Roughness of Retrieved Cobalt-Chromium Femoral Components: Influence of Age *in vivo* and Bone Cement

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Introduction: Cobalt-chromium alloy (CoCr) is widely used as a bearing surface in joint replacement, but is subjected to corrosion and roughening *in vivo* [1,2]. The purpose of this study was to determine whether the roughness of cast cobalt-chromium alloy (ASTM F75) femoral components retrieved from revision total knee replacement increased with age *in vivo*. We hypothesized that the roughness of CoCr retrievals would increase with age *in vivo*, and femoral components affixed with methyl methacrylate (bone cement) would roughen more rapidly than cementless (affixed via bone ingrowth) components.

Materials and Methods: Femoral components were retrieved from revision total knee arthroplasty, disinfected with hydrogen peroxide, and thoroughly rinsed. Retrievals were included in this study if they were manufactured by Smith & Nephew and had been implanted more than four months, for n = 31 specimens (Table 1), including nine specimens examined previously [3]. Reasons for revision included loosening (n = 14), infection (n = 8), and bone fracture (due to a fall, etc.; n = 7). Three never-implanted CoCr femoral components (Genesis II, Smith & Nephew) provided "baseline" measurements.

The condyles of each specimen were scanned in flexion by optical profilometry at a magnification of 10x (632 µm x 475 µm scan area, six scans/specimen). After subtracting macroscopic curvature, roughness statistics (average roughness Sa, skewness (polarity) Ssk, and bearing ratio parameters Sk, Spk, and Svk) were calculated and correlated to age *in vivo*, with $p < 0.05$ for significance. Slopes of regression lines were compared by GraphPad Prism, and means of groups were compared by t-tests.

Table 1. Summary of the 31 retrievals examined.

Specimen		Cementless	Cemented
Designs (n)		Profix (11), Genesis (3)	Genesis (12), Genesis II (4), Profix (1)
Age *in vivo*	Range	0.77-9.16 years	0.45-12.3 years
	Mean	3.17 years	4.49 years

Results and Discussion: The surface topography of all specimens was dominated by carbides, with retrievals also exhibiting scratches (Figure 1). Roughness increased with age *in vivo*, but the regression lines were not significant and their slopes were not significantly different (Figure 2; $p = 0.277$). The data were similar to previous studies of short-term retrievals [3-6], but the lack of significant roughening up to 12 years *in vivo* was unexpected.

After pooling all retrieval data, there was no significant correlation between roughness and age *in vivo* ($p = 0.156$). Carbides exerted more influence on the polarity of the surface (positive skewness) than small scratches formed by either extracted carbides or other third bodies, such as bone chips or bone cement particles. Comparing each group, "baseline" roughness statistics were higher than the cemented and cementless retrievals, but only the baseline "core roughness" Sk was significantly higher ($p < 0.05$; Table 2). The lower Sk values in both cemented and cementless retrievals suggests that normal articulation *in vivo*, coupled with the corrosive environment inside the knee, serves to slowly polish the surface, extracting embedded carbides but also exposing new carbides [1].

Conclusions: This study did not find a significant increase in roughness with age *in vivo*, regardless of whether cemented or cementless femoral components were used. The surface topography was dominated by positive features (carbides) rather than scratches. Future work will include additional measurements on the same specimens to evaluate patellofemoral contact areas.

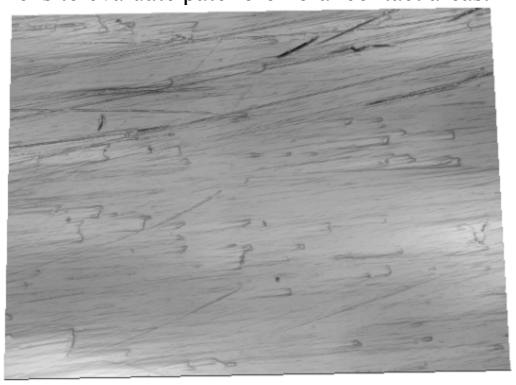

Figure 1. Typical retrieval topography (12.3 yr *in vivo*).

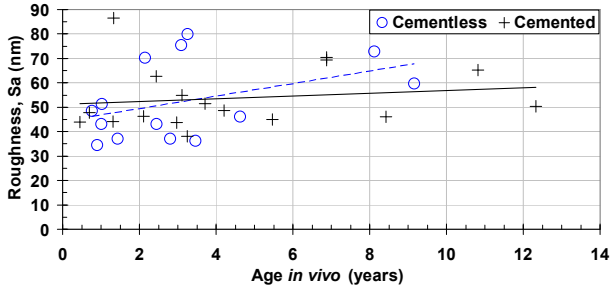

Figure 2. Average roughness Sa as a function of age *in vivo* for cementless (circles/dotted regression line) and cemented (crosses/solid regression line) retrievals.

Table 2. Roughness statistics (mean ± S.D.) by group.

Roughness statistic	Baseline (n = 3)	Cementless (n = 14)	Cemented (n = 17)
Sa (nm)	62.4 ± 6.0	52.5 ± 16	53.8 ± 13
Ssk	0.520 ± 0.12	0.526 ± 0.48	0.434 ± 0.38
Sk (nm)	88.0 ± 5.4	69.6 ± 23	73.4 ± 19
Spk (nm)	65.1 ± 9.1	53.9 ± 13	52.8 ± 12
Svk (nm)	38.2 ± 3.9	32.2 ± 11	32.1 ± 8.6

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