Learning Curve of Robotically Assisted UKA

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Introduction

Successful clinical outcomes following unicompartmental knee arthroplasty (UKA) depend on accurate component alignment, which can be difficult to achieve using manual instrumentation. To this end, a new technology has been developed using tactile robotics that replaces traditional UKA instrumentation (Figure 1). However, integrating new technology into the operating room can be associated with a significantly long learning curve, which introduces inefficiency in to the surgeon's practice and the hospital's OR work flow. This study quantifies the learning curve of a new robotic technology developed to improve the accuracy of UKA.

Figure 1. Robotic arm guided implantation.

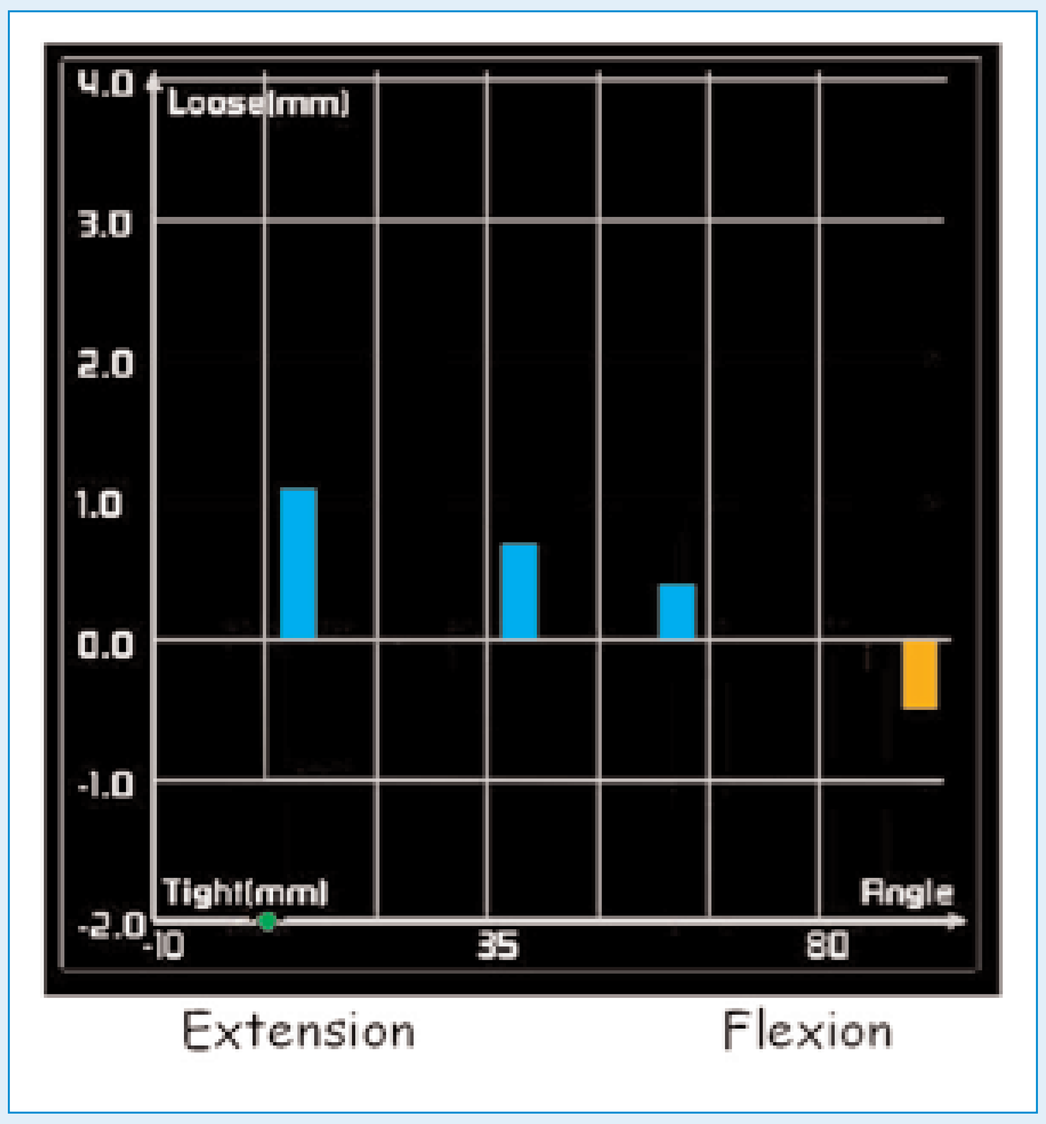
Methods

- 244 patients received a UKA performed by 5 different surgeons with a robotically guided implantation system.
- Each surgeon had performed at least 30 surgeries with the new technology.
- The surgical time of the final 20 surgeries of each surgeon was averaged for a steady state surgical time.
- Surgical time was defined as the time from the insertion of the bone pins to the acceptance of the implant component trials.
- For each surgeon, the number of surgeries required to have 2 consecutive and 3 total surgeries completed within the 95% confidence interval of the steady state surgical time of that particular surgeon was also noted.

Surgical Technique

- Patient specific pre-operative CT scans are used to create 3-D model reconstructions of the femur and tibia and are then combined with 3-D computer-aided design models of the implant components.
- Pre-operative planning of implant position, overall leg alignment, gross anatomical deformities, overlapping of components through flexion, and geometric alignment of varus/valgus measurements is performed using the patient specific 3-D bone models.

