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Case Report

Conversion of Patellofemoral Arthroplasty to Robotic-Assisted Total Knee Arthroplasty

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ABSTRACT

Conversion of patellofemoral arthroplasty to total knee arthroplasty (TKA) has been described as similar to primary TKA, although it may come with more challenges and worse outcomes. With the increased rate of revision following conversion TKA vs primary TKA, robotically assisted TKA provides an alternative technique to manual conversion. We present 3 cases of robot-assisted conversion of prior patellofemoral arthroplasty to TKA with good mechanical and clinical outcomes and no intraoperative complications.

Introduction

Patellofemoral arthroplasty (PFA) is utilized for isolated patellofemoral osteoarthritis [1,2]. While rare, it may be favored in younger patients to preserve bone and soft tissue [3,4]. However, revision surgery rates following PFA are as high as 8% to 18.1% over 5 years and are more likely to occur in younger women [5]. Revision surgery most commonly involves conversion to total knee arthroplasty (TKA) and is most likely caused by osteoarthritis progression, pain, or implant loosening [5]. While previous studies have shown that patients who underwent conversion from PFA to TKA have similar pain relief and range of motion compared to primary TKA, these patients have higher infection rates and complications, similar to TKA and revision TKA surgery [6].

Previous studies have shown robotic-assisted (RA) arthroplasty to be effective for revision TKA. There have been case reports and a limited series of medial-sided unicompartmental knee arthroplasty (UKA) and robotic-assisted TKA showing successful outcomes [7,8]. Furthermore, 2 case studies and a retrospective series have confirmed the feasibility of TKA to RA revision TKA [9-11]. From these series, there is evidence that RA revision TKA improves accuracy of implant placement, allows for soft tissue protection, and achieves balanced knees [11]. To our knowledge, there has yet to be a reported PFA to RA conversion TKA. Conversion of PFA to RA TKA is currently not approved by the Food and Drug Administration and is thus off-label. This report presents 3 cases of robot assisted conversion of prior PFA to TKA using the Stryker Mako SmartRobotics system with good mechanical and clinical outcomes and no intraoperative complications.

Case histories

Case 1

The patient is a 44-year-old female with a history of hypertension, obstructive sleep apnea, severe obesity body mass index (47.9 kg/m^2) status post (s/p) gastric bypass, gastroesophageal reflux disease, fibromyalgia, and osteoarthritis of the left knee. At the initial preoperative visit, she was 10 years s/p left onlay patellofemoral knee arthroplasty. Her chief complaint at the time of presentation was a 1-year history of gradually worsening medial-sided left knee pain, now currently 10/10 in severity. Preoperative range of motion was 0°-120° with a Knee Injury and Osteoarthritis Outcome Score Joint Replacement (KOOS Jr) score of 21. The patient had attempted to control the pain with nonsteroidal anti-inflammatory drugs and activity modification without success.

Preoperative x-rays showed a PFA component in position with acceptable alignment and no evidence of loosening (Fig. 1a-c).

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Figure 1. Case 1 preoperative (a) AP, (b) lateral, and (c) sunrise views of the left knee showing patellofemoral joint arthroplasty in place with no evidence of loosening.

There was no clinical concern for infection, and standard preoperative labs were within normal limits.

Case 2

This patient is a 58-year-old female with a history of osteoarthritis of the left knee who was 8 years old s/p onlay PFA. Her body mass index was 26.6 kg/m^2. She has a history of asthma, gastroesophageal reflux disease, chronic spondylosis of T12-L1, and depression. At her preoperative clinic visit, she was complaining of a few months history of gradually worsening left knee pain and swelling that had not responded to activity modification, intra-articular steroid injection, or nonsteroidal anti-inflammatory drugs. Preoperative range of motion was 0-120° with a KOOS Jr score of 52. X-rays at that time revealed a left patellofemoral joint arthroplasty with no radiographic evidence of loosening as well as some medial joint space narrowing (Fig. 2a-c). There was no clinical concern for infection and standard preoperative labs were within normal limits. She elected to proceed with a conversion to TKA with robotic assistance.

