**In Vivo Evaluation of Edge-Loading during Functional Activities in Metal-on-Metal Hip Resurfacing Patients with Pseudotumours**

+1Kwon, Y.M.; +1Mellon, S.A.; +1Gill, H.S.; +1Murray, D.W
+1Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, United Kingdom
young-min.kwon@ndorms.ox.ac.uk

**Introduction:** Edge-loading, a phenomenon whereby the femoral component comes into contact with the edge of the acetabular component, has been suggested to increase wear in metal-on-metal hip resurfacing arthroplasty (MoMHRA). Despite the encouraging short-term clinical follow-up studies of MoMHRA, the recent reports of the occurrence of abnormal periprosthetic soft-tissue reactions (‘pseudotumours’) in patients with MoMHRA are causing concerns. These pseudotumours have been associated with elevated serum and hip aspirate metal ion levels. This study aimed to investigate in vivo edge-loading in MoMHRA patients with pseudotumours by quantifying dynamic loci of the hip joint segment force relative to the acetabular component during functional activities.

**Materials and Methods:** A total of 21 MoMHRA patients (30 hips) in two groups were investigated in this Institutional Review Board approved study: (1) 6 patients with pseudotumours detected using ultrasound/MRI; (2) 15 patients without pseudotumours. Three-dimensional lower limb motion analysis (12 camera Vicon Nexus Motion Analysis System) was performed to estimate hip joint segment force during level walking, chair-rising and stair-climbing. CT scans were used to determine each patient’s specific hip joint centre and acetabular component orientation. Edge-loading was defined to occur when a hip joint segment force vector/cup intersection (termed ‘force path’) was located within 10% of the cup radius from the edge of the cup (Figure 1). The inner bearing surface of the cup was thus divided into concentric zones, with the zone furthest from the centre of the cup designated as zone 1 (edge-loading zone). Serum cobalt and chromium levels in all patients were analysed using Inductively-Coupled Plasma Spectrometer. Inter-group comparisons of the zone duration and the force impulse variables between the patient groups were performed using the Student’s t-test. Inter-group comparisons of the non-normally distributed serum metal ion levels were performed using the Mann-Whitney non-parametric tests.

**Results:** Edge-loading in the pseudotumour group occurred with significantly (p=0.02) longer (4-fold increase) duration (Figure 2) as well as greater magnitude (7-fold increase) of force, compared to the non-pseudotumour group. The duration and force of the edge-loading were activity-dependent, with proportionally greater difference observed during stair climbing. The majority (16/21) of the acetabular cup inclination and anteversion values of the hips in the non-pseudotumour group was found within the safe zone of Lewinnek. On the contrary, the cup orientation values in the pseudotumour group were found within the safe zone in one third (3/9) of the hips with the remaining two thirds (6/9) outside the safe zone.

**Discussion:** Edge-loading (defined as the force path occurring at a distance less than 10% of the cup face radius from the acetabular component edge) in MoMHRA patients with pseudotumours occurred in vivo with significantly longer duration and greater magnitude of force impulse compared to the patients with a well functioning MoMHRA during activities of daily living. This suggests that edge-loading may be an important mechanism that leads to localised high wear, with subsequent elevation of metal ion levels in MoMHRA patients with pseudotumours. Although the acetabular component malposition, such as increase in both inclination and anteversion angles, appears to be an important factor in edge-loading, the aetiology of edge-loading is likely to be multi-factorial. Further research is required to elucidate the relative importance of implant, patient, and surgical factors that lead to edge-loading in order to minimise the occurrence of such an adverse clinical outcome and to ensure long-term implant survivorship in young and active patients.

**Acknowledgements:** The authors thank Ms. Jo Copp and Mrs. Barbara Marks for their kind help in data collection.

**Figure 1:** Force paths projected on the acetabular cup viewed in the direction that is through the centre of the cup. In patient A (shown in blue), the force path does not enter the outer most radial zone (zone 1), thus no edge-loading is observed. In patient B (shown in red), the force path enters the outer most radial zone (zone 1), indicating edge-loading. The black circles (●) indicate force path at heelstrike and the black triangles (▲) indicate force path locus at toe-off.

**Figure 2:** Distribution of zone duration (the percentage of total stance time spent by the force path in each zone) during functional activities: walking (a), stair climbing (b), and rising from a chair (c). Zone 1 is defined as the edge-loading zone. The error bars represent standard errors of mean. Asterisk (*) indicates significant difference between the two MoMHRA patient groups.