Figure 2. Knee gap kinematics are displayed in real-time.



- Intra-operatively, bone pins are inserted into the femur and tibia and mounted with bicortical surgical navigation markers, which are also mounted on the robotic arm to be recognized by a standard optical infrared camera. This allows the robotic arm burring tip to realize the relative position of the bone.
- Bony landmarks are identified and digitized to register actual bone geometry to the virtual 3-D reconstruction to allow real time tracking and adjustments to obtain correct knee kinematics and soft tissue balancing to finalize the implant volume to be resected (Figure 2).
- The robotic arm facilitates controlled bone resection by applying stereotactic boundaries to the cutting burr tip; these boundaries are virtual walls created by the software and implemented through the robotic arm hardware to restrict the cutting tip to within the predefined resection volume, which is defined by the shape of the implant and depth of resection (Figure 3).
- Permanent graphical feedback on the navigation screen visualizes the actual achieved versus the planned cavity, specifically based on pre-operative planning.
- Once both the tibial and femoral cavities have been prepared, component trials are inserted and a complete flexion-extension arc is performed in conjunction with computerized simulation of the implants in situ showing actual overlapping of implants and determining leg alignment and knee gap kinematics; Once trials are accepted, they are replaced with cemented implant components and a final range of motion is performed to compare with the trials (Figure 4).

Figure 3. Graphical visualization of bone resection showing real time feedback of the burr, indicating what remains to be resected (green).

