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An analysis of dislocation of the domed Oxford Lateral Unicompartmental Knee Replacement

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ABSTRACT

Background: The Oxford Unicompartmental Knee Replacement (OUKR) uses a mobile bearing to minimise wear. Bearing dislocation is a problem in the lateral compartment as the ligaments are loose in flexion. A domed tibial component has been introduced to minimise the risk of dislocation, yet they still occur, particularly medially. The aim of this mechanical study was to compare the domed and flat tibial components and to identify surgical factors that influence the risk of dislocation.

Method: A jig was constructed to assess the amount of vertical distraction of the lateral OUKR for a dislocation to occur. Three methods of dislocation were assessed: laterally, medially, 'over the wall' and anteriorly. The study focused on medial dislocation.

Results: Significantly ($p = 0.02$) greater vertical distraction was required to dislocate the bearing with the domed tibia rather than the flat. For medial dislocation bearing distance from the wall, femoral component external rotation and tibial rotation were associated with significantly less distraction for dislocation. With the optimal technique with the domed tibia the distraction required to dislocate the bearing medially was 6.4 mm, whereas with poor technique it was 4.6 mm.

Conclusions: This study suggests that to minimise the risk of dislocation the domed tibia should be used. The component should be implanted so the bearing is close to the wall, but does not hit it, and in flexion the femoral and tibial components should be neutrally aligned.

1. Introduction

Unicompartmental Knee Replacement (UKR) is an established treatment for isolated compartment osteoarthritis [1]. The medial Oxford UKR (OUKR), (Biomet, Swindon, UK), has a well-documented history of clinical success [1]. However, the original Lateral OUKR, (Biomet, Swindon, UK), had an 11% rate of bearing dislocation [2]. To address this unacceptably high rate the operative technique was changed and the implant design modified [3]. The new design has a spherically convex domed tibia which more accurately reflects the anatomy of the natural lateral compartment [3]. Full congruity was maintained by having a bi-concave bearing, which should increase entrapment.

The introduction of the domed Lateral OUKR, with the associated changes in operative technique has resulted in a substantial decrease in the dislocation rate. In the reported designer series, the cumulative dislocation rate was 1.7% and clinical outcomes good [3]. However, in other series higher dislocation rates have been reported [4].

The aim of this study was to compare the bearing stability with the domed and flat lateral tibial components and to identify surgical factors that influence the risk of dislocation.

2. Method

A jig was constructed in which the amount of distraction of the lateral compartment could be measured. A replica medium femoral component was constrained above a size C tibial component. The femoral component could be moved up and down with a screw. The amount of movement was measured with a linear potentiometer (Model PS-C95P, Strainsense, Potterspury, UK) with an accuracy of 0.01 mm, using a Powerlab (ADInstruments Ltd, Dunedin, New Zealand) analogue to digital converter (Fig. 1). Additionally, the femoral component could be moved within 10° of internal and external rotation. As dislocation commonly occurs in flexion, the anatomical position of the components was described assuming the knee was in flexion.

The tibial component was fixed to a micro-rotation stage, (Standa Ltd, Vilnius, Lithuania), that allowed internal and external rotation to the nearest 0.5 arcmin and medial/lateral translation of the tibial component to 0.005 mm.

Initially, with a size C flat tibial component *in situ*, the jig was calibrated. Five sheets of stainless steel with known thicknesses,

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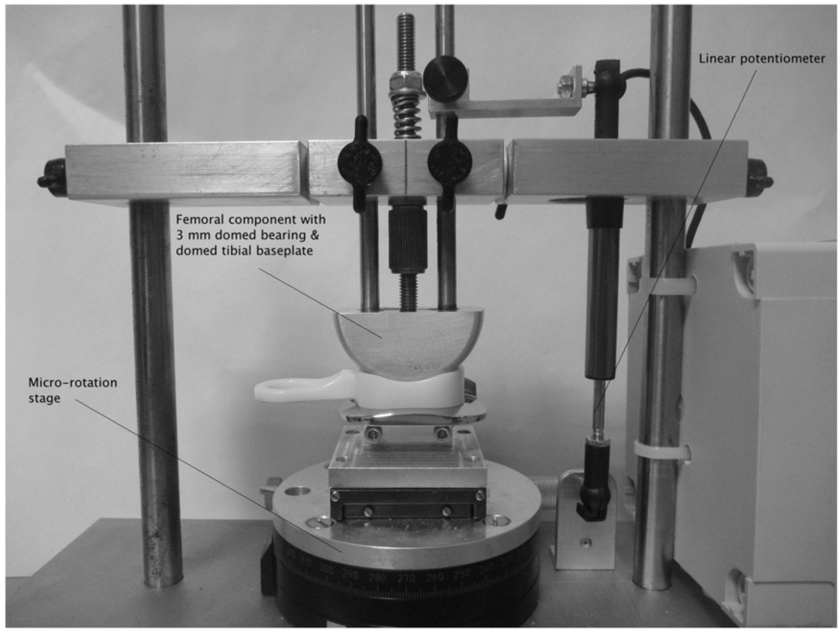

Fig. 1. An image of the jig illustrating the femoral component fixed in neutral with a domed tibial plate secured *in situ* a 3 mm domed bearing engaged. The linear potentiometer is attached onto the strut on the right.

