Effect of Bearing Design and Anatomical Angles on Frictional Torque

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INTRODUCTION:
Prosthetic hip dislocations remain one of the most common major complications after total hip arthroplasty procedures, which has led to much debate and refinement geared to the optimization of implant and bearing options, surgical approaches, and technique [1]. The implementation of larger femoral heads has afforded patients a larger excursion distance and primary arc range motion before impingement, leading to lowered risk of hip dislocation [2,3]. However, studies suggest that while the above remains true, the use of larger heads may contribute to increased volumetric wear, trunnion related corrosion, and an overall higher prevalence of loosening, pain, and patient dissatisfaction, which may require revision hip arthroplasty [4,5]. More novel designs such as the dual mobility hip have been introduced into the United States to optimize stability and range of motion, while possibly lowering the frictional torque and modes of failure associated with larger fixed bearing articulations [6,7]. Therefore, the aim of this study is to compare the effect of bearing design and anatomic angles on frictional torque using a clinically relevant model [8].

METHODS:
Two bearing designs at various anatomical angles were used for evaluation; a fixed and a mobile acetabular component at anatomical angles of 0°, 20°, 35°, 50°, and 65° degrees. The fixed design consisted of a 28/56mm inner diameter/outer diameter (Trident, Stryker Orthopaedics, Mahwah, NJ) acetabular hip insert that articulated against a 28mm CoCr femoral head (n=6). The mobile design consisted of a modular dual mobility hip (MDM, Stryker Orthopaedics, Mahwah, NJ) that incorporates a CoCr femoral head into an unconstrained polyethylene insert in size 28/48mm inner diameter/outer diameter that articulates against a 48mm CoCr liner, which is mechanically secured into a cementless acetabular shell (Trident, Stryker Orthopaedics, Mahwah, NJ) (n=6). The inserts for both bearing designs were made of sequentially crosslinked and irradiated polyethylene (SXL). The study was conducted dynamically using an MTS hip joint stimulator (MTS, Eden Prairie, MN). All components were oriented anatomically with load held constant at 2500N load level for at least two rotational cycles at the aforementioned angles. All 3 axes of load and all 2 axes of moments were measured at 10kHz using an ATI-IA load cell (ATI, Apex, NC) as shown in figure 1. This clinically relevant model has been published elsewhere (8). Component assemblies were lubricated using Alpha Calf Fraction serum (HyClone Labs, Logan Utah) diluted to 50% with a pH-balanced 20-miliMole solution of deionized water and EDTA (protein level approximately 20 grams/liter).

RESULTS:
A statistical difference was found only between the anatomical angles comparison of 0 vs 65 degrees in the mobile bearing design (p<0.05). In the fixed bearing design, a statistical difference was found between the anatomical angles comparison of 20 vs 35 degrees, 20 vs 50 degrees, and 35 vs 65 degrees (p<0.05). No anatomical angle effect on frictional torque between each respective angle or bearing design was identified (p>0.05). As illustrated on figure 2, frictional torque was found to decrease as a function of anatomical angle for the fixed bearing design ($R^2=0.7347$), while no difference on frictional torque as a function of anatomical angle was identified for the mobile bearing design ($R^2=0.0095$). It is important to note that the decrease in frictional torque as a function of anatomical angle for the fixed bearing may be due to reduction in contact area at steeper angles.

DISCUSSION:
The effect of bearing design and anatomical angles on frictional torque was investigated in this study. These results indicate that frictional torque for a 28mm femoral head is not affected by either anatomical angle or bearing design (p>0.05). This data suggests that mobile design, while similar to the 28mm fixed bearing, may provide lower frictional torque when compared to larger fixed bearings > or = 32mm [7,8]. Previous work by some of the authors [8] show that frictional torque increases as a function of femoral head size. Therefore, this option may afford surgeons the ability to achieve optimal hip range of motion and stability, while avoiding the reported complications associated with using larger fixed bearing heads (2,3,4,5,8). It is important to understand that frictional behavior in hip bearings may be highly sensitive to many factors such as bearing clearance, polyethylene thickness/stiffness, polyethylene thickness/design, contact area and host related factors, which may outweigh the effect of bearing design or cup abduction angle. These factors were not considered in this study. Further evaluation comparing larger fixed bearings and designs and the role of combined acetabular implant version is necessary to comprehensively determine the ultimate construct.

![Figure 1: Test set up](image1.png)
![Figure 2: Bearing design vs angle](image2.png)
SIGNIFICANCE:
Frictional torque is believed to contribute to aseptic loosening with larger bearings. The aim of this study is to provide results of frictional torque of a fixed and a mobile bearing at various anatomical angles.

References:
(3) Morrey, B., et al. Size of the Femoral Head and Acetabular Revision in Total Hip Replacement Arthroplasty. JBIS Vol 7-1A, No 1, January 1989