In Vivo Sound and Separation Correlation of Different Bearing Surfaces

Diana A. Glaser¹, Harold E. Cates², Richard D. Komistek³, Douglas A. Dennis⁴, Mohamed R. Mahfouz¹, Fei Liu¹, Filip Leszko¹
¹Mechanical, Aerospace and Biomedical Engineering Department, University of Tennessee, Knoxville, TN; ²Tennessee Orthopaedics Clinic, Knoxville, TN; ³Colorado Joint Replacement, Denver, CO
dglaser@utk.edu

Introduction: Audible squeaking of hip replacements is an established and observed phenomenon reported as early as the 1950s. Squeaking is often associated with hard-on-hard bearing surfaces, though some noise of polyethylene bearings has also been previously reported. The causes and conditions of audible hips are not truly understood yet and no known studies have been able to correctly analyze the measured audible effects. Therefore, need of objective research on hip replacements regarding noise sources has become essential. The study objective was to correlate 3D hip kinematics and subsequent audible effects using a sensor device for subjects having a THA under in vivo conditions and to evaluate if separation might be a reason for the undesired sound.

Materials and Methods: Post-operative gait kinematics and the related sound of twenty subjects were analyzed under in vivo, weight-bearing conditions using video-fluoroscopy and sound measurement while performing gait on a treadmill (Figure 1).

Results: The highest separation magnitude was achieved by the M/P group and was on average 4.5mm, whereas the M/M-PS group achieved the lowest magnitude of separation with an average of 1.3mm of separation. For all patients, the sound signals were examined and compared to the kinematics findings. Interestingly, there was a distinct correlation of a high frequency sound occurring at the time when the femoral head slides back into the acetabular component (Figure 2).

Discussion: This is the first study to document and correlate visual effects with audible emission of THA under in vivo conditions. This study correlated three-dimensional THA kinematic data with sound under in vivo weight-bearing conditions. Variable audible signals were detected for the different bearing surfaces, leading to the assumption that the type of material could affect the attenuation of frequencies. Also, implant design and the pattern of sliding of the femoral head within the acetabular component could lead to frequency and sound variations. Sound and frequency identification under in vivo conditions for THA generates new possibilities for better understanding of wear and failure modes in THA.


Correlation of separation, sound and abduction/adduction for M/M-PS patient. HS: heel strike, TO: toe-off.

Subjects with M/P and C/P THA experienced femoral head sliding (separation) within the acetabular component. A “clicking” sound was detected when the femoral head impacted the polyethylene liner. Subjects with M/M or C/C THA also experienced femoral head sliding, but very different sounds were generated. C/C THA subjects experienced a “squeaking” sound that varied in magnitude, while subjects having a metal-on-metal THA exhibited a sound similar to a “rusty door hinge”. Squeaking and screeching sounds are possibly an outcome of a forced vibration which is induced by a driving force and results in dynamic response. The driving force can be associated with the impact following hip separation and the dynamic response may lay for some implants in audible frequencies of the human ear. For patients experiencing no separation no sound was detected. Only background sound was audible even with very high signal amplification. The spectral analysis of three distinct sounds is presented in Figure 3, showing frequency (vertical axis) excitation with respect to time (horizontal axis).

Spectral analysis for 3 distinct sound measurements. a: M/P with clicking sound, b: C/P background noise with no sound, c: M/M with “rusty door hinge” sound.