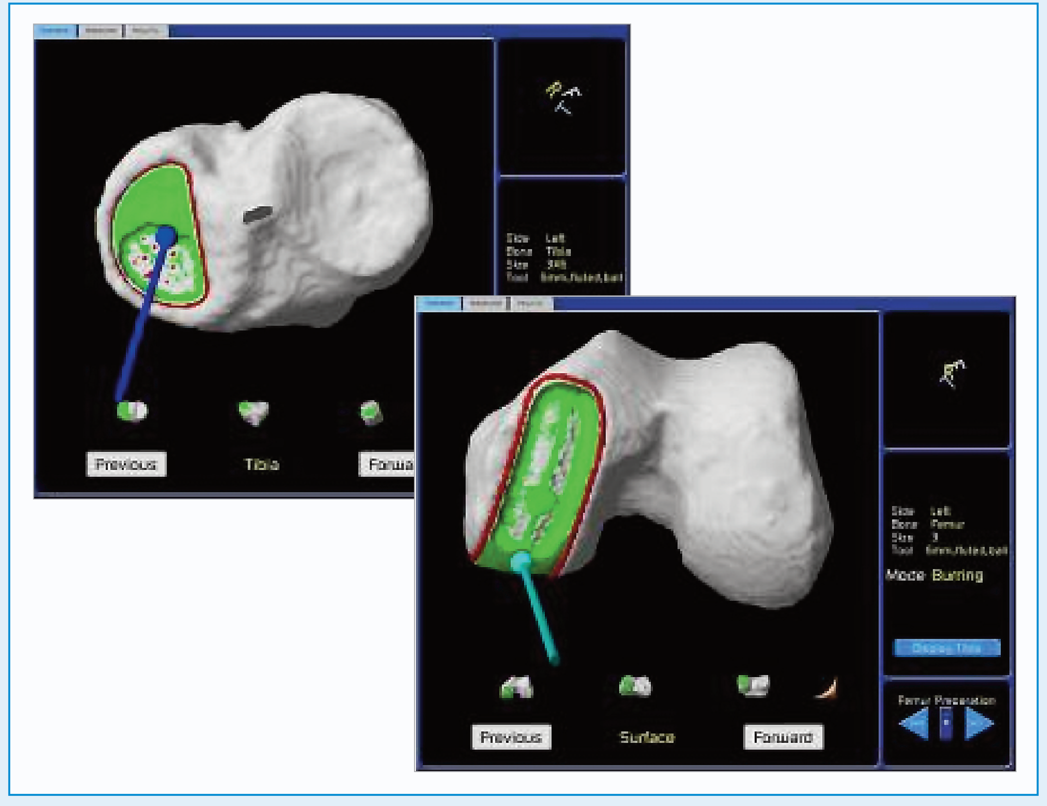
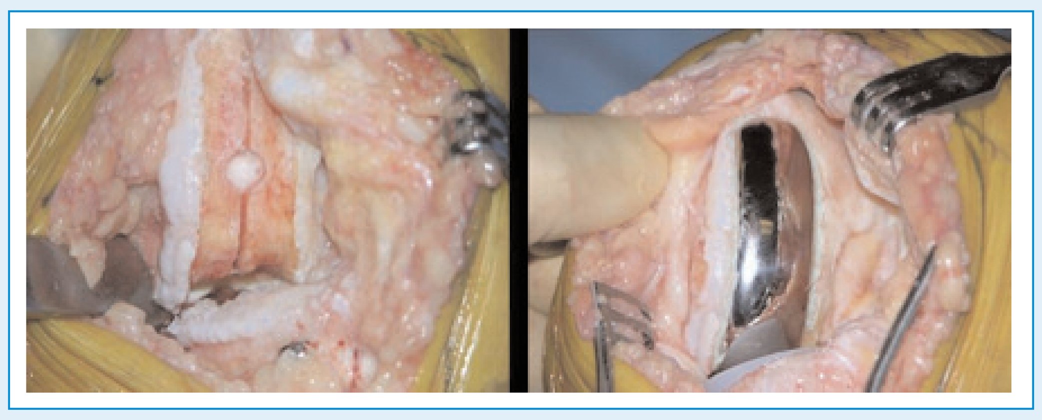


