Do Patient and Implant Factors Influence Wear in Unicompartmental Knee Arthroplasty? A Retrieval Study

[1]Carolina S. Haboba Nebel MS, [1]Ajay S. Potluri BS, [1]Aditya S. Yadav MS, [1]Anne Debenedetti MS, [1]Spencer Schulte MD, [1]Jennifer L. Wright, [1]Deborah J. Hall, [1]Robin Pourzal PhD, [1]Craig Della Valle MD
[1]Rush University Medical Center, Department of Orthopedic Surgery, Chicago, IL
Email of presenting author: carolina_habobanebel@rush.edu

DISCLOSURES: Haboba Nebel (N), Potluri (N), Yadav (N), Debenedetti (N), Schulte (N), Wright (N), Hall (N), Pourzal (2-CeramTec, 5-Stryker, 6-Zimmer-Biomet, Enovis), Della Valle (1-Zimmer-Biomet; 3B-Zimmer-Biomet, DePuy; 8-Orthopaedics Today; 9-Knee Society, MAOA)

INTRODUCTION: Unicompartmental (UNI) knee arthroplasty (UKA) is a vital option for patients with arthritis limited to a single compartment of the knee, when conservative treatments have failed, and the patient has intact ligaments and no significant knee stiffness or inflammation. UKA is often considered for younger, more active patients to preserve more of their natural knee function, allowing for faster recovery, and, if needed, conversion to a total knee arthroplasty (TKA) at a later time. UKA relies on the same bearing materials as TKA, with a polyethylene (PE) or highly-crosslinked PE tibial bearing on either the medial or lateral side, and a CoCrMo alloy femoral component. Wear particles generated at the PE bearing surface may contribute to local inflammation and loosening of the implant. The objective of this study was to determine whether patient- and implant-related factors influence the location and size of polyethylene wear scars in retrieved unicompartmental knee arthroplasty (UKA) liners. We hypothesized that sex, body mass index (BMI), manufacturer, prosthesis model, and time in situ would affect both wear scar area and displacement of the wear scar centroid relative to the articular surface centroid.

METHODS: Retrieved polyethylene liners with low conformity from patients with primary UKAs undergoing revision from 2006–2024 at a single large academic referral center were collected. Liners that were grossly fractured or damaged during removal were excluded. Left knees were normalized to right orientation, and medial and lateral inserts were analyzed separately. Patient and surgical information was collected. Wear scar and articular surface areas and centroids were quantified using ImageJ, an open-source image processing software. Centroid shift was defined as the vector distance between scar and articular centroids (*Fig.1*), expressed in mm and as a percentage of condyle size. Statistical analyses included t-tests, one-way ANOVA, correlation, and linear regression ($\alpha = 0.05$) were used to assess relationships between patient and implant factors and wear scar area or location.

RESULTS: A total of 119 liners were included (98 medial [40 M, 58 F], 21 lateral [9 M, 12 F]), with articular surface dimensions averaging 960.3 ± 178.4 mm². Of these, the Zimmer Unicompartmental Knee (ZUK) (n = 61), DePuy Sigma Partial Knee (n = 22), and the Zimmer Miller-Galante (MG) (n = 18) were the three most common designs. The mean wear scar area was 369.8 ± 151.6 mm² in medial inserts, 266.2 ± 123.6 mm² in lateral inserts, and 344.8 ± 151.4 mm² overall. In *Fig.2*, wear scar area ranges by the most common prosthesis design are presented. The mean wear scar size relative to the articular surface was 34.4% (95% CI: 32.1–36.6) for medial UKAs and 29.3% (95% CI: 23.8–34.8) for lateral UKAs. Revision indication did not influence wear scar area or distance of the wear scar from the center of the articular surface (all $p > 0.05$). Centroid shift did not differ by sex: in medial inserts, 13.0% ± 7.7% (male) vs. 11.8% ± 7.5% (female), $p = 0.45$; in lateral inserts, 12.0% ± 6.6% (male) vs. 18.0% ± 10.3% (female), $p = 0.09$ (two-tailed). BMI showed no association with centroid shift (medial $r = 0.055$, lateral $r = –0.101$) or with normalized wear scar area (medial $r = –0.05$, lateral $r = 0.02$). Manufacturer (Zimmer, DePuy, Smith & Nephew, Stryker, DJO/enovis, Biomet) had no effect on centroid shift ($p = 0.086$ medial; $p = 0.526$ lateral) or scar area. Implant design, evaluating three prosthesis models (ZUK, Sigma, MG), influenced wear scar area (p = 0.029) in medial UKAs, with the MG design having the highest wear scar area, while no significant impact was found in lateral inserts ($p = 0.78$). Time in situ showed weak correlations with centroid shift ($r = 0.15$ medial; $r = 0.29$ lateral, $r = 0.28$ globally) (*Fig.3)* and negligible correlation with normalized scar area.

