INTRODUCTION:

Major complications following total hip replacement that require revision, are implant loosening, dislocation, instability, fracture and infection. It is hypothesized that vibration, in the range of the resonance frequencies, may cause pain, bone degeneration and fracture. A further understanding of the physical response resulting from impact during femoral head sliding may lead to valuable insight pertaining to THA failure. Therefore, the first objective of this present study was to determine if frequencies propagating through the hip joint near resonant frequencies may lead to wear or loosening of the components.

Recently, studies also found that femoral head sliding, often referred to as hip separation, between the acetabulum cup and the femoral head does occur, which may also play a role in complications observed with THA today. Separation may be a major contributor to implant loosening and wear, but a further understanding of the effects of hip separation and the response of its occurrence has not yet been studied or determined. Therefore, the second objective of this study was to determine if a sound sensor, externally attached, could be used to correlate impact loading sounds with femoral head sliding in the acetabular cup.

METHODS:

Overall five subjects having press-fit THA with variable bearing surface interfaces: ceramic-on-ceramic, ceramic-on-polyethylene, metal-on-metal, metal-on-polyethylene and metal-on-metal with polyethylene inner layer are initially involved in the study. All the patients were judged as clinically successful (HHS> 90) and were analyzed under fluoroscopic surveillance while performing gait on a treadmill. Using a 3D to 2D registration technique the three-dimensional in vivo kinematics were obtained.

The impact of two objects leads to impulse loading conditions and excitation of natural frequencies. By executing a gait activity, an impulse may be generated if femoral head sliding leads to the impact of femoral head in acetabular component. For this reason, a sound sensor and two tri-axial accelerometers were attached to the greater trochanter and the pelvis. During impact, energy is dissipated through vibration. When a system undergoes free vibration, the system vibrates at its natural frequency. This condition can be used to find the in vivo natural frequencies of the human hip system. Additionally, the sound sensor attached to the hip joint was used to determine if sound could be correlated with the incidence of hip separation. Fluoroscopic videos were evaluated during stance and swing phases of gait. The kinematics obtained were used to determine if femoral head separation from the acetabular cup occurs and if the measured sound signal could correlated with the femoral head moving in the acetabular cup. The fluoroscopy video and the sensor measurements were synchronized, analyzed and compared during one full cycle of gait. The two accelerometers could also be used to determine in vivo transfer functions across the human hip joint.

RESULTS:

Early results revealed differences in kinematic patterns between the various bearing surfaces. The sound and accelerometer results for each patient group differed in magnitude and pattern. Interestingly, there was a distinct correlation of a high frequency sound occurring at the time of hip separation. As the femoral component impacted the acetabular cup, the sound sensor revealed a high frequency sound depicting impact conditions (Figures 2 and 3).

DISCUSSION AND CONCLUSION:

Few studies have been conducted evaluating various bearing surfaces for THA regarding in vivo kinematics. Even fewer studies are reported with respect to an in vivo assessment of frequencies across the hip joint and no studies have been conducted correlating hip separation with sensor measurement. The accelerometer and the sound transducer were used to examine bone frequencies and determine distinctive patterns during hip separation. The frequencies were consistent with previous research conducted under in vitro conditions, showing excitation at extreme femoral head movements. Also, most interesting was the impact sound that was heard at heel-strike, which correlated with the femoral head impacting the acetabular cup. Results from this study may give researchers and implant developers a better understanding of kinematics around the hip joint and how they vary with respect to different THA bearing materials. The comparison of the variable bearing surfaces will enable improvements in future implant development. Further analysis is being conducted on more subjects before definitive conclusion can be made.

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