First Experiences with ROSA® Partial Knee System: Case Presentations

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Introduction

Partial knee arthroplasty (PKA) offers multiple functional advantages compared to total knee replacement (TKA) when treating isolated medial compartment osteoarthritis.[1-4] The reported benefits of this procedure include a less-invasive surgical approach,[5] lower blood loss,[6] decreased risk of infection,[7] improved pain management,[8] better short term function,[9] lower risk of opioid addiction,[10,11] more satisfied patients[12] as well as a more physiological gait pattern.[13] In terms of cost effectiveness, it was suggested that medial PKA is preferable to TKA by decreasing lifetime costs and improving quality of life in patients.[14,15] However, despite the well documented effectiveness of the conventional PKA, 5 - 10% of patients are dissatisfied with their post-operative outcomes.[16,17] Additionally, the documented revision rates are higher than the ones seen in TKA.[18] Common reasons associated with the need for revision include technical errors of implant malalignment and malpositioning.[19,20] These are mostly observed in low volume PKA surgeons.[21] A great effort has been made to implement new technologies[22] that would reduce the surgical variability of the PKA between the high and low volume centers.[23] The most recent advancement is the introduction of robotic-assisted surgery in the orthopedic theater with the purpose of optimizing bone preparation, component alignment and positioning, as well as soft tissue balance.[24] The purpose of this paper is to summarize the first two cases performed in the US with the ROSA® Partial Knee System (Zimmer Biomet, Warsaw, IN, USA), a novel robotic orthopedic surgical assistant that recently received FDA clearance

Case Presentation

The robotic surgical assistant used in these two cases was the ROSA Partial Knee System, which is designed to help surgeons performing medial PKA by assisting with bone resection and assessment of the soft tissue. The system incorporates two components: (1) a robotic arm and base unit, which are positioned on the same side as the surgeon, and (2) an optical camera unit, which is positioned on the contralateral side of the patient. The ROSA Partial Knee System can be used with (image-based) or without (image-free) pre-operative radio-graphs. Using optical trackers fixed to the tibia and the femur, the surgeon can define bony landmarks, intra-operatively, and guide the intra-operative decision-making for the resection plans and soft tissue balancing. The robotic arm assists in the placement of cutting jigs for the planned resections, allowing the surgeon to still maintain the tactile "feel" of cutting the bone.

Both cases presented here are image-free PKA, and consent was obtained from both patients in order to be included in this case report.

Case 1.

The patient was a 79-year-old athletic man with severe medial unicompartmental osteoarthritis (OA) of the left knee. He presented with isolated pain and a varus deformity (Fig 1). The subject was initially scheduled for a total knee replacement; however, given the isolated medial compartment OA and the advantages of robotic-assisted PKA the patient and surgeon opted for robotic-assisted PKA.

A. B.

Figure 1. A. Pre-operative AP, Lateral and sky view. B. Pre-operative Stress View (case 1)

The initial knee evaluation performed with the robotic system prior to performing any bone cuts showed a flexion contracture of 10.5 degrees, a varus deformity of 8.5 degrees and a tight extension gap of 1 mm (Fig 2). Multiple osteophytes, sclerotic bone and thickened capsular tissue were observed intra-operatively, making the correction in the coronal plane and the assessments of the ligaments challenging.

After placement of the femoral and tibial trackers, the bony landmarks were acquired: all mandatory landmarks were accepted on first attempt.

The ROSA Partial Knee application has an intra-operative planner that allowed for an objective assessment of tibial, femoral varus/valgus angles and laxity parameters that influence the final limb alignment. This data is used to help determine the best implant fit for the patient. The final decision was to reduce the varus deformity to 6 degrees by using a size 9 implant bearing. The measurements done by the robot were used to guide the plan for resection, based on the implant positioning and its size. Given that this was the surgeon's first case using the application, the tibia

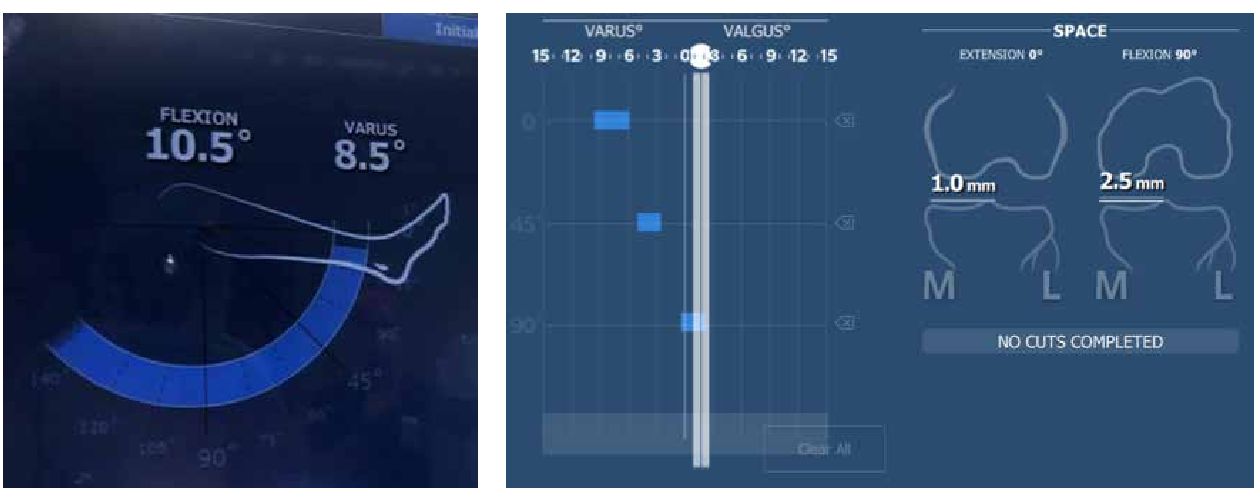

Figure 2. Pre-operative evaluation of the knee (case 1)