Case 3

A 55-year-old female with a history of bilateral onlay PFA around 20 years ago with tibial tubercle osteotomies, acute kidney injury, type 2 diabetes mellitus, deep vein thrombosis, and anemia presented for worsening knee pain bilaterally that was not responsive to rest, analgesics, or steroid injections. Preoperative range of motion was 0-100° on the right and 0-100° on the left with a right KOOS Jr score of 45 and left KOOS Jr score of 47. X-rays showed medial joint line narrowing bilaterally with implants in mild varus (Fig. 3a-d). There was no clinical concern for infection, and standard preoperative labs were within normal limits. She elected to proceed with a staged conversion surgery to TKA with robotic assist, starting with the right knee.

Procedure

All cases were performed with the medial parapatellar approach. Noncemented components were used in case 1, while cemented components were used in cases 2 and 3. These cases were performed by different surgeons at different institutions owned and operated by the same health-care system.

A preoperative computed tomography (CT) scan was obtained in all cases using the Stryker Makoplasty Protocol (Stryker, Mahwah, NJ), and a metal artifact reduction program was used to assist in visualizing the distal femur during the scan. The results were evaluated by a Mako product specialist, as patient motion and metal artifact from existing implants can affect image quality. The final scan was then uploaded to the database for preoperative planning (Fig. 4).

During robot registration, the Mako tibial array was placed on Schanz pins intraincisional, medial to the tibial tubercle at the most distal end of the incision. The femoral array was placed on Schanz pins intraincisional into the medial condyle of the femur. Tibial and femoral check points were placed in standard fashion. The registration process was performed prior to PFA component removal, linking the array placement to the local anatomy and to the previously loaded CT data for which the preoperative plan was confirmed (Fig. 5). This includes the tibial tubercle screws in case 3, in which registration was performed first, followed by removal of hardware. Preoperative range of motion was recorded (Table 1). Poses were taken at 0° and 90°, and knee balance adjustments were

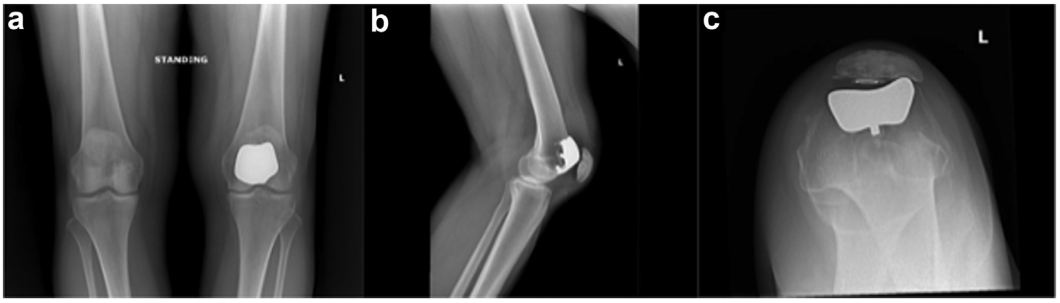

Figure 2. Case 2 preoperative (a) AP, (b) lateral, and (c) sunrise views of the left knee showing patellofemoral joint arthroplasty in place with no evidence of loosening. Medial compartment joint space narrowing is evident.

