Introduction:
The stresses and strains in the proximal femur after total hip arthroplasty (THA) are influenced by implant geometry as well as the implant materials properties. The importance of the bone remodelling resulting from the produced stress and strain distribution has obvious implications for long-term implant stability. Clinical success of polished double tapered stems and subsidence have been reported [1]. A 3rd taper in the lateromedial term implant stability. Clinical success of polished double tapered stems and subsidence have been reported [1]. A 3rd taper in the lateromedial plane may provide additional stability and load transmission and has been incorporated in a recent design. There are, however, no publications to date examining the relative stability of double and triple tapered stems in a composite femur (Pacific Coast Sawbones, USA) FE model.

Methods:
The geometry of a polished double tapered (Exeter, Howmedica, NJ) and a triple tapered stem (Cstem, DePuy International, UK) were scanned using a 3D technique (Dr. Picza, Roland Digital Group, Japan). Two FE models of the stems (Figure 1(a& b)). in a composite femur were created using the PATRAN (V8.5) pre-processing software (MSC, Los Angeles, CA). The models were tested under varying contact and friction conditions. The composite femur was constructed of a cortical shell (E = 17GPa and ν = 0.3) filled with cement (E = 2.2 GPa and ν = 0.35). The stems were assigned identical materials properties (E = 200GPa and ν = 0.3) and the coefficient of friction set to 0.25 [1]. The models were analysed using the ABAQUS software package (HKS, Rhode Island).

A variety of bone / cement interface conditions were tested. The difference in stress and strain environment was considered with the surfaces tied together with no relative surface motion allowed. The surfaces were then allowed to slide and interface micromotion examined under ISO 7206-4 orientation and single legged stance (820N head force load at 10° adduction and 10° flexion) loading. In addition, the contact interface local to the distal tip of the stem was removed to form a distal centraliser present (ie no cement plug). The cement / bone interface was assumed to be bonded throughout and the models were constrained at the base.

Results:
When tied contact was assumed, both stems displayed similar Von Mises stress distributions along the length of the shaft with peaks of 87MPa and 72MPa for the triple and double tapered implants respectively. Upon the introduction of sliding contact conditions, the peak stresses remained constant in the double tapered stem, with a marked translation of regions of high stress towards the distal tip. Peak stresses in the triple tapered stem decreased to 82MPa, but displayed a more continuous contour distribution along the length of the implant. The associated cement stresses showed proximal values of 16MPa in the double tapered stem and 11MPa in the triple tapered implant. Torsional loading of the stems reduced the magnitude of the distal tip stresses. Opening of the contact surfaces occurred to a much greater degree in the triple taper stem. The relative sliding distances are presented in table 1 with a cement plug and with a simulated distal centraliser.

<table>
<thead>
<tr>
<th>Contact Condition</th>
<th>Sliding distance (mm)</th>
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<tbody>
<tr>
<td>Cement Plug</td>
<td>Distal Centraliser</td>
</tr>
<tr>
<td>Triple Tapered Stem</td>
<td>0.05</td>
</tr>
<tr>
<td>Double Tapered Stem</td>
<td>0.19</td>
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</tbody>
</table>

Table 1: Relative surface sliding distances

Discussion:
Since the two stems are compared directly within the same composite femur model, the results highlight the differences in the stems due to their intrinsic geometry.

Larger values of interface slip have been reported in the literature for the double tapered design of implant [1] and may be attributed to these changes in geometry. Under the conditions presented here, it is possible that the cement mantle thickness may differ and mediate the applied loading and form a more continuous smooth layer for distribution of the stresses along the entire length of the stems. The result of this may be that a more continuous support may reduce the magnitude of the interfacial slip and also the peak stem stresses when sliding contact is incorporated. In addition, the analysis does not take into account any form of material creep (time-dependent) or failure properties. All conditions reported were entirely within the elastic regions of the material properties modelled.

The relatively large opening of the contact surfaces on the posterolateral surface of the triple tapered stem was most likely a function of the difference in neck angle. The addition of the 3rd taper appears to provide additional axial and torsional stability along with a more even stress distribution compared to the double taper.

Literature cited