented for simultaneous robotic-assisted UKA with single-bundle ACLR.

Skin preparation and draping was performed in standard fashion. Diagnostic arthroscopy was first performed to ensure intact lateral tibiofemoral joint and lateral patellar facet cartilage, and to look for any concomitant intra-articular pathology. Femoral and tibial tunnel footprints were prepared with radiofrequency device. Midline skin incision was performed starting from the upper pole of patella to just below tibial tuberosity for ease of hamstring autograft harvesting. Standard medial parapatellar approach was utilised. Limited medial soft tissue release

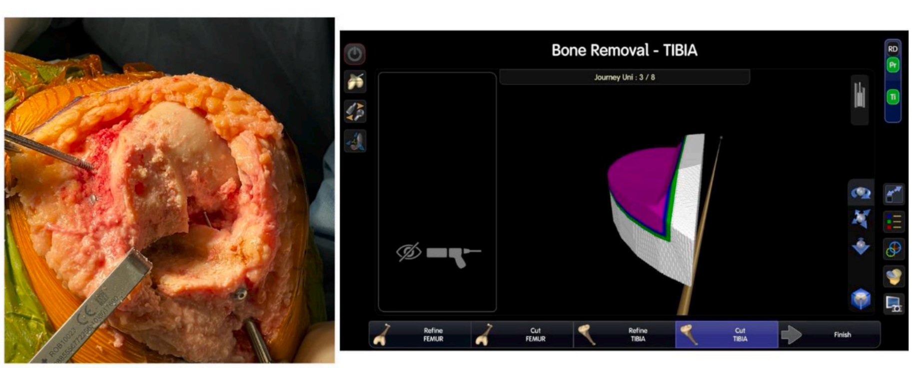

Fig. 2. Intra-op photo and corresponding computer screenshot showing placement of robotic probe in the tibial tunnel and confirming adequate distance from tibial component placement.

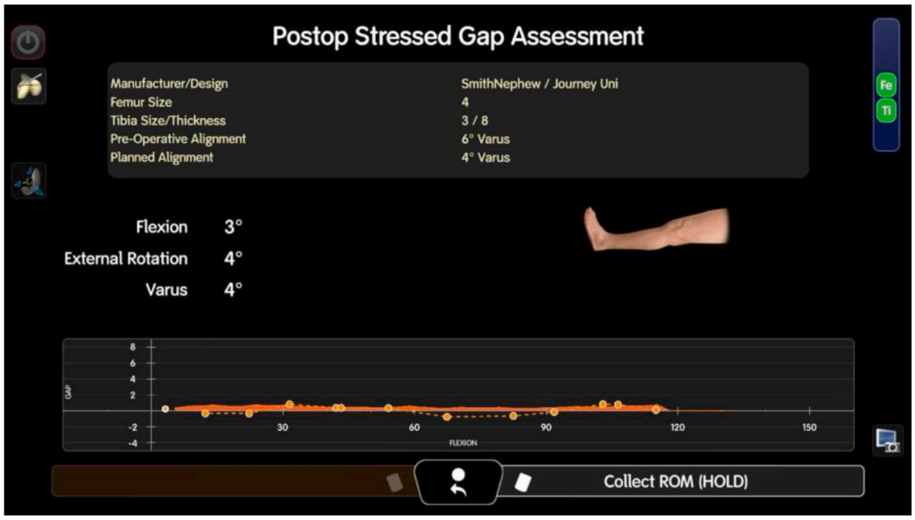

Fig. 4. Intra-op screenshot of robotic system showing final alignment and medial gap.

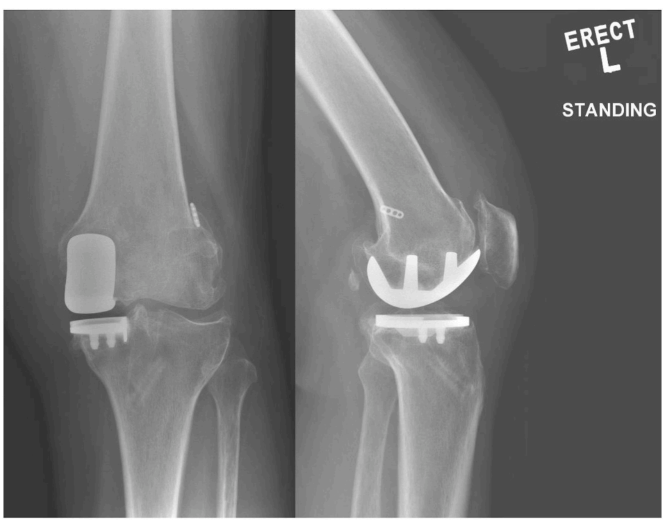

Fig. 5. Post-operative standing radiograph of the left knee.