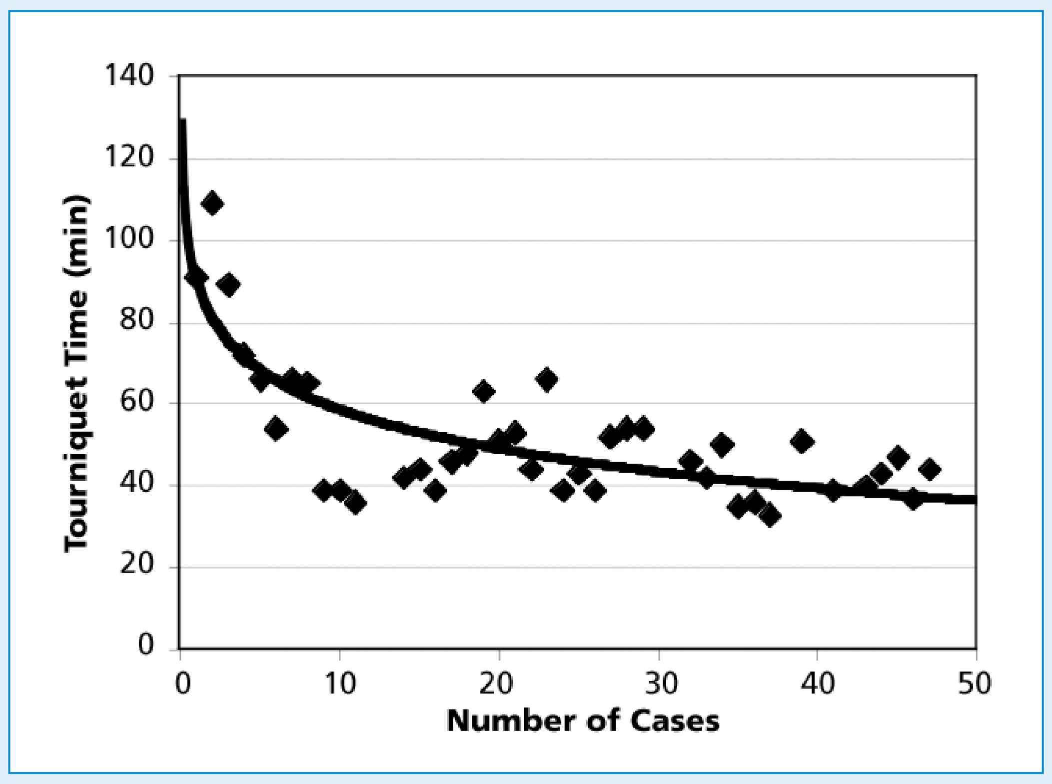
Figure 4. Intra-operative image showing resected femoral cavity and placement of implant component.



Results

- The average surgical time for all surgeries across all surgeons was 59 ± 21min (range: 27min to 165min).
- The surgeon with the shortest steady state surgical time averaged 43 ± 8min, while the surgeon with the longest steady state surgical time averaged 76 ± 16min.
- The number of surgeries required to have 2 consecutive surgeries completed within the 95% confidence interval of the steady state surgical time was 7 (range: 4 to 12).
- The number required to have 3 surgeries completed within the 95% confidence interval of the steady state surgical time was 8 (range: 5 to 13), (Figure 5).

Figure 5. Typical learning curve graph showing one surgeon's first 50 cases.



Conclusion

New technology has been introduced that essentially replaces traditional manual instrument sets with a passive robotic arm that precisely executes a pre-operative plan. The learning curve of this novel surgical technique is reasonable and is much shorter than has been reported with the introduction of other orthopedic technologies in the OR, which is very promising for the acceptance of this novel robotic arm assisted technology.

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Does Conversion of a UKA to a TKA Require Medial Augmentation?