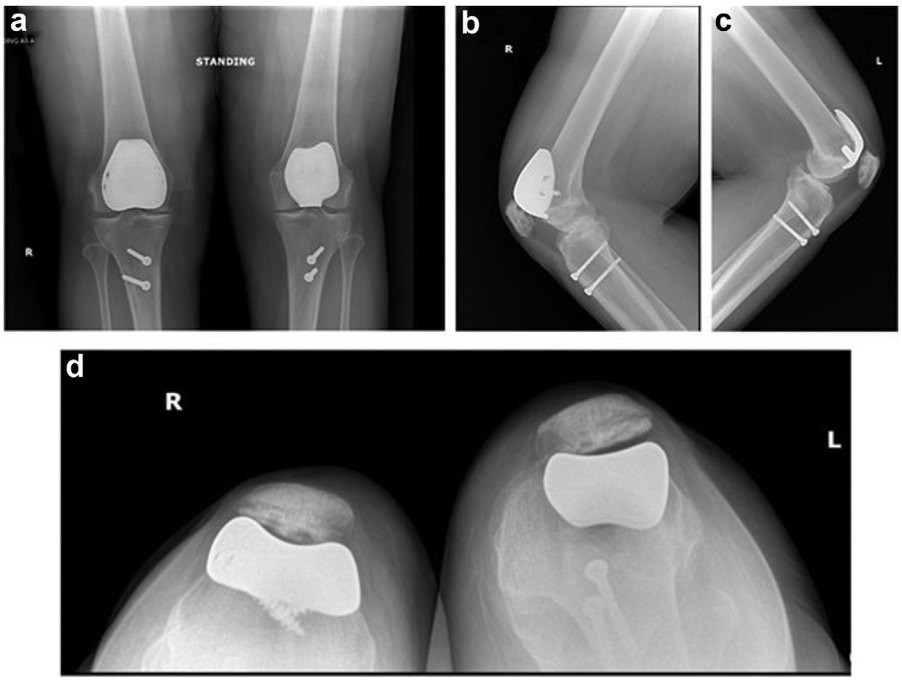

Figure 3. Case 3 preoperative (a) AP, (b) right and (c) left lateral, and (d) sunrise views of the left knee showing patellofemoral joint arthroplasty in place with no evidence of loosening. Medial compartment joint space narrowing is evident.

made in prosthetic placement and sizing. The ligament tension was optimized, as was the femorotibial tracking.

The patellofemoral components were explanted using a combination of osteotomes.

A horizontal saw was used to make the posterior, anterior chamfer, and anterior cuts on the femur as well as the proximal tibial cut. The saw head was then switched to a vertical configuration for the distal and posterior chamfer cuts made on the femur.

The patella was found to be damaged in case 2 requiring patellar revision intraoperatively. Circumferential release was performed with cautery.

Case 1 utilized press-fit components including a size 2 cementless Stryker Triathlon cruciate-retaining femoral component and a size 3 cementless Stryker Triathlon tibial component with a 10 mm cruciate-retaining articular polyethylene insert. Range of motion was 0° to 124° with components and trial in place with 4° varus.

Cases 2 and 3 utilized cemented components with third-generation cementing techniques. For case 2, the implants were then placed including a size 3 left Stryker Triathlon cruciate-retaining femoral component (cemented), a size 3 Stryker Triathlon universal cemented tibial baseplate, a 33 mm Stryker Triathlon patellar component, and a 9 mm cruciate retaining articular insert. For case 3, the implanted components included a size 3 right and left Stryker Triathlon cruciate-retaining femoral component (cemented), a size 4 right and left Stryker Triathlon universal cemented tibial baseplate, and a 9 mm right and 11 mm left cruciate retaining articular insert. Range of motion was 2° to 120° with 5° valgus for case 2, and −1 to 120 degrees with 7 degrees of varus on the right, and 0 to 120 degrees with 3 degrees of varus on the left for case 3.

All patients remained stable throughout the procedure and were transferred to recovery in stable condition. Postoperative x-rays were obtained (Figs. 6-8). Discharge included standard instructions with deep vein thrombosis prophylaxis and physical therapy referrals.

Follow-up

Case 1 currently has had 1-year of follow-up appointments and has reported doing well with no pain or mechanical/ instability issues at 3 weeks, 8 weeks, 4 months, 7 months, and 12 months postoperatively. At 1-year, the wound was healed without complication, there is no clinical deformity, and range of motion demonstrates extension to 0° and flexion to 120° without quadriceps lag. Patients with KOOS Jr improved from 21 preoperatively to 80 at 1 year. No pain was present with range of motion, and no instability was noted due to varus or valgus stress. Radiographs show stable, well-aligned components (Fig. 6a-c).

Case 2 currently has had 6 months of follow-up and reports that her pain is slowly improving and that she has no mechanical or instability issues with the arthroplasty. Her range of motion is 5° to 120°, and the incision is healing well. Radiographs show stable, well-aligned components (Fig. 7a and b). Patients with KOOS Jr improved from 52 preoperatively to 60 at 6 months, although patient states she has significant pain from fibromyalgia.

Case 3 has 6 months of follow-up on the left and 10 months on the right. Her range of motion is 0° to 120° bilaterally and has good function. She has no instability or pain with range of motion. Radiographs show stable, well aligned components (Fig. 8a-d). Patients with KOOS Jr improved on the right from 45 to 100 at 10 months and improved from 47 preoperatively to 100 at 6 months.

Written informed consent was obtained from all 3 patients prior to case submission and publication.