resection cut was more conservative allowing for final readjustments, if required. The plan was performed to achieve a 4.00 mm tibial cut and a posterior slope of 5 degrees. Prior to proceeding to femoral cuts, the tibial cuts were validated. This validation ensures the accuracy of the cuts and verification of the range of motion (ROM) and soft tissue balance. Femoral cuts were performed with the knee flexed at roughly 10 degrees and the validation was successful. However, as expected, the tibia needed to be recut an additional 2 mm in order to reach a balanced knee in both flexion and extension. As per the manufacturer's instruction, an additional tibial re-cut is possible when using the second pinhole of the cutting guide for tibial re-cut fixation. Final validation with the implants cemented showed a final varus angle of 5.5 degrees, within 0.5 degrees of planning (Fig 3).

Figure 3. Pre-operative evaluation of the knee (case 1)

The patient made an uneventful recovery and was discharged on the second post-operative day. At the two-week follow-up, radiographs revealed the appropriate correction of alignment and implant positioning (Fig 4). ROM measured with a goniometer was 5-125 degrees, the incision looked healthy (Fig 5), the patient was off narcotics, and reported being very satisfied.

This case illustrates the ability of this robotic partial knee system to achieve accurate restoration of knee alignment in more complicated cases, i.e. a large varus deformity. This may enhance surgeon confidence to proceed with PKA in isolated medial compartment OA with such deformities, that perhaps they initially would not have considered.

Figure 4. Post-operative X-ray at the 2 weeks follow-up appointment

Case 2.

A 74-year-old female, with normal BMI, presented with anterior medial osteoarthritis in the right knee resulting in localized pain to the anterior compartment and stiffness. No other symptoms were present. Based on the pre-operative radiographs, the patient was determined to be an ideal candidate for PKA (Fig 6). Moreover, the contralateral knee previously underwent partial knee replacement with Persona® Partial Knee (Zimmer Biomet, Warsaw, IN, USA), the same implant used with the ROSA Partial Knee System and the patient is happy with the outcome of that procedure after two years.

The current surgery followed the steps indicated by the manufacturer in the surgical technique. After optical tracker fixation, computer registration was performed by mapping pre-specified anatomical landmarks with all required references being accepted from the first trial. The intra-operative knee evaluation revealed a hip knee angle (HKA) of 0 degrees. Based on the acquired landmarks,

Figure 5. Post-operative physical exam 2 weeks after surgery: Weight-bearing, extension and flexion

the surgeon was able to easily plan for component size, alignment and final implant position. After doing some minor adjustment to the tibial cut depth, the final plan suggested an 8 mm tibial cut and a slope of 5 degrees. A large Gelpi retractor was used to expose the joint prior to bringing the robotic arm in to pin the cutting guide. The tibial cut was performed easily and the validation of the cut showed excellent results being within 2 degrees of the planned value, allowing thus to proceed to the laxity assessment and femoral planning.

The distal femoral resection depth was reduced in order to balance the knee in extension with the flexion gap. A Gelpi retractor was used again to expose the knee prior to bringing in the cutting guide. The femoral cut was done in full extension and the final validation revealed the cut to be within 1 mm of the planned valued. The planned laxity was a 2 mm gap in extension and a 2.5 mm gap in flexion, which was confirmed to be the exact result at final validation. The post-operative radiographs taken two weeks after the surgery showed acceptable alignment and good implant positioning (Fig 7).

Figure 6. Pre-operative AP, Lateral and sky view (case 2)

Figure 7. Post-operative X-ray at the 2-week follow up

Discussion

This paper describes the first two PKA cases performed in the United States with the newly launched ROSA Partial Knee System. The two different cases illustrate the versatility of the ROSA Partial Knee System being able to accommodate complex situations (case 1) and straightforward cases (case 2). Given the numerous reported benefits that PKA has over TKA[1-4] it is surprising that the frequency of PKA procedures is consistently reported to be under 10% of all primary knees in the UK National Joint Registry.[25] It is believed that based on the extended inclusion criteria for PKA to include younger patients,[26] obese patients,[27] and very active patients,[28] up to 47% of the primary cases would actually qualify for this type of procedure,[29,30] while other data suggests that the optimal usage of PKA starts at 20%. In fact, the NICE guidelines[31] have been updated and now recommend that the patient with isolated medial compartmental osteoarthritis be given the choice between partial and total knee replacement with the potential benefits and risk for each option discussed. Based on this recent recommendation, one would expect the frequency of PKA procedures to rise, especially those using robotic assistance. Having the surgeries conducted with the assistance of a robotic system, could improve accuracy and implant positioning,[32] which have been shown to be important for early outcomes, but highly dependent on the surgeon's experience.[33] Thus, the implementation of robotic-assisted PKA in operating theaters could potentially improve the reproducibility of the surgical technique and eliminate differences in component positioning between high and low volume surgeons.[34]

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