The Keel plays a role in Periprosthetic Fractures of the Tibial Component in Cementless Unicompartmental Knee Replacement (UKR)

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INTRODUCTION:

In cementless UKR, primary fixation of the tibial component is achieved by press-fitting a keel (i.e. with interference) into a vertical slot cut into the proximal tibia. While the fixation of the keel into the tibial slot is essential to prevent implant loosening, it may also reduce the structural integrity of the proximal tibia, increasing the risk of peri-prosthetic fractures. Such fractures are rare in the western population (<1%), but relatively more common Asian populations (4-8%). The risk of fracture has been found to be 7 times more likely in very small tibias which receive the very small tibial components (Size AA and A), components which are not usually used in western populations [5]. Despite these correlations, the mechanical and physiological processes underlying peri-prosthetic stress fractures are not known. This study explores the effect of keel-related features in fracture risk of these very small tibias.

METHODS:

This *in-vitro* study compares the effect of keel and slot depth (standard vs 33% shallower vs no slot) and loading position (anterior/posterior gait range limits: mid-tibia vs 8mm posterior to midline) on fracture load and path. 3D-printed titanium tibial components were implanted in bone-analogue foam machined to a CT-reconstructed very small tibia which subsequently experienced a peri-prosthetic fracture. Implantation was performed using surgical instrumentation and technique. Implants were loaded to failure using a materials testing machine. Loads to fracture, and consequent bone fracture paths, were assessed.

RESULTS:

Introducing a standard slot reduces load to fracture by 50% (1421N vs 710N, $p<0.0001$). Press-fitting a standard keel into this slot further reduces load to fracture by 40% (710N vs 423N, $p=0.0001$). A shallower keel inserted into a shallower slot increases load to fracture substantially (shallow vs standard slot: 27% increase, 904N vs 710N $p=0.0003$, standard vs shallow slot+keel: 60% increase, 683N vs 423N $p=0.0004$). Standard-sized keel resulted in significantly more vertical fractures (standard 8.2° vs shallow 15.5° vs no keel 21°, degrees-to-vertical, $p<0.0001$). These vertical fractures are consistent with fracture patterns seen clinically. There was a small but significant difference in fracture load between loading positions with no keel (13% lower, central 1422N vs posterior 1231N, $p=0.0038$), but this significance was lost when standard (11% lower, 423N vs 376N, $p=0.330$) and shallow (9% lower, 684N vs 624N, $p=0.635$) keels were inserted.

DISCUSSION AND CONCLUSION:

This study finds that the cementless tibial component keels contribute to peri-prosthetic tibial fractures: making a keel slot, and inserting a keel, both reduce the load needed to induce a fracture. These fractures also follow the path of the keel. As fractures are more common with very small tibial components (size A or AA), surgeons may wish to consider cementing these as this decreases the fracture risk. Smaller keel variants of these components may also decrease the fracture risk. In general, surgeons implanting cementless UKR tibias should avoid oversizing tibial components. They should also ensure keel slot is neither too long, by preventing the template from moving, nor too narrow, by ensuring a trial component can be inserted with finger pressure. Postoperatively, patients should be advised to avoid motions resulting in excess posterior loading (e.g. deep lunges) in the period prior to bone remodelling.