(2.02 mm, 3.06 mm, 4.01 mm, 5.04 mm, 6.02 mm), were placed on the flat tibial component and the voltage change registered by the linear potentiometer measured. All measurements were taken three times to gain an accurate mean (Fig. 2). From these readings, a formula to accurately convert voltage change into millimeters was constructed, ($H = (-2.59\ V) + 20.60$), where H = height of distraction and V = change in voltage).

Three directions of dislocation were assessed for all bearings: laterally, medially, over the tibial wall and anteriorly. Initially, the position of the femur was measured with the femoral component in full contact with the bearing. The femoral component was progressively elevated until the bearing could be dislocated. The difference between the height of the femur at dislocation and base line was considered to be the vertical distraction required for dislocation.

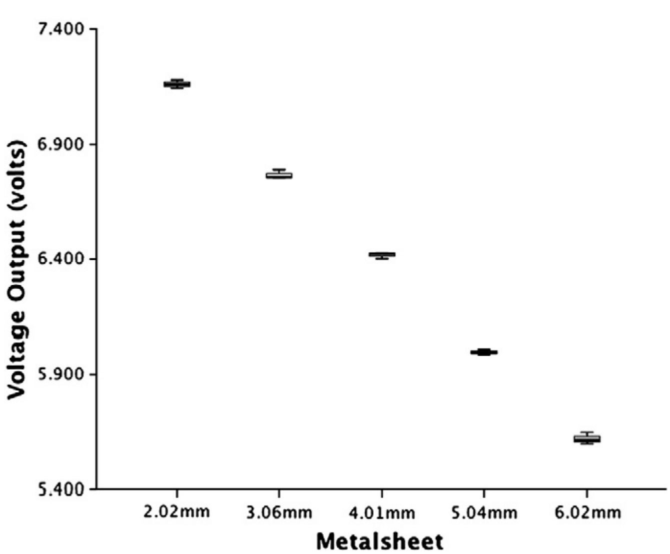

Fig. 2. Box-plot illustrating the voltage output for all tests carried out to as certain the calculation required to convert voltage output into distance of femoral component distraction.

The 3 mm bearings were too thin to reliably manipulate and gain an accurate measurement. As a result, 3 mm bearings, (exactly matching the domed and flat bearings of the lateral OUKR), were fashioned with an anterior "tongue" which allowed the bearing to be manipulated. The experimental procedure was performed a total of three times for each method of dislocation in each position.

A comparison was first performed between the domed tibia with biconcave bearings and the flat tibial with flat bottomed bearings. Bearings, (range 3 mm to 8 mm), were tested in 0° of rotation. The femoral component was fixed in a neutral position with all bearings 1 mm from the tibial wall.

Using the domed tibia and a 3 mm bearing further analysis was carried out. The effect of tibial component rotation on the distraction required to dislocate the bearing was assessed in 5°, 10°, 15° and 20° of internal rotation and 5° and 10° of external rotation. The effect on bearing position relative to the tibial wall was assessed. Distances of 0 to 8 mm, (in increments of 1 mm), from the medial tibial wall were tested with the femoral component in a neutral position and the tibial component in 0 degrees of rotation. Finally, with the tibial component fixed in 0 degrees of rotation and with bearings 1 mm from the tibial wall the orientation of the femoral component was altered from 10 degrees of external rotation to 10° of internal rotation in 5° increments. Using the calibration data the voltage levels at baseline and dislocation were converted into the distraction height necessary for dislocation.

Statistical analysis was performed using SPSS for Windows v 18.0 (SPSS Inc., Chicago, Illinois). Analysis of the data illustrated that it was not normally distributed. Therefore, analysis was performed using the Mann–Witney U test or the Kruskal–Wallis test. Intra-observer and inter-observer variability was assessed with the Kappa statistical test for reliability by dislocating the 3 mm bearing laterally with the bearing in 0° of rotation and 1 mm from the wall with the femoral component in neutral position 10 times. Significance was set as $p < 0.05$.

3. Results

Inter-observer reproducibility was good with $\kappa = 0.68$ and intra-observer variability was $\kappa = 0.76$.