Total knee arthroplasty (TKA) restores joint function through articulation between a metallic femoral component and a polyethylene tibial insert. Polyethylene wear accounts for ~15% of long-term TKA failures, yet metallic femoral wear is less studied. Surface topography enables quantitative assessment of three-dimensional surface features. This study characterizes femoral wear at tibiofemoral contact regions by comparing surface texture across regional components (apex versus edge).

Seven cadaveric femurs were scanned with a Sensofar Neox 3D optical profilometer at 20× magnification. Two rows of 877 × 660 μm scans were collected across each condyle at 45° of flexion and full extension. 70+ surface texture parameters—including root mean squared height (Sq), maximum peak height (Sp), maximum pit depth (Sv), auto-correlation length (Sal), and Sdq (root mean square gradient) —were extracted. Independent two-sided t-tests were used for statistical comparisons.

Visual inspection revealed anterior–posterior scratches along articular surfaces. Significant differences ($p<0.05$) in roughness parameters between apex and edge regions, respectively, were observed— Sq (0.73 ±0.26 μm; 0.15 ±9.5e-3 μm; $p=0.036$), Sp (13.92 ±2.53 μm; 5.73 ±1.51 μm; $p=0.007$), Sv (12.11 ±1.98 μm; 4.89 ±0.25 μm; $p<0.001$), Sal (88.94 ±1.88 μm; 96.80 ±1.51 μm; $p=0.001$), and Sdq (0.82 ±0.33; 5.6e-2 ±1.2e-2; $p=0.027$).

These findings demonstrate that femoral component surface wear strongly differs between apex and edge regions, reflecting distinct metallic–polyethylene contact mechanics and load bearing regimes. Variations in texture features are suggestive of differences in regional load within the prosthetic joint that may contribute to localized polyethylene wear and long-term implant degradation. Characterizing femoral surface changes can improve understanding of prosthetic wear mechanisms and improve implant design, alignment, and postoperative performance.