Introduction: The treatment of osteoarthritis in the young, active patient still poses a difficult problem, as conventional arthroplasty does not provide a life long solution. An alternative type of joint replacement is hemiarthroplasty, which preserves more bone stock for potential revisions and is thus more suited to the younger patient. Clinical studies have shown that although hemiarthroplasties have a variable rate of success, erosion of the opposing articular cartilage (AC) is a considerable late complication [1-3]. The tribological regime in both healthy synovial joints and those replaced with spacers is very complex. The mechanisms of AC degradation are not completely understood. The aim of this study was to investigate the effects of contact stress on spacer implants, using a tribological simulation of the medial compartment of a bovine knee. A pendulum friction simulator was used to apply physiological loads and motions to the natural knee.

Materials and Methods: Medial condyle preparation: Saggital sections (15-20mm wide) were dissected from bovine femoral condyles, 24-48 hours after slaughter. The bone was cut into a wedge shape, and the condyles were potted with PMMA bone cement in jigs for the simulator. Tibial counterface preparation: For a control group the medial side of tibial surfaces were dissected from bovine tibia and articulated against their corresponding femoral condyle. The meniscus remained in position, with its attachments to the tibia intact. PMMA bone cement was used to maintain position and give additional support. For the hemiarthroplasty simulations a smooth stainless steel (SS) plate was attached to the tibial specimen holder. Experimental set-up: A pendulum friction simulator (Simulation Solutions, UK) was used to apply physiological loading and motion to the bovine condyles articulating against bovine tibia controls (AC-AC) or SS (AC-SS). Tests were performed in 25% (v/v) bovine serum in saline. The loading and motion profiles (derived from BS 14243-3:2004), were adjusted to allow for the lack of lateral condyle and soft tissue support. A dynamic load was applied and the motion amplitude was between -10° and 13° with a frequency of 1Hz. The coefficient of friction (μ) was measured through a piezo-electric transducer. Contact stresses (CS) were measured using pressure sensitive Fuji Film. Surface roughness and geometry of the worn specimens were measured using a Form Talysurf profilometer (Taylor Hobson, UK). Initial experiments were performed for 3600 cycles with a peak load (PL) of 1036N. A similar experiment was performed at lower load (PL=259N). A third investigation looked at the influence of CS by increasing the PL. These dynamic loads ranged from a maximum PL of 259N to 1.5kN. AC-AC was tested at the lowest and highest loads as a control. It was found that the damage on the AC articulating with the SS plate increased with load and CS, from mild surface fibrillation at PL=259N to complete failure of the AC through to the bone at high PL=1295N and PL=1550N. CS ranged between 8.9MPa and 31.3MPa. The AC from the AC-AC controls remained intact throughout the test and functioned without wear, at CS<7MPa.

Results: When femoral condyles were tested against SS plate (PL=1036N) the AC failed catastrophically through to the underlying bone. However, using the same load there was no damage visible on the AC surfaces when testing AC-AC (Fig 1). In order to determine if the CS was causing the AC deterioration, the load and thus CS were varied. Following the failure of the AC-SS the same experiment was carried out at a lower load (PL=259N). In this experiment the AC sustained the load for 3600 cycles, with only mild surface fibrillation after the experiment. The μ for the AC-SS experiment ranged between 0.06 and 0.11, increasing throughout the test. These results indicate that CS was a contributory factor in the destruction of AC. The reduced μ found for AC-AC at low load is shown in fig 1. The average surface roughness (Ra) of AC articulating against SS increased from 0.96μm before the test to 5.15μm after. There was no change in Ra for AC-AC for either load condition.

Acknowledgements: EPSRC and DePuy International