A NEW METHOD TO MEASURE IN VIVO HIP JOINT SEPARATION USING HOUGH TRANSFORM

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INTRODUCTION: Previous in vivo kinematic analyses on early post-operative hip joint replacements have determined that the femoral head slides supero-laterally from the acetabular cup in a metal-on-polyethylene (MOP) THA, but not in a metal-on-metal (MOM) THA. Follow up studies conducted at two and three years post-operative concluded that femoral sliding occurred in both MOP and MOM THA. In this study, a new method based on Generalized Hough Transform (GHT) [1] was developed and used to detect a geometric shape, which can be expressed parametrically, such as a circle or an ellipse. The input to the Hough Transform is an image that has been preprocessed by Canny edge detection [1]; the acetabular cup is represented as a half sphere, which will always project as a half circle. If a point lies on the circle, then the direction of the gradient at that location points to the center. This allows for the measurement of the center of the acetabular cup relative to the femoral head. Previous studies analyzed subjects under non weight-bearing conditions during the swing phase of gait and only at selected frames of the fluoroscopic video. This study analyzed subjects during the weight-beariing, stance-phase of gait to determine if the incidence of hip joint sliding varies based on articular surface material. The robustness of the GHT allowed for the analysis of every fluoroscopic image.

METHODS: Twenty-three subjects were analyzed in vivo using video fluoroscopy. Twenty subjects had a MOM THA and 3 subjects had a MOP THA. Video fluoroscopy data was gathered and processed using the proposed method of the GHT. Once the center of each component was found for a full video sequence, each was plotted, and the maximum separation points were determined.

RESULTS: During gait, femoral head sliding was observed in subjects having both MOM and MOP THA. Figure 2 and Figure 3 show fluoroscopy images with corresponding implant centers fit for subjects having a metal-on-polyethylene THA, and a metal-on-metal THA. But in general, the sliding noticed in MOM is much less than MOP. These are samples from the video sequence showing some of the maximum separations observed.

DISCUSSION: This study shows that sliding of the prosthetic femoral head in the acetabular component can occur during the weight-bearing portion of gait for MOP and MOM. It appears from our analysis that while the foot of the implanted leg remains on the ground the contra-lateral leg induces an anterior thrust that causes the acetabular cup to slide away from the femoral head. The findings of this study are preliminary results, which require further statistical analysis. Potential effects resulting from femoral head separation could include variations in polyethylene wear rates in MOP, unknown loading conditions and questionable hip stability. Multidirectional wear vectors or excessive loading may be created due to eccentric motion of the femoral head. This data may be of value in hip simulation studies to more consistently duplicate wear patterns observed in retrieved components and to assist in the understanding of the lubrication regimes and wear rates in THA designs.

Reference:

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