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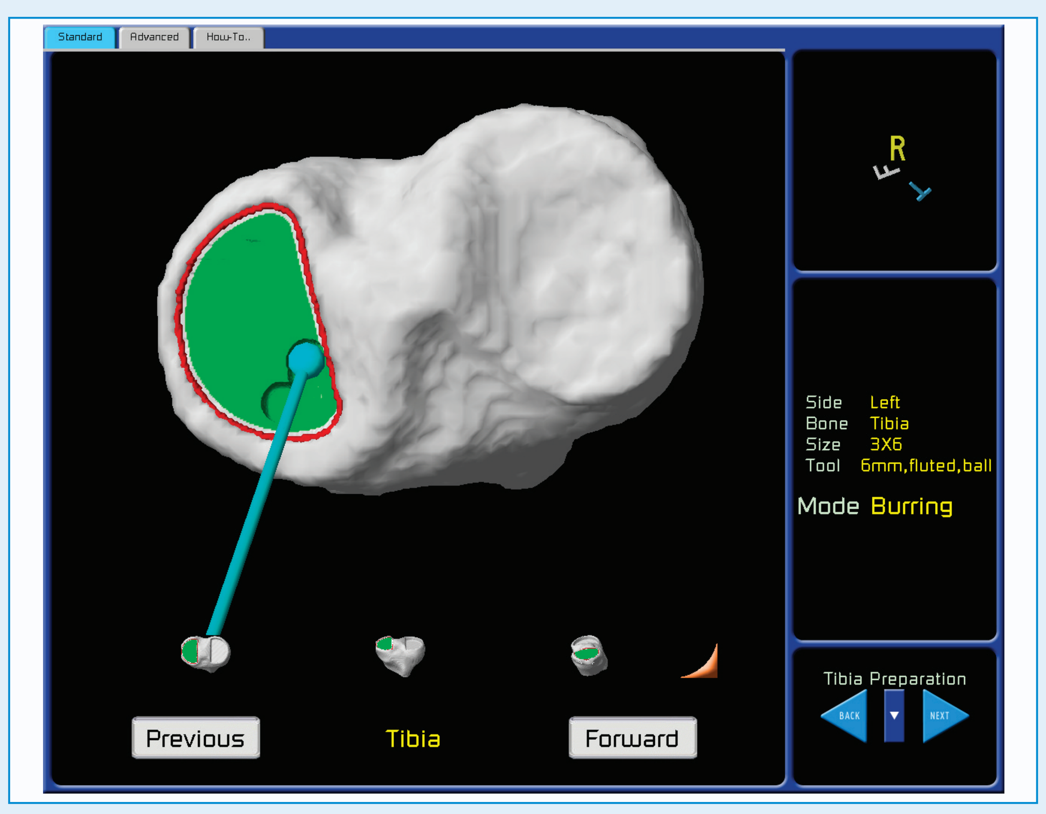
Introduction

Renewed interest in UKA necessitates further investigation into the ramifications of conversion to TKA due to either implant failure or progressive joint disease. The purpose of this study was to compare the depth of tibial resection at UKA and the resulting implications for conversion to TKA using two different UKA techniques and implant designs.

Materials and Methods

- 42 UKA patients from a single surgeon were included in this study
  - 16 patients receiving an all-poly tibial onlay implanted using manual instruments
    - 7 males, 9 females
    - Average age: 68 years
    - Average BMI: 28
  - 26 patients receiving an all-poly inlay implanted using a robotic arm system
    - 11 males, 15 females
    - Average age: 65 years
    - Average BMI: 30
- Both systems were "MIS resurfacing" implants
- The two groups were identical in terms of age, gender and BMI (p>0.05)



