# ACCURACY OF IMAGELESS ROBOTICALLY ASSISTED UNICONDYLAR KNEE ARTHROPLASTY

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## INTRODUCTION

Utilisation of unicondylar knee arthroplasty (UKA) has been limited due in part to high revision rates. The National Joint Registry (NJR) reports that only 8% of knee arthroplasty surgeries completed in the England and Wales are UKAs (NJR 2014). They reported that the revision rate at 9 years for Total Knee Arthroplasty (TKA) was 3% compared to 12% for UKAs (NJR 2014). UKA failure has been associated with excessive polyethylene wear, progression of arthritic disease, and aseptic implant loosening which have all been linked to improper component alignment (Collier 2006, Ridgeway 2002). However, the benefits of UKA have also been reported with patients reporting better functional outcome, shorter hospital stays and a quicker recovery rate compared to TKA (Lombardi 2009).

In the last decade semi active robots have been developed to be used for UKA procedures. These systems allow the surgeon to plan the size and orientation of the tibial and femoral component to match the patient's specific anatomy and to optimise the balancing the soft tissue of the joint. The robotic assistive devices allow the surgeon to execute their plan accurately removing only 'planned' bone from the predefined area.

This study investigates the accuracy of an imageless navigation system with robotic control for UKA, reporting the errors between the 'planned' limb and component alignment with the post-operative limb and component alignment using weight bearing long leg radiographs.

## MATERIALS AND METHODS

The system uses infrared optical tracking to give real time feedback about the position of the patient and the equipment. It uses a bicortical, twin pin system for attachment of the femoral and tibial optical tracking arrays. This system is CT free, so relies on accurate registration of intraoperative knee kinematic and anatomic landmarks to determine the mechanical and rotational axis systems of the lower limb. The surface of the condylar is based on a virtual model of the knee created intra operatively by 'painting' the surface with the tip of a tracked, calibrated probe. The ligaments and surrounding soft tissue structures are assessed by applying a valgus stress (for medial UKA) or a varus stress (for lateral UKA) through a range of motion. The implant size and orientation can be adjusted to best fit the patients' anatomy and subsequent steps determine the gap and ligament balance if the implant plan was executed. The position of the components can be altered, for example by changing the depth of resection or anteriorisation the femoral component to achieve a virtual soft tissue balance of the joint. This plan then determines the volume of bone to be removed which is graphically displayed on the monitor. The buring mechanism is robotically controlled through either 'exposure' or 'speed' control. In 'exposure' control the system controls the depth of the bur which extends past the protective metal guard. When outside the 'target' bone zone then the bur retracts to hide within the guard. In 'speed' control the system controls the speed of bur rotation where the speed is ramped down to zero as the bur reaches the 'target' bone depth. The position of the hand piece is continuously updated which results in adjustments in the bur tip and the depth of bone being cut.

We prospectively collected radiographic data on 92 patients who received medial UKA using an imageless robotic assisted device across 4 centers (4 surgeons).

## RESULTS

The study shows the 89% of the patients' post-operative alignment recorded by the system was within $3^{o}$ of the planned coronal mechanical axis alignment. The RMS error was $1.98^{o}$.

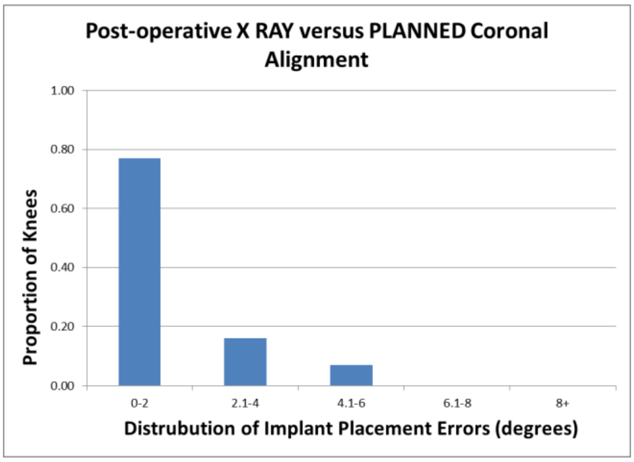
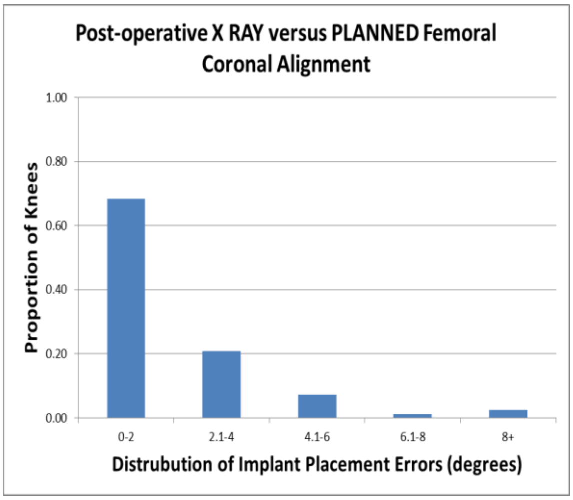