Discussion

With an increasing number of younger patients indicated for knee arthroplasty, there is interest in patellofemoral replacement to preserve physiology at the tibiofemoral joint at a lower cost than TKA [4,12,13]. While improvements in PFA designs have led to better outcomes, conversion remains a concern due to progressive osteoarthritis in the other compartments [5,14]. Conversion of PFA

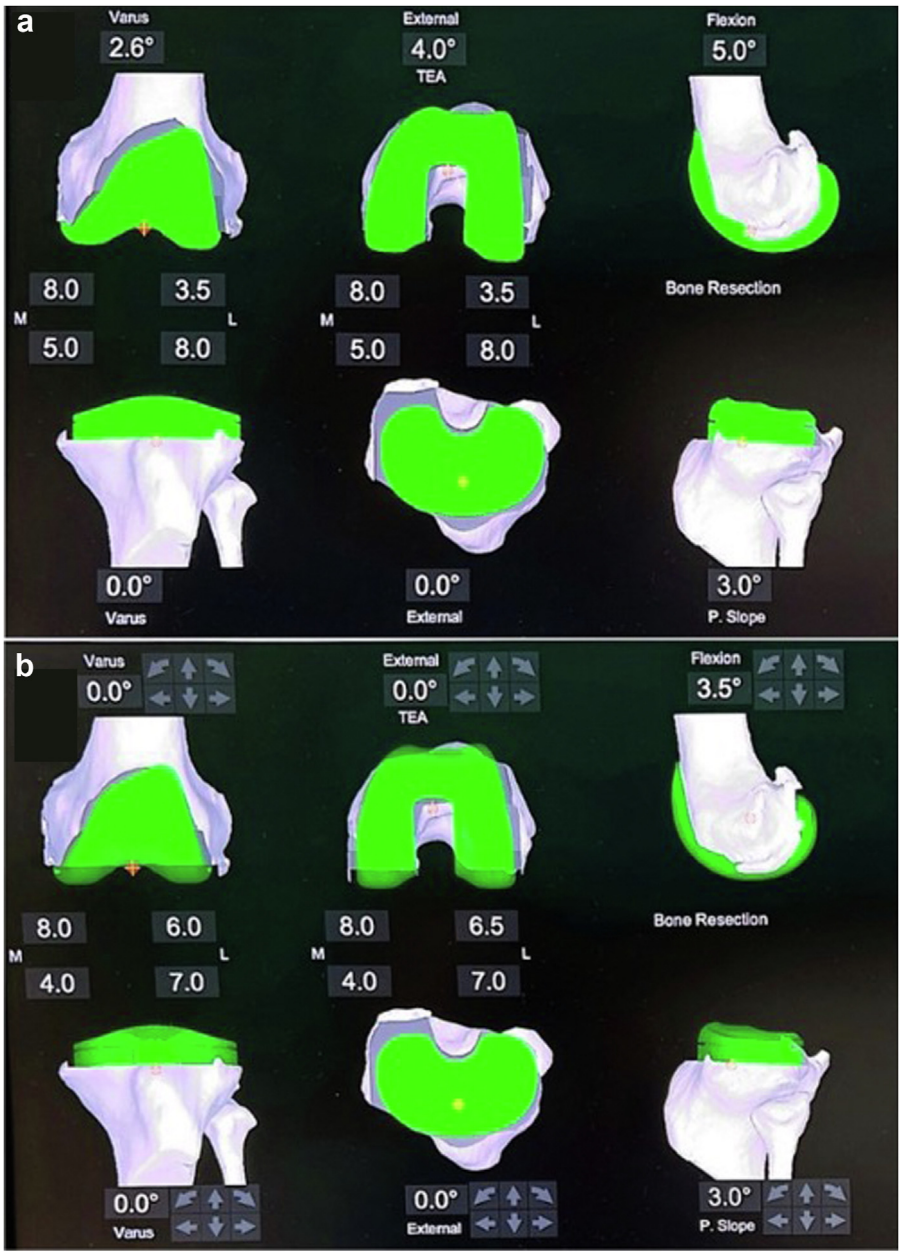

Figure 4. Case 1 (a) preoperative and (b) intraoperative screenshots from the MAKO robot used in bone preparation and balancing.

to TKA has been described as similar to primary TKA, although need for second revision is significantly higher after conversion than primary TKA alone [15]. Thus, further research to minimize revision risk in these patients undergoing conversion surgery is needed.

