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Autonomous Reconstruction of TKR Tibial Inserts to Measure Wear

Total knee replacement (TKR) is an increasingly common orthopedic surgery to reduce pain and restore mobility to a gradually younger and more active patient population. However, wear of the polyethylene tibial component resulting in periprosthetic osteolysis remains a primary cause of device failure. Measurement of wear in surgically retrieved components is challenging because the original surface is not available. The purpose of this study was to develop and validate a method of calculating the volume loss on the articulating surface of a cruciate ligament retaining tibial insert. It was hypothesized that the developed method would be less accurate than estimation either by computer-aided design (CAD) model or by size-matched unused inserts but would correlate strongly to gravimetric measurements. Three unworn inserts were digitized, and points were removed to simulate worn regions. An autonomous reconstruction method, in which design-congruent curves were least-squares fit to the unworn regions, allowed for the interpolation of the original surfaces in worn regions. Seven inserts worn in knee simulator testing were also digitized. Volume loss was calculated using autonomous reconstruction and compared to measured mass loss. For a 707 mm^2 simulated worn area on unworn inserts, the volume difference for autonomous reconstruction (9.85±6.78 mm^3) was significantly less than that for CAD estimation (28.89±8.27 mm^3, p=0.001) and not significantly different than that for size-matched unused insert estimation (8.89±7.69 mm^3, p=0.82). Geometric volume loss on the simulator inserts correlated linearly to gravimetric wear (R^2=0.94) with a regression slope near unity (m=1.38±0.15, p=0.06.) The results of this study indicate that autonomous reconstruction can be used to accurately measure wear when the original surface of an insert is not available, as with *ex vivo* implants. Geometric measurement can analyze the spatial distribution of wear, which provides insight and new metrics to the *in vivo* wear process of TKRs.