Introduction:
Multi-axial knee simulators are commonly used to evaluate the durability of new designs and materials in total knee replacement. However, significant doubt exists as to whether the modes of surface damage generated by this form of pre-clinical testing truly match those seen in vivo. This has led to increased interest in the interpretation and analysis of the damage modes observed in retrieved tibial inserts. In this study, we demonstrate the occurrence of a new mechanism of extra-articular damage to the polyethylene bearing surface which appears to have been overlooked in previous studies.

Materials and Methods:
148 tibial components (104 cemented, 44 uncemented) of 24 different designs were examined after intra-operative retrieval following an average of 51 months in situ (range: 0 – 180 months). The articulating surface was examined for the presence of any indications of damage, classified as abrasion, creep, burnishing, delamination, scratching, and pitting. Digital images of the articular surface of each insert were recorded (Figure 1). In approximately one third of components, a zone of severe, localized abrasion was observed at sites immediately adjoining the edges of the bearing surface. In each of these cases, the location of each abrasive wear scar was recorded and its surface area was measured using image analysis software.

Results:
All abrasive wear scars were located beyond the areas of articulation of each tibial insert, as indicated by areas of the other damage modes, principally burnishing and scratching. Significant abrasive scars were observed in 32% (33/104) of retrievals with cemented femoral components and 9% (4/44) from non-cemented components (p<0.01). Of the retrievals exhibiting this abrasive wear mode, 38% experienced multiple site damage. The area of damage for each abrasive scar varied widely, averaging 78±68mm². Within the group of worn inserts, the majority of abrasive scars (70%) were located along the extreme medial edge of the bearing surface, with less frequent occurrence laterally (16%), posterior/medially (30%), and posterior/laterally (19%). In abraded posterior stabilized components with an open femoral box design (13/37), scarring of the superior surface of the tibial post was also observed (5/13).

We hypothesize that the most common source of this mode of surface damage is localized contact between acrylic cement left protruding from the edges of the femoral component intraoperatively. This hypothesis was confirmed by examination of several (n=8) retrieved femoral components containing either fixed cement protruding from the posterior condyles or from the medial and lateral edges (Figure 2). In one additional uncemented case, localized abrasion occurred through impingement of osteophytes embedded in the posterior capsule (Figure 3). The corresponding inserts exhibited significant abrasive scarring at those locations. In many cases, impingement of cement on the bearing surface could only be replicated if some degree of condylar lift-off occurred, presumably secondary to excessive joint laxity and/or soft-tissue imbalance.

Discussion:
We have observed a previously unrecognized source of polyethylene damage resulting in gouging, abrasion and severe localized damage in cemented and uncemented total knee replacements. Our observations show that acrylic cement, in bulk or particulate form, often contributes to severe damage of the tibial surface. Improvements to instruments and cementing techniques need to be developed to prevent this wear mechanism.

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Figure 1. Locations of observed extra-articular abrasion with examples of medial edge, lateral edge and proximal/lateral spine edge damage.

Figure 2. Extra-articular abrasion of a retrieved cemented TKA (left panel). Same components with residual bulk cement overhanging the medial edge of the femoral component (right panel).

Figure 3. Extra-articular abrasion located on the posterior/lateral edge of the insert of a retrieved uncemented TKA (left panel). Radiograph of retrieved femoral component and distal femur from same patient with osteophyte in the posterior capsule.

Figure 4. SEM images of shredded, gouged polyethylene due to abrasion from residual polymethylmethacrylate.