Robotic-assisted primary and revision arthroplasty have shown good outcomes. RA TKA demonstrates improved alignment compared to conventional TKA [16-18], suggesting RA may aid in conversion implant placement. Studies have found RA TKA to have decreased postoperative pain, enhanced early functional status, and decreased time to hospital discharge compared to conventional TKA, although some studies show equivocal results [19]. Robotic-assisted conversion has yet to be approved by the Food and Drug Administration. To our knowledge, these are the first reported cases of conversion of PFA to TKA using robotic assistance.

Previous studies have shown good outcomes with robotic-assisted conversion of UKA or TKA to revision TKA. Kalavrytinos et al. [7] first presented robotic-assisted conversion of failed UKA to TKA. Wallace et al. reported on 4 conversions of UKA to TKA, finding that robotic-assisted conversion led to accurate intraoperative bone cuts and preserved bone stock [20]. Yun et al. found robotic-assisted conversion TKA required fewer augments and lesser polyethylene thickness [8]. Steelman et al. [10] and MacAskill et al. [9] first described TKA to revision TKA utilizing robotic assistance with good outcomes at 6 months. Furthermore, Ngim et al. [11] found 19 patients undergoing RA revision TKA to have good outcomes between 6 and 18 months. Taken together, these outcomes support RA conversion of knee arthroplasty surgery as feasible and show promising outcomes in small cohorts of patients.

In revision and conversion arthroplasty, previous bone cuts and soft tissue loss can make implant positioning and knee balancing challenging. Robot-assisted arthroplasty gives a surgeon the ability

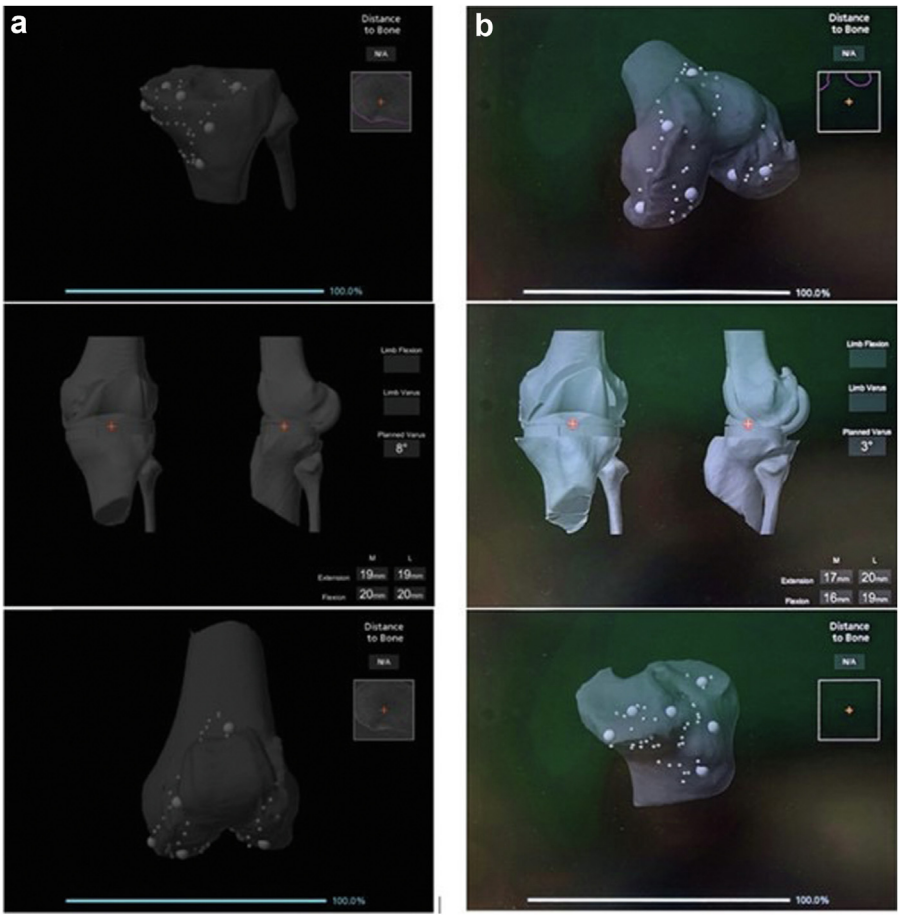

Figure 5. (a) Case 1 and (b) case 2 intraoperative registration with the Mako robot.

Table 1
Preoperative range of motion of all 4 PFA to RA TKA measured by the Mako robot.

