Innovative Undersurface Geometry to Mitigate Lipid Contamination in Cemented Total Knee Arthroplasty: A Simulation Study

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INTRODUCTION:

Lipid contamination of the implant-cement interface appears to be a primary cause of aseptic implant loosening following cemented total knee arthroplasty (TKA). Recent studies suggest contemporary implants trap and disperse lipids along their undersurface leading to debonding of the cement from the implant. We hypothesized that changes in undersurface geometry could direct the amount and location of lipid contamination leading to significant reductions in the percentage of undersurface contamination.

METHODS:

Transparent acrylic models of a contemporary tibial implant were 3D printed. The undersurface was then altered to include six different geometries including reservoirs, grids, and channels (R, G, GC, RC, GR, GRC; Figure 1) specifically designed to direct potential contamination away from the undersurface. A simulation of cementing was then performed (Figure 2). The surface area of lipid contamination was calculated for each trial implant and statistical analysis performed (Figure 3).

RESULTS:

Our results indicate a significant difference in undersurface contamination across all six models ($p<0.001$). Modification with a grid system alone had the highest percentage of contamination (33.3%). Introduction of reservoirs and channels to plate geometry resulted in significantly less undersurface contamination (R 16.2%, GC 15.2%, RC 10.9%, GR 10.5%; all $p<0.02$). The smallest percentage of contamination was seen in a design combining grids, reservoirs, and channels (5.5%).

DISCUSSION AND CONCLUSION:

Geometric modification of the undersurface of a tibial implant with combinations of grids, reservoirs, and channels lead to significant reductions in undersurface contamination. Fluid was either extruded through channels or contained within reservoirs, preventing dispersion through the undersurface of the implant. Therefore, we believe that simple modifications to the undersurface of tibial implants could be incorporated to limit lipid contamination and possibly prevent aseptic loosening in cemented TKA.

Figure 2: Example of each base plate after undergoing simulation of cementing

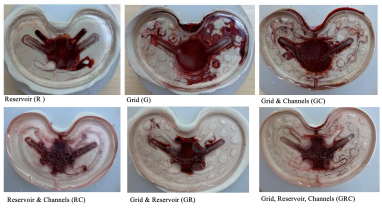

Figure 1: Acrylic tibial baseplate models 3D printed with modifications including grids, channels, and reservoirs

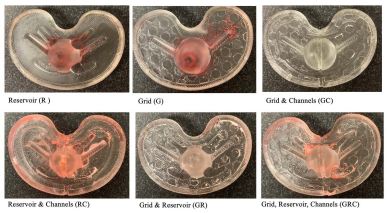

Figure 3: Demonstration of our calculation of undersurface contamination. Surface area was measured using ImageJ processing software. Percent contamination was calculated as area of contamination with dye divided by total baseplate surface area. The area of the keel was subtracted both from the area of contamination and the overall surface area.