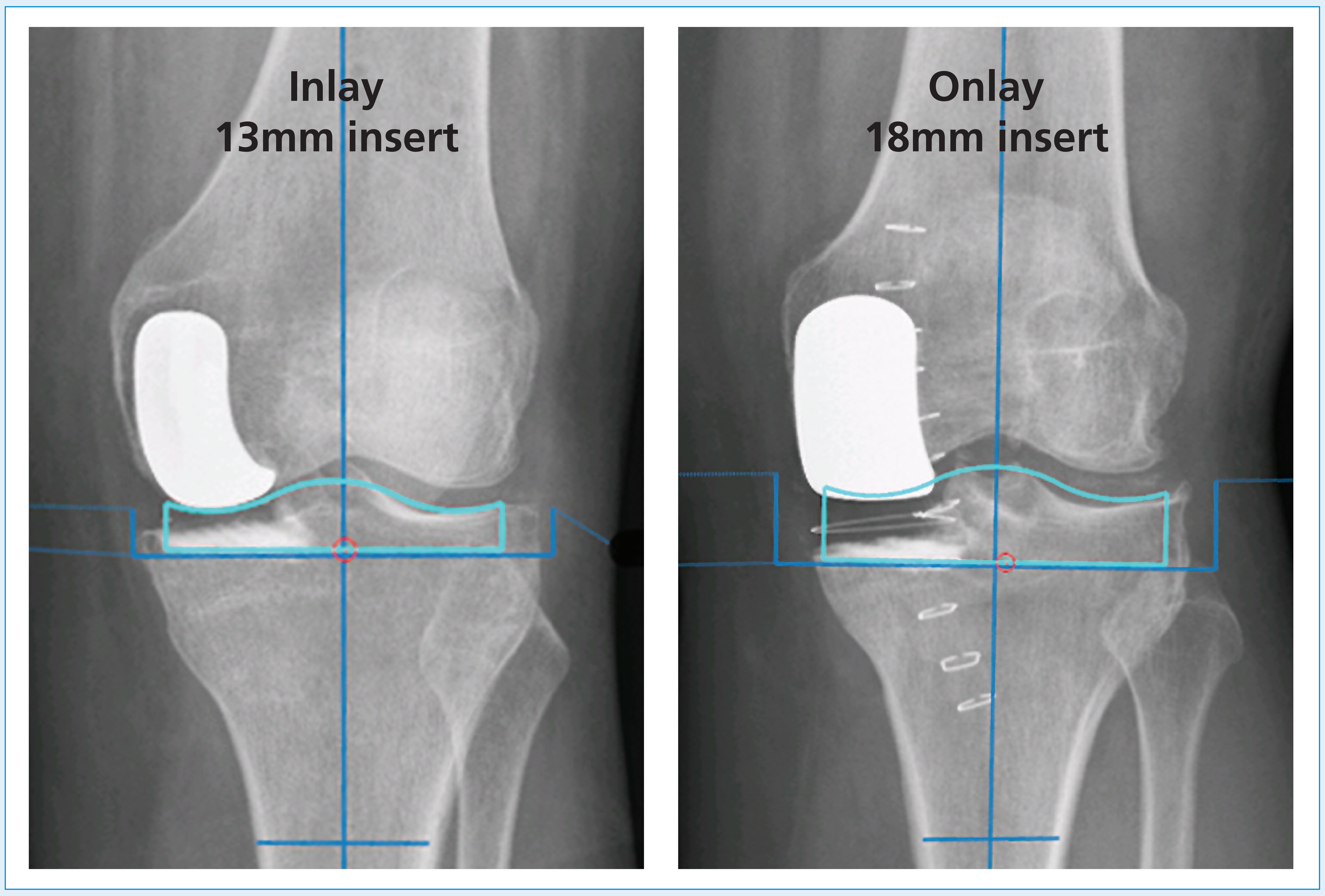
- Analyzed anteroposterior radiographs
  - Measured depth of medial plateau resection relative to the initial medial joint line
  - Templated for primary TKA using TraumaCad 2.0 (Orthocrat)
  - Predicted requirement of medial augmentation at conversion to TKA based on templated tibial insert thickness greater than 15mm