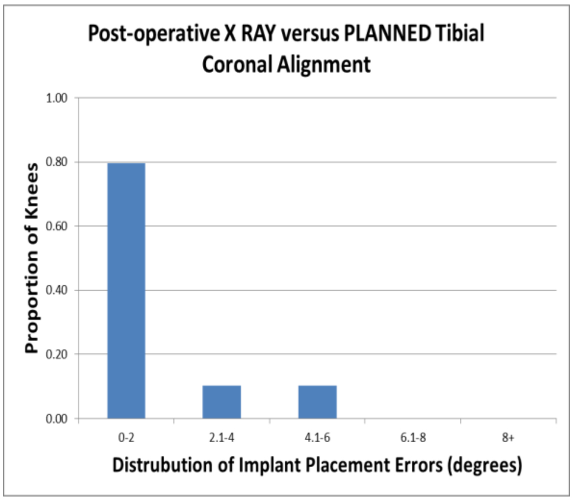

**Figure 1: Implant errors comparing the 'planned' coronal mechanical axis alignment with the post-operative alignment measured on radiographs.**

The RMS errors between the robotic system's implant plan and the post-operative radiographic implant position was; femoral coronal alignment (FCA) $2.6^{o}$, tibial coronal alignment (TCA) $2.9^{o}$ and tibial slope (TS) $2.9^{o}$.

(a)




(b)




(c)

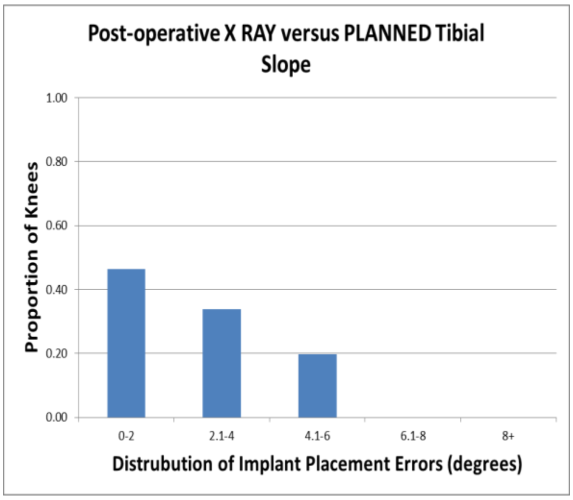



**Figure 2: Implant errors comparing the 'planned' alignment with the post-operative alignment measured on radiographs (a) femoral coronal implant placement (b) tibial coronal implant placement (c) tibial slope implant placement.**

## DISCUSSION

This is the first clinical series using the imageless robotic navigation system for UKA comparing the system's planned overall lower limb mechanical alignment and the component alignment with post-operative radiographs. Poorly aligned UKA components is thought to lead to polyethylene wear and a progression of the disease to the non-involved compartment of the knee joint (Aleto 2008). Based on the intra-operative valgus stress test the implants were positioned to optimise the soft tissue balance of the knee and result in a coronal alignment which was optimum for the patient. 89% of cases in this study were within $3^o$ of the planned overall coronal mechanical axis alignment.

CT based robotically assisted systems for UKA have reported RMS errors of $2.1\text{-}2.6^o$ for FCA, $1.5\text{-}2.1^o$ for TCA and $1.7\text{-}1.9^o$ for TS alignment (Dunbar 2012, Cobb 2006). Manual instrumentation reported RMS errors; FCA $4.1^o$, TCA $4.1^o$, TS $6.0^o$. This compares to this current study which reported RMS errors of $2.6^o$ (femoral coronal alignment), $2.9^o$ (tibial coronal alignment) and $2.9^o$ (tibial slope alignment).

The analysis of the CT based systems involved measuring errors in placement by overlaying the planned and achieved CT data and therefore minimising the measurement error. The reported errors are a sum of all errors associated with both the surgery and the measurement process. One limitation with the methodology in our study was associated with using different methodologies to record the data points. The intra-operative plan data was recorded with the patient in a supine position and based on the systems registration points recorded in 3 dimensional space compared to 2 dimensional weight bearing long leg radiographs.

In conclusion, the imageless robotic surgical system for UKA accurately prepared the bone surface of the tibia and femur which resulted in low errors when comparing planned and achieved component placement. This resulted in a high level of accuracy in the planned coronal mechanical axis alignment compared to that measured on post-operative radiographs.

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**DISCLOSURES**

Julie Smith and Branislav Jaramaz are employees of Blue Belt Technologies.

Frederic Picard and Jess Lonner are on the scientific advisory board for Blue Belt Technologies.