Analysis of Bone Ingrowth in Retrieved Porous Tantalum Tibial Trays

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Disclosures:

Introduction: Initial large-scale clinical studies of porous tantalum implants have been generally promising with well-fixed implants and relatively few reported cases of loosening. However, retrieval studies of porous tantalum tibial trays have been limited to small numbers of retrieved devices [1-2]. The goal of this study was to investigate bone ingrowth in retrieved porous tantalum modular and monoblock tibial trays. We asked: (1) Will the amount of bone vary based on location? (2) Will design type affect the amount or location of bone ingrowth?

Methods: Between 2003 and 2013, 44 porous tantalum tibial trays were retrieved during revision surgeries under an IRB approved multicenter program. The tibial trays consisted of 4 modular and 40 monoblock components (8 CR-Flex and 32 LPS-Flex). The tibial trays were implanted for 1.9±1.4 years (modular), 1.0±0.3 (monoblock: CR) and 2.4±2.7 years (monoblock: LPS). The main reasons for revision of the tibial components were instability (n=15, 34.1%), infection (n=6, 13.6%), loosening (n=5, 11.4%) and pain (n=5, 11.4%). A subset of implants, all primary surgeries consisting of 3 modular and 20 monoblock implants were dehydrated, plastic embedded, sectioned, polished and analyzed using BSE SEM. Analyzed trays were implanted for 1.8±1.5 years (modular), 1.3±0.2 years (monoblock: CR) and 1.7±1.2 (monoblock: LPS). Six slices per tibial tray and one slice for each peg were analyzed. The analysis measurements included bone overall volume fraction and bone volume fraction based on three zones by depth. The zones were defined as: Zone 1 (0-500um), Zone 2 (500-1000um) and Zone 3 (1000um - full depth). Comparison of the monoblock components based on location (central, lateral, medial and peg) was also conducted. Nonparametric statistical tests were used to investigate differences in bone volume fraction by location, design and depth (Related samples - Friedman’s Two-Way Analysis of Variance by Ranks, Non-related - Kruskal-Wallis Test). Post-hoc Dunn tests were completed for subsequent pairwise comparisons.

Results: For the monoblock components, there were no significant differences between the CR and LPS components, which were grouped for further analysis. When compared to the grouped monoblock trays, the modular tray slices had a significantly higher bone volume fraction (p=0.028, Figure 2). Bone ingrowth was higher in zone 1 than either of the deeper zones with significantly higher ingrowth compared to zone 3 for the modular trays (p=0.043) and higher ingrowth than either zone 2 (p=0.003) or zone 3 for the monoblock trays (p<0.001; Figure 2). Bone growth in the monoblock pegs was also predominantly seen on the periphery of the peg (Figure 1B). The depth of ingrowth observed in the monoblock components (tray section) was limited reaching a maximum of 91% of the available depth. However, bone ingrowth spanning the full depth of the available porous tantalum was observed on one of the modular trays (Figure 1A). Bone ingrowth into the modular tray pegs was not different than that observed under the tray (p=0.655). For the monoblock components, bone volume fraction was significantly higher in the pegs than the central region (p=0.005), however similar in lateral (p=0.568) and medial (p=0.059) regions.
Figure 1: A) SEM image of a modular tibial tray will bone spanning the full depth. B) SEM image of a tibial tray peg showing bone
ingrowth on the periphery.
Discussion: Our results demonstrated that bone ingrowth in porous tantalum tibial components is concentrated in the superficial 500 um (Zone 1). This may provide the opportunity to reduce the thickness of the porous layer thus conserving more bone in future designs. Although our sample size was limited, it appears that modular components may provide an environment that stimulates a greater degree of ingrowth, concentrated in the superficial zone and pegs. However, it should be noted that the available porous tantalum coating for monoblock trays is thicker than for the modular. At this time, it is unknown whether the observed differences were due to differences in the local biomechanical environment or other factors. Further work focused on analysis of additional modular tibial trays and histological analysis of porous tantalum tibial trays will increase the understanding of this bone-implant interface.

Significance: Loosening of the tibial component has been a concern in historical designs for uncemented total knee arthroplasty. Retrieved porous tantalum tibial tray implants were analyzed to quantify bone ingrowth.

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