Case	Extension	Flexion	Varus/valgus
Case 1	10	104	8 of varus
Case 2	−3	120	9 of varus
Case 3 R	−6	120	8 of varus
Case 3 L	−4	120	8 of varus

to adjust metrics on the revision components such as implant rotation without relying on anatomic structures of the knee for guides or visual aids [21]. Patellar complications are a well-documented source of poor outcomes in TKA (both with and without patella resurfacing) that can require reoperation and component revision [22]. Hypothetically, improvements in femoral and tibial component positioning in RA TKA would aid in patellar complications, such as minimizing patellar maltracking.

Technically, manually performed patellofemoral conversion arthroplasty to TKA is thought to be similar to primary TKA, although there is a higher rate of re-revision compared to primary TKA [23]. Concern for obscuration on preoperative CT and registration difficulties with previous implants has been a concern for RA conversion to TKA. We experienced no difficulties in registration, bone cuts, or knee balancing compared to primary TKA after removal of PFA hardware. Notably, no extra complications or difficulties in exposure occurred in the patient with bilateral tibial tubercle osteotomies in which registration was performed, followed by hardware removal. We found that the robot was also able to accurately account for the boney defect from the PFA implant in making boney cuts. Notably, we utilized intraincisional pin

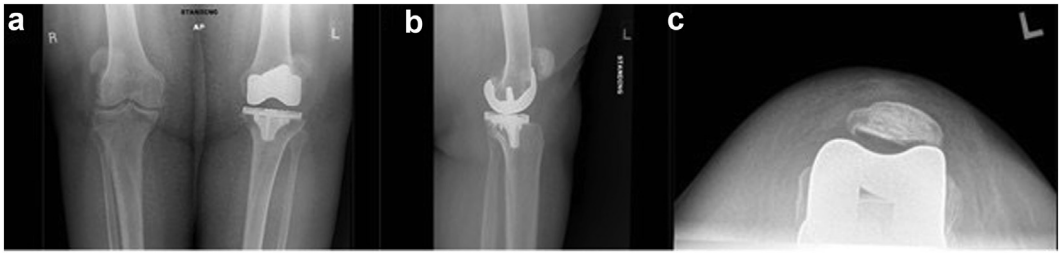

Figure 6. Case 1 postoperative x-rays with (a) anterior to posterior, (b) lateral, and (c) sunrise views showing total knee arthroplasty in good alignment.

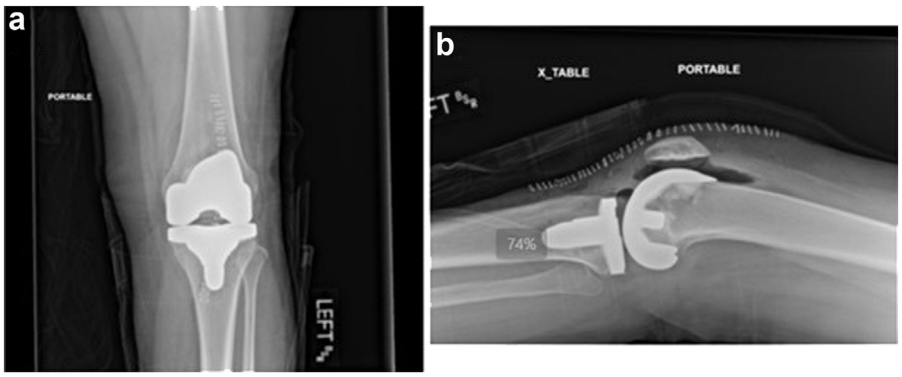

Figure 7. Case 2 postoperative x-rays with (a) AP and (b) lateral views showing total knee arthroplasty in good alignment.

placement, which may lend to pins closer to the tibial tuberosity. While this is generally more proximal than the 10 cm from the tibial tuberosity recommended in the Mako surgical guide [24], we have not had patients fracture through this site previously. Increased procedure time may be considered a drawback of primary RA TKA compared to manual TKA [25], although all cases were performed under 1 hour. Thus, RA conversion of PFA to TKA is a technically feasible procedure from our experience.