DISCUSSION: These findings demonstrate that common patient and implant factors, including sex, revision indication, BMI, and manufacturer, do not significantly influence wear scar location or size in retrieved UKAs. The prosthesis model in medial UKAs and time in situ in both medial and lateral UKAs showed a weak association with lateral centroid displacement, suggesting a minor effect of implant design and duration. The finding of a larger wear scar area in the MG design is not surprising, considering it was made from historical polyethylene that was not sterilized in an inert environment and thus was prone to oxidation and higher material loss. Limitations include modest sample size for lateral inserts, surgical heterogeneity, and methodological constraints in wear scar quantification. Future work will use optical coordinate measurements to quantify volumetric wear, improve quantitative accuracy, reduce intra-operator variability to identify other potential relationships between these factors, and correlate wear scar position and extent with surgical positioning factors. Furthermore, we will expand our analysis to UKA liners with more confirming bearing surfaces.

SIGNIFICANCE/CLINICAL RELEVANCE: Polyethylene wear remains a critical determinant of UKA longevity. This study shows that conventional demographic and implant factors may not substantially affect wear patterns, underscoring the importance of surgical technique and joint mechanics. Enhanced quantitative methods could refine risk assessment and guide improvements in implant design and performance.

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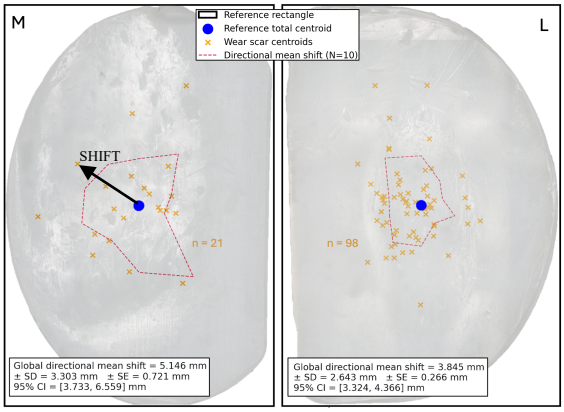

Fig.1-Wear scar centroids mapped to reference rectangle (Shift arrow = vector distance between scar and articular centroids)

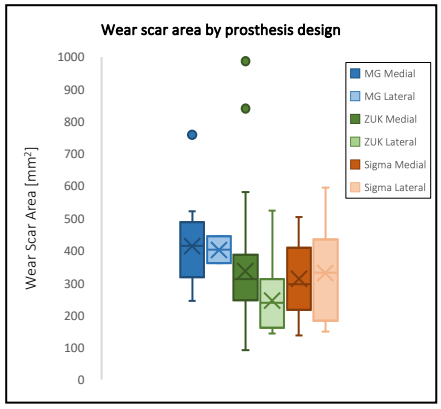

Fig.2-Wear-scar area by design (MG, ZUK, Sigma)

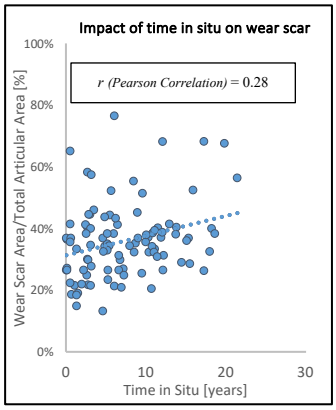

Fig.3-Time in situ vs. wear-scar area (%)