INTRODUCTION
The design philosophy of polished tapered THR stems, such as the Exeter (Stryker Howmedica Osteonics, Newbury, UK), intend for them to migrate distally within the cement mantle. In addition it is likely that micromotion occurs as a result of functional activity. The pattern of induced stresses will be a function of stem geometry & surface finish, as well as applied loading. If dynamically induced micromotion (DIMM) occurs and can be measured, it will be a result of loading, and not be complicated with re-modeling effects. Understanding the effects of loading on the stem/cement construct is an important step in developing models capable of predicting failure of new devices. The present study aims were to develop a means of measuring DIMM in vivo for the Exeter stem and use these results to develop and validate finite element (FE) models that can predict the mechanical stress environment in the implant/cement construct.

METHODS
Using Roentgen Stereophotogrammetric Analysis (RSA) dynamically induced micro-motion (DIMM) was measured in 21 patients. In all procedures, a posterior approach to the hip was used, and standard Exeter femoral components were implanted with centralisers, using CMW 3G cement (DePuy International Ltd, Leeds, UK); third generation cementing techniques were used. All patients received an Elite cup (DePuy International Ltd, Leeds, UK). 0.8mm diameter tantalum marker balls were placed in standardized positions in the femur[1] implanted with Exeter stems.

RSA measurements using an enclosing hip calibration cage[1] were performed 3 months post-operatively. DIMM was measured as the difference in stem position in going from double to single leg stance on the operated limb. The study had full ethical approval.

A finite element (FE) model of the femur, including all muscles[2,3] was used to investigate the stress distribution within the cement. The model was modified to include a standard femoral resection and a femoral canal based on the geometry of the final rasp. The cement mantle included a void at the tip which represented the centraliser of the Exeter system. The stem was modeled with ten node tetrahedral elements, contact between stem and cement was modeled with sliding elements allowing separation. In the first instance the loads placed on the implant were derived from the work of Bergman[4] and Duda[5]. The model was validated by comparison to the DIMM measurements.

RESULTS
Significant dynamically inducible micromotion of the implant was seen at 3 months (Table 1) in all subjects. At 3 months the head moved 0.05mm inferiorly (p<0.05) and 0.09mm medially (p<0.05) on moving from DLS to SLS. The head also moved 0.08mm posteriorly (p<0.05). The tip moved 0.22mm anteriorly (p<0.01), but showed no significant inferior or A-P micromotion.

The FE model, with sliding contacts was able to predict similar distal migration of the head. The peak minimum principal stress in the mantle was approx 33MPa and occurred in the proximal medial region. Movements occurred at the model’s stem/cement interface.

<table>
<thead>
<tr>
<th></th>
<th>A-P (mm)</th>
<th>Med-Lat (mm)</th>
<th>Distal (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>-0.08</td>
<td>0.09</td>
<td>0.05</td>
</tr>
<tr>
<td>Tip</td>
<td>0.22</td>
<td>-0.10</td>
<td>0.0</td>
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Table 1: 3 month DIMM measurements

DISCUSSION
It is possible to measure DIMM in the Exeter stem and combining this with FE modeling the mechanism of stress transfer between the stem and mantle can be investigated in a manner that can be validated. With this method cemented THR stems can be analyzed, allowing optimal stress transfer designs to be developed. The analysis provides an insight into the mechanism of de-bonding.

REFERENCES