Standard components were utilized for all patients, consistent with previous findings [15]. Augments or revision components

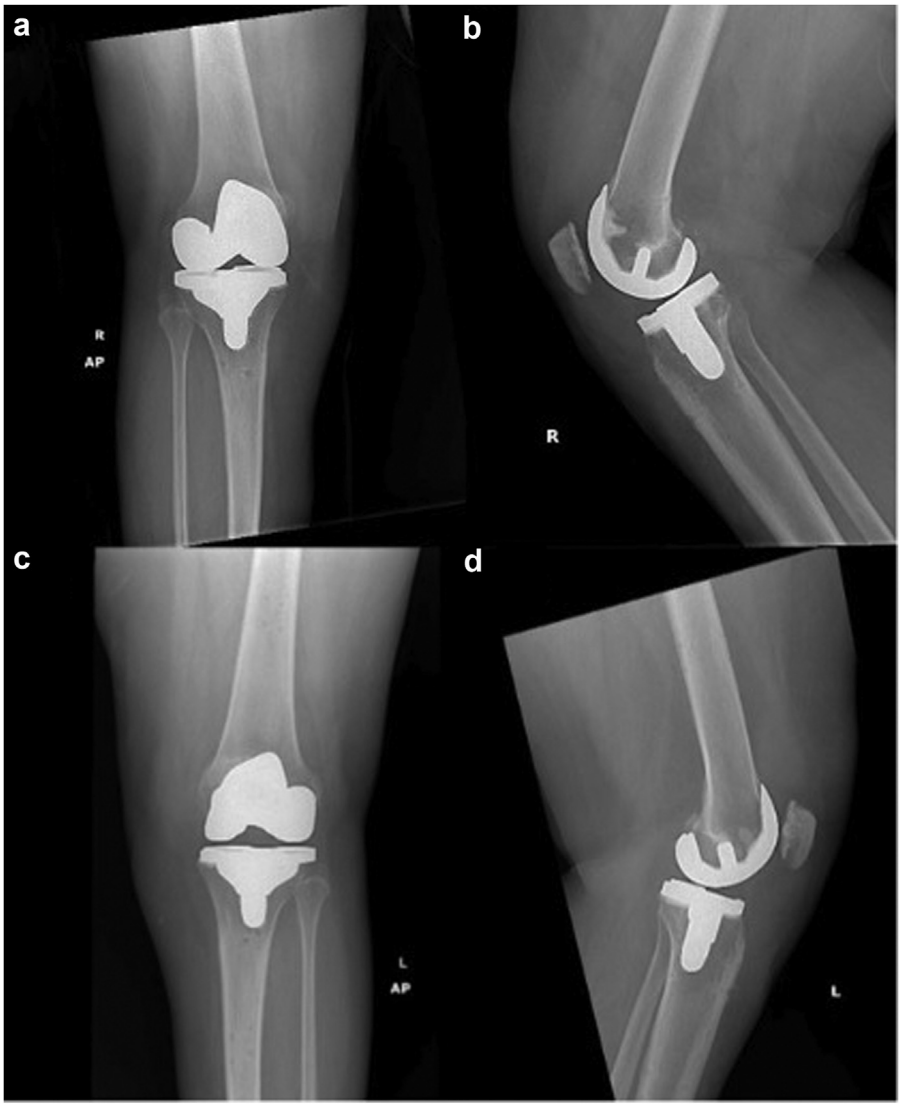

Figure 8. Case 3 postoperative x-rays with (a and c) AP and (b and d) lateral views showing total knee arthroplasty in good alignment.

were not needed similarly to previous studies that show manual conversion of PFA to TKA to be similar to primary TKA [15]. The patella was revised in one of these cases but not in the others. Lewis et al. [15] found no difference in second revisions between patellar components that were revised or retained during conversion surgery. In a systematic review, McDonald et al. [26] found no differences in midterm performance and survivorship with retained vs revised patellar button in conversion PFA to TKA, even with implant mismatch. These findings are similar to that of revision TKA, in which patellar component revision did not make a difference [27]. From this evidence, standard components can be used in conversion TKA without the need to revise the patellar component.

We describe what we believe to be the first technique of PFA conversion to TKA in 3 patients. If there was obscuration due to hardware on CT and robotic registration, it did not appear to affect conversion surgery or patient outcomes from 6 months to 1 year. With the increased rate of revision following conversion TKA vs primary, RA TKA provides an alternative technique to manual conversion. Future study is required to determine if conversion of PFA to TKA is more efficacious than previously described techniques.

Conflicts of interest

The authors declare there are no conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101215.

Informed patient consent

The author(s) confirm that written informed consent has been obtained from the involved patient(s) or if appropriate from the parent, guardian, power of attorney of the involved patient(s); and, they have given approval for this information to be published in this case report (series).

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