INTRODUCTION:
The sliding hip screw is the implant of choice for the treatment of stable pertrochanteric femoral fractures. The current “gold standard” uses a four-hole side plate with four bicortical screws perpendicular to the plate to allow full weight bearing immediately after operation. Fracture at the distal end of the plate is also a potential site for failure as a result of the stress concentration that occurs at this point with this particular construct. The stress concentration that occurs at the distal end of the plate is evidenced by bone remodelling. Insertion of oblique screws at the ends of standard lateral plates was indicated to improve the fixation strength in a pullout construct [1].

The aims of this study are (a) to determine the effect of angling the distal screw obliquely on a two-hole and five-hole plate using finite element analysis (FEA) (b) to determine the stress occurring at the distal end of the plate.

METHODS:
A three-dimensional finite element model (FEM) of a femur was developed from computed tomography (CT) images of a cadaveric hip. Two models of the sliding hip screw were modeled: a two-hole and a five-hole model with a laterally side plate with 4.5mm bicortical screws on the superior half of the femur. The distal most screw for each model was angled in three different inclination angles (1) perpendicular to plate (straight or 0 degree) and obliquely inclined to the longitudinal axis of the plate (29 degrees and 45 degrees). The models were meshed with second order modified tetrahedral elements using MSC Patran (MSC Software, Santa Ana, CA, USA). The femur was assigned isotropic, linear-elastic material properties calculated using Hounsfield Unit values from the CT images with apparent bone density of 0.1-2.0g/cm³. The plate, hip screw and cortical screws were assigned the material properties of stainless steel (E=200GPa). Bone-screw interfaces were fully bonded while the bone-plate and osteotomy interfaces were surface contact with a friction coefficient of μ=0.9. The hip screw and barrel interface was modelled as frictionless sliding contact. The cortical screws were pre-tensioned to replicate the tightening torque during screw insertion. The FE model was loaded under peak walking load as studied by Heller et al.[2]. The muscle attachments were modelled similar to that normally occurring during surgery, including the muscles located beneath the plate which are usually split but left unsutured.

RESULTS:
The results from the FEA model were analysed, including the stresses in the bone at the end of the plate, the contact pressure along the whole plate length and the model and the stresses in the cortical screws. The two-hole model showed increasing tensile stress of the bone at the plate end while the five-hole model showed a reduction in tensile stress as the inclination angle of the distal cortical screw increased (Figure 1). The tensile stress at the plate end of the two and five-hole models both showed a significant difference in an obliquely inclined screw (29 degrees and 45 degrees) compared to a straight, perpendicular screw (0 degree) (p<0.05) (Figure 2).

The stress measured in the distal screw at the plate end showed a cyclical change from tensile to compression compared to the other proximal cortical screws. The more oblique distal screws (29 and 45 degrees) showed less fluctuation from tensile to compression and vice versa than the straight screw at 0 degree.

DISCUSSION:
The sliding hip screw is frequently chosen to treat a trochanteric femoral fracture due to ease of use, load sharing capacities and relatively low incidence of failure [3, 4]. The orientation of the distal most cortical screw is important for a stable fixation system and also to prevent further fracture of a trochanteric hip fracture. The oblique distal screw at 29 or 45 degrees at the end plate provided a longer effective screw length which engages into the bone and increases the pullout resistance and subsequently the fixation strength.

Previous studies based on cadaveric testing and clinical studies were varied in determining the optimal number of screws and the effective plate length to be used; ranging from two holes to a minimum of four holes [1, 3, 4, 5]. The mechanical and clinical benefits of two-hole versus multi-holed plates should aim to achieve fracture stabilization that would improve the healing process and minimizing the risk of fracture at the end of the plate. While the clinical advantages of using a short plate include shorter operating time and reduction of blood loss in a less invasive procedure [4], the overall stability of a longer plate (and more screws) confers the necessary long term integrity for the fixation system.

REFERENCES: