Coronal Plane Measurement Of Patella Tracking Following Knee Replacement: A Novel Use Of Ultrasound and Motion Capture
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Introduction
Total knee replacement (TKR) is the standard treatment for end-stage osteoarthritis when conservative measures have failed. Previous attempts to study coronal plane patellofemoral kinematics have suffered from the patella being obscured by the components and/or metal artefact (1,2). The aims of this study were:
1) To develop an accurate and reliable technique to measure patellofemoral kinematics.
2) To assess whether there was any significant difference in the coronal plane patellofemoral kinematics between normal and replaced knees using ultrasound in combination with a motion capture laboratory.

Method
A 12 camera Motion Capture System was used to capture images of markers mounted on subjects’ lower limbs and an ultrasound probe. A mapping between the ultrasound image and the motion capture system was established. Thus, the ultrasound could be used to determine the locations of the patella and bony landmarks on tibial and femoral segments, during a squat exercise.

The accuracy of the technique was measured in terms of Vicon Residual (calculated as a residual error of all 12 cameras), Systematic Error (accuracy of the calibration) and Measurement Error (human error, intra-observer error). Inter-observer error was calculated using two operators on 10 observations.

For this pilot study, patients were recruited into two groups; normal healthy volunteers (Normal), and TKR patients (TKR). Measurements were taken during a squat exercise.

At each flexion angle, patellofemoral kinematics were measured relative to both the femur and tibia in 6 degrees of freedom.

Results
The accuracy of the motion capture system was ±0.29 mm. The accuracy of this technique registering the ultrasound images within the motion capture system was 2.54mm (Table 1). Mean inter-observer variability was 1.77 mm. Preliminary data shows medio-lateral movement of the patella during flexion was greater for the normal group, 10.09 mm than for the TKR group 1.12 mm (Figure 1).
Similarly, when compared with normal subjects, the TKR group showed reduced ranges of the following patella kinematic variables: Patella Tendon angle; 4° vs 11°, Patella Flexion; 3° vs 8°, TILT; 2° vs 10° and SPIN; 7° vs 13°.

Discussion
We present a new, accurate, reliable in vivo technique for measuring 6 degrees of freedom patellofemoral kinematics by combining ultrasound and motion analysis. The overall error is 2.54mm. These preliminary results suggest that coronal plane kinematics of the patella after TKR are considerably altered in comparison to normal.

Acknowledgements
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References

Table 1. Showing significance of measured variables to radiological instability

<table>
<thead>
<tr>
<th>Type of Error</th>
<th>Value (mm)</th>
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<tbody>
<tr>
<td>Vicon Residual</td>
<td>0.29</td>
</tr>
<tr>
<td>Systematic</td>
<td>0.52</td>
</tr>
<tr>
<td>Measurement</td>
<td>2.54</td>
</tr>
<tr>
<td>Maximum error</td>
<td>2.54</td>
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Figure 1 – Showing technique for assessing positions of the leg and probe (providing position of bony landmarks and patella)

Figure 2 - Graph showing mediolateral displacements of the patella.

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