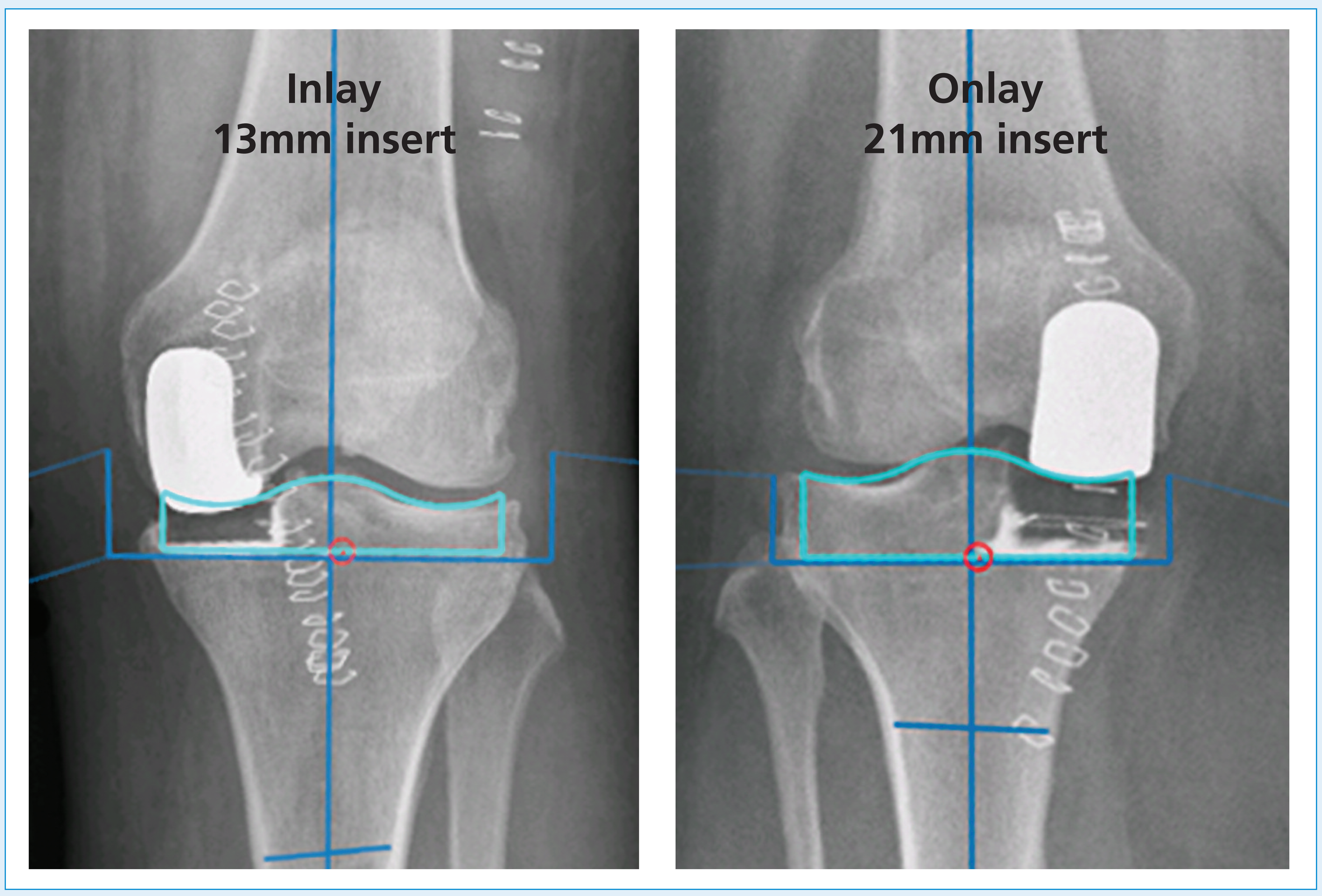
Results

- Average depth of bony medial plateau resection was significantly greater in the standard technique onlay design group (8.5 ± 2.26 mm) compared to the robotically assisted inlay group (4.4 ± 0.93 mm) (p<.0001).
- At conversion to a standard TKA, the proposed tibial osteotomy would require medial augmentation/revision components in 75% of the onlay group as compared to 4% of the robotically assisted inlay group (p<.0001).

Conclusion

- Robotically assisted UKA using a tibial inlay design results in half the tibial bone resection compared to a similar MIS onlay design.
- This is a truly resurfacing procedure with respect to the tibia that will lead to a simpler conversion to TKA not requiring tibial augmentation.





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