ABSTRACT INTRODUCTION:
Poor glenoid component stability is one of the major complications in reverse shoulder replacement, potentially leading to pain, dislocation and the need for revision surgery [1]. Micromotion from 28 to 150 micrometers at the interface between the glenosphere and the bone has been shown to inhibit bone ingrowth [2,3]. Therefore, minimizing micromotion at the time of initial fixation should lead to a better surgical outcome. The current best practice for implant primary stability testing consists in measuring micromotion at the interface between a bone surrogate and the implant using a displacement gauge after a preconditioning with cyclical loading. However such gauges can measure displacement along one axis only, and cannot differentiate micromotion at the interface from deformation of the test setup. The objectives of this study were twofold. First we assessed if high resolution, telecentric digital imaging could lead to a more precise determination of micromotion at the bone-prosthesis interface. Second, we performed a digital image analysis of micromotion of three popular reverse implant designs.

METHODS:
The standard in vitro method for glenoid implant stability testing [4,5] was implemented (Figure 1). The glenoid components of a Delta III and Delta Xtend Reverse prostheses (Depuy Orthopaedics, Inc. Warsaw, IN), and a Zimmer Anatomical Shoulder™ Inverse / Reverse prosthesis (Zimmer, Warsaw, IN) were implanted according to manufacturer guidelines, each into six Sawbones 15pcf polyurethane blocks (Pacific Research Laboratories, Inc. Vashon, WA) mimicking trabecular bone density. A compressive load of 700N was maintained and a vertical shear load of 700N was applied for 1000 cycles. Micromotion between the baseplate and the sawbone was quantified by means of a displacement gauge. In addition to the gauge method, we performed a digital image analysis of micromotion at the implant/block interface using high resolution video cameras (Basler A622F, Basler Vision Technologies AG, Ahrensburg, Germany) mounted with telecentric lenses (Zeiss Visionmes, Carl Zeiss AG, Jena, Germany) positioned perpendicular to the implant/block interface.

RESULTS SECTION:
Displacement gauges and digital images both have a similar accuracy (10 micrometers). With the displacement gauge, typically reported micromotions (above 100 microns) were measured. In contrast, statistically significant (p<0.001) lower values of micromotion were detected in all three image analysis locations (Figure 2). The Delta IV implant indicated significantly less micromotion than the other implants (p<0.05), but with increased susceptibility to dislocation under shear load (results not shown).

DISCUSSION:
In contrast to previous reports, this study demonstrates that the tested prostheses were more stable in vitro biomechanical testing. Studies that assess motion of the baseplate using gauges instead of relative motions at the interface confound elastic deformation of the testing system with the intended micromotion measurement. This artefact can be avoided with a direct image analysis of relative motion at the implant-bone interface. Further, while gauge measurements can characterize motion along one axis only, image analysis allows assessment of displacements in 2D (shear and rocking). Therefore, we strongly advise the use of digital imaging to appropriately measure micromotion, and recommend that new standards be developed for in vitro assessment of primary stability.

REFERENCES: