DOES IMAGE FREE ROBOTIC ASSISTED UNICONDYLAR KNEE ARTHROPLASTY ACHIEVE THE SURGEONS' SPECIFIC PLAN?

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INTRODUCTION

Unicondylar Knee Arthroplasty (UKA) is an alternative surgical option to a Total Knee Arthroplasty (TKA) for knee arthritis suffers with early to mid-stage disease. It has evolved over the last four decades as new instruments and implants have been developed. However, the utilisation of this procedure within the UK has been limited to around 8% of all knee arthroplasty procedures (NJR 2014). It has been reported that there is the potential for growth as Willis et al reported that up to 47.6% of knee arthroplasty patients fit the criteria for UKA (Willis 2009). It is a technically demanding procedure, with a steep learning curve. For many surgeons it is a low volume procedure within their hospitals which means that there is the possibility that they do not overcome the 'learning' section of the curve. The results tend to agree with this assumption in that low volume hospitals (Gioe 2003) have reported high revision rates which differ greatly from the high volume sites. The national joint registry also reports revision rates of 12% at 10 years for UKA compared to 4.5% at 10 years for TKA (NJR 2014).

The philosophy behind UKA is to correct the overall alignment of the patient's lower limb to their pre diseased state. Therefore, the surgery should be tailored to the individual patient through the assessment of their ligaments and the correctable deformity. Unfortunately, manual instrumentations are generic and set the implant position to the prosthesis company's standard with limited flexibility to adapt to the patient. Manual surgical systems also lack any feedback as to the outcome of the surgery intra-operatively.

Robotic assisted UKA has grown in popularity, where 14% of UKA procedures use robotically assisted devices in the USA (Orthopedic Network News 2013). The ligaments of the knee are assessed intra-operatively through a stress varus or valgus test depending on whether the disease has affected the medial or lateral compartment. The plan uses this stress test data to calculate the gap balance through a range of flexion for the plan set by the surgeon. Before any cuts are made the position of the femoral and tibial components can be altered to find the optimised component position with respect to the gap balance of the knee through flexion.

The bony surface is then removed using a high speed rotating spherical bur which is robotically controlled to cut the exact plan. It is important that the alignment which the surgeon plans for intra-operatively is achieved post-operatively. Therefore, the outcome measure for this study was the change in the tibiofemoral angle which was defined as the difference between the planned and achieved angle in the coronal plane reported by the surgical system.

MATERIALS AND METHODS

Between July 2012 and June 2014, 298 patients have been selected based on the pre-operative assessment as candidate for image free, robotically assisted UKA. These procedures were performed by 22 surgeons in 16 hospitals across Europe and the USA. A complete dataset with regards to planned and achieved alignment, as well as the implanted prosthesis size and thickness was recorded.

The tibiofemoral coronal axis angle was calculated by the image free robotic surgical system. This was the angle between the mechanical axis of the femur and the tibia. From this data the surgical system calculated the pre-operative tibiofemoral coronal angle, as well as the predicted angle if the surgical plan for the implant placement was achieved. After the cutting phase of the procedure, the tibiofemoral coronal angle was recorded using the trial implants and then again when the implants had been cemented in their final position. The achieved and planned tibiofemoral coronal angles were compared where when the lower limb was in full extension.

RESULTS

The results are presented on the 298 cases where the final cemented tibial insert thickness was unchanged with respect to the intra operative plan.

Difference in Tibiofemoral Angle (^{o})	Number of Cases
0-2	288
2.1-4	8
4.1-6	1
6.1-8	1

Table 1: The absolute difference between the planned and achieved tibiofemoral angles and the number of cases in each group.

The achieved tibiofemoral angle was within 1^o, 2^o and 3^o of the surgical plan in 88.9%, 96.6% and 99.3% of the cases respectively. The differences between the tibiofemoral angles planned and achieved are shown in figure 1. The mean difference in the planned and achieved was -0.1^o (SD 1.03^o).

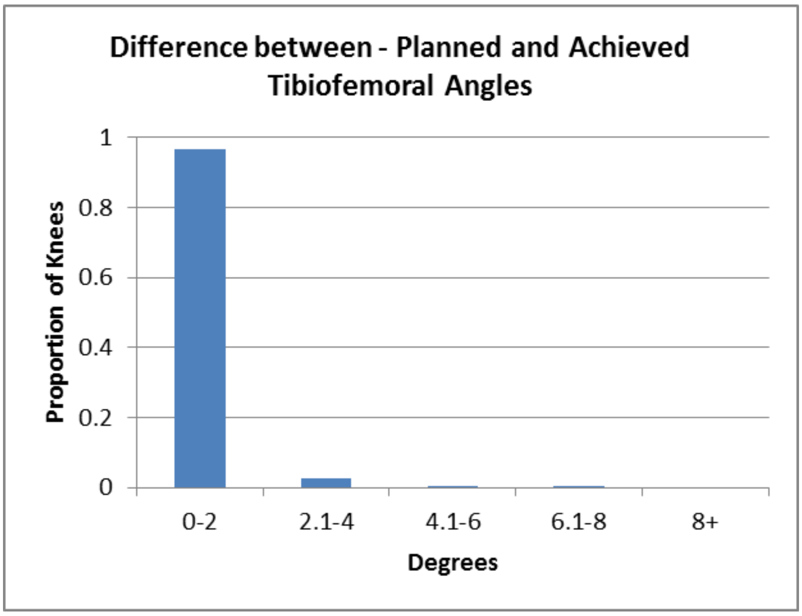

Figure 1: Difference in tibiofemoral coronal angle planned and achieved.

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DISCUSSION

This study confirms that the image free robotic surgical system allows accurate bone preparation which resulted in small errors in the tibiofemoral angle achieved compared to the angle planned by the surgeon intra-operatively. Cobb et al calculated the difference in the planned and achieved tibiofemoral coronal angle in manual and robotically assisted UKA procedures (Cobb 2006). They reported that 100% of their robotically assisted UKA patients were within 2^o of the planned coronal position compared to 40% of the manual UKA patients. Our study reported 97% of cases were within 2^o of the planned alignment.

All new surgical techniques have an associated learning curve. For this medical device it has been reported that it takes around 8 cases to reach a steady state surgical time (Wallace 2014). This study did not distinguish between case number and experience as the hypnosis was that this would not affect the accuracy of the bone surface preparation using the robotic assisted tool. The learning curve is instead associated with the surgical time.

In conclusion, image free robotics provides a new tool for accurately preparing bone in UKA. This study reported excellent levels of accuracy between the achieved and planned tibiofemoral angle. This was a large case series which included patients from multiple hospitals. The data series includes results from the first to the most recent cases; therefore it includes data from cases which would be included in their 'learning' phase of the learning curve for new technologies. However, this did not affect the consistency of the bone preparation or the tibiofemoral angle error calculated.

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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.