DISRUPTED LUBRICATION METHODOLOGY TO REPLICATE SQUEAKING ON CERAMIC ON CERAMIC HIP JOINT REPLACEMENTS

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Introduction and Method

Ceramic on ceramic (CoC) total hip replacement clinical reports may on occasion note a noise or squeaking. There is much debate on whether this is an actual concern, but some medical centres want to avoid any possible negative impact on the patients' wellbeing due to the noise generated [1]. The aim of this study is to determine factors influencing squeaking for CoC.

Three different diameters CoC (BIOLOX Delta) hip replacements (28, 32 and 36mm, PINNACLE, n=3 each) were tested with a customised method to increase the severity of edge loading [2] in an electromechanical simulator. Loading and flexion were applied as Figure 1, whereas the abduction was maintained at -15 degrees and the internal and external rotation kept at 0 degrees. Edge loading was applied via a translational mismatch [3]. Deionised water was used as lubricant. Medial-lateral displacement was measured using a linear variable displacement transformer. Testing was carried out until a squeaking could be heard. The sound was recorded (Zoom H4n) with a RODE NTG-2 microphone placed inside the equipment. The audio signals were analysed with MATLAB (MathWorks, USA) through a Fast Fourier Transform (FFT) function (Figure 2). Surface roughness was measured on an undamaged area (pole) and the wear scar area of the head with a Talysurf CCI3000. The ceramic liner profile was measured by a coordinate measuring machine (ZEISS PRISMO) to determine the rim distance from the top surface.

Results

Squeaking frequencies averaged to 2.2kHz, whereas, the frequencies with the highest amplitude averaged to 1.7kHz for all samples. The squeaking frequency range was as follows; for the 28mm, 1.0-5.2kHz, for the 32mm, 1.6-1.8kHz, and for the 36mm 1.2-5.1kHz. The mean cycles tested until squeaking was heard were as follows; 440, 1650 and 520 cycles for the 28, 32 and 36mm respectively. After squeaking was heard the testing was stopped.

Discussion

The profile developed in this study was designed to increase the severity of edge loading, that is to say, the duration and magnitude of loading under rim contact. The severity increased for all samples as the test continued (example in Figure 3). Squeaking was defined when the frequency was 1kHz or higher [4]. The occurrence of squeaking varied between the bearing size, where the 32mm bearing size took the longest for squeaking to occur. An important relationship of the bearing size in this study is the rim geometry. The rim geometry varied for each bearing diameter group. The 32mm had the shortest rim distance. A second important relationship for squeaking in this study is the damage created to the head due to edge loading. Edge loading increased the surface roughness and this in turn may increase the friction when in contact with the bearing or the rim section. The increased surface roughness (mean increase of 0.183µm) may play a role in the occurrence of squeaking and increased severity of edge loading due to the higher friction.

A new methodology was developed to determine the occurrence of squeaking under lubricated conditions and determine the ceramic liner design factors which influence the results.

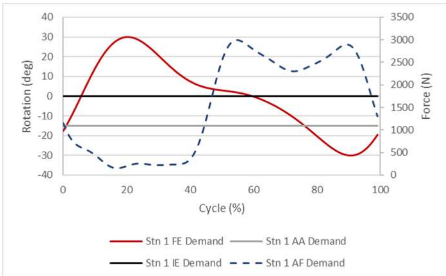

Figure 1: Input profile for disrupted lubrication methodology.

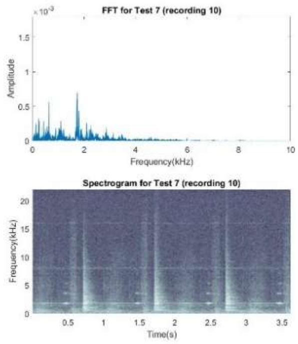

Figure 2: FFT analysis of in vitro CoC squeaking.

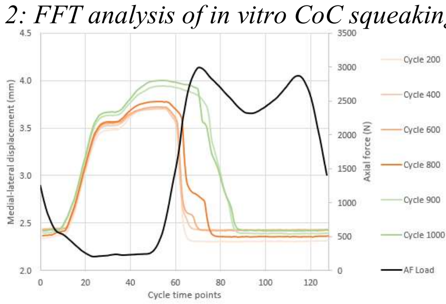

Figure 3: Medial-lateral displacement measurement for increasing cycles leading to increased severity of edge loading.

References

1. Barrow et al., 2019, EJOST 29, 1243–1251.
2. O'Dwyer Lancaster-Jones et al., 2017, J Biomed Mater Res Part B 2018: 106B: 1897– 1906.
3. ISO-14242-4 2018.
4. O'Dwyer Lancaster-Jones and Reddiough, 2023, JMBBM.