was performed with removal of any significant osteophytes over the patella, medial condyle and intercondylar notch. Tracker pins were inserted to the anteromedial aspect of the distal femur and mid-shaft of tibia. Surface mapping was performed with a hand-held probe, and gap assessment was performed with valgus and varus stress through the full knee range of motion. Implant positioning was planned using system software. Bone cut was performed using robotic-assisted burr. During this time, semitendinosus and gracilis tendons were harvested using a closed-loop tendon stripper, quadrupled, and whipstitched with an Endobutton (Smith&Nephew, London, UK). The hamstring autograft was measured, and femoral bone tunnel was created at standard 2 o'clock position using an offset guide in an open manner. Care was made during tibial tunnel placement to avoid the tibial component or weakening of the tibial plateau; the tunnel entry site should be placed as lateral as possible on the medial surface of proximal tibia, with the exit site slightly lateral to the standard ACL footprint. The handheld probe can then be directly placed in the tibial tunnel to ensure adequate distance from the tibial component (Fig. 2). Subsequently, femoral and tibial UKA components were cemented and placed in standard fashion. ACL graft was then pulled through tibial and femoral tunnels. Gap assessment was performed a final time before tightening of the ACL graft with the aid of robotic system to ensure a balanced knee (Figs. 3 and 4). Tibial fixation was performed with interference screw (Biosure Regenesorb, Smith&Nephew, London, UK). Closure was performed in standard fashion with intra-articular transamine injection. No drain was inserted. Post-operatively, the patient was allowed to partial weight-bear with full knee range of motion. A standing radiograph of the left knee was captured (Fig. 5). Full weight-bearing was initiated on the third week post-operatively as per our hospital's protocol for ACLR rehabilitation.

3. Discussion

To our understanding, this is the first published case using an imageless robotic system for simultaneous UKA and ACLR. This operation is technically demanding and requires careful planning as well as gap balancing to achieve good patient outcomes.[10–12] This report shows the novel usage of robotic system to assist in tibial tunnel placement and accurate tensioning of ACL graft to achieve a balanced knee.

In isolated ACLR, tibial tunnels are conventionally placed 40 % of the medial-to-lateral width of the interspinous distance with the graft being closer to the medial condyle in isolated ACL reconstruction.[13] However, the traditional placement of the tibial tunnel may risk disruption to the tunnel and the implant.[14] Therefore, lateral placement of the tibial tunnel and adequate distance from the tibial component, aided by the hand-held probe, is essential to prevent medial tibial plateau fracture, avoid tibial component impingement, and to avoid tunnel convergence with tibial cuts.

One important factor in achieving good UKA outcomes include appropriate soft tissue balancing and alignment.[15] However, surgeon-defined assessment (SDA) has been shown to be a poor predictor of soft tissue balance in knee arthroplasty, which was not improved by surgeon experience and had considerable between-surgeon variability.[16] With the use of robotic system, real-time gap assessment and balancing can be performed, without fear of over- or under-constraint during ACL graft tensioning. After implant cementation, the ACL graft is passed through the bone tunnels and temporarily secured with a clamp. The knee is brought from full extension to full flexion; first without any applied stress, and then subsequently with valgus stress. This ensures that the fixation of ACL graft does not cause over-constraint to the medial gap at all ranges of motion of the knee. The system provides quantifiable data points during the operation in addition to the tactile assessment from the surgeon, allowing for more standardised and reproducible results.

The result from this case is consistent with previous studies have shown that combined medial UKA and ACLR is an effective treatment options for patients with an average long term follow-up duration of 10 years.[11] This surgical option may be best suited for young patients with considerable post-operative functional demand.

In conclusion, robotic-assisted simultaneous UKA and ACLR is a safe, reproducible surgery allowing for a balanced and well-aligned knee.

Declaration of competing interest

The author(s) have no conflicts of interest relevant to this article.

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