

# Factors Influencing the Initial Strength of the Tibial Tray-PMMA Cement Bond

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## Disclosures:

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**Introduction:** Aseptic loosening of the tibial component remains a major cause for revision (1-4). The incidence of aseptic loosening of tibial components varies by surgeon (5), which implicates technical factors. Because of the lack of *in-vitro* data on the initial strength of the metallic tibial baseplate-cement interface, we developed a laboratory model to investigate the effect of different clinically relevant variables on the strength of this interface. To the authors' knowledge, this is the first study to use commercially available tibial baseplates in a study of metal-cement interface bond strength. The test configuration allows insertion of the tibial plate into a space similar to the one made during surgery, mimicking the displacement of the cement, and the influence of potential contaminants (i.e., fat, blood, saline). We hypothesized: 1) that initial bond strength was a function of the timing of apposition of the baseplate to the cement (early apposition stronger than later); 2) cementing of the keel provides greater initial bond strength than only cementing the plateau; and 3) contamination of the interface with fat (marrow) would decrease bond strength, but cementing the underside of the tibial tray might mitigate this. The purpose was to provide information to surgeons that could reduce the occurrence of tibial component debonding (loosening).

**Methods:** Forty-eight size 4 Triathlon<sup>®</sup> tibial trays were cemented into a cylindrical acrylic holder (diameter 3 1/2", height 2 1/8") using two different cements: Simplex<sup>®</sup> and Palacos<sup>®</sup>; three different cementing times: early (low viscosity), per manufacturer (normal, medium viscosity), and late (high viscosity); two different cementation techniques: cementing tibial plateau only and cementing tibial plateau and keel; and two different fat (marrow) contamination conditions: metal/cement interface and cement/cement interface. A minimum of 48hrs after bonding, a push-out test was applied at a velocity of 0.05 mm/s, and the load recorded continuously throughout the test at a rate of 10Hz using a universal load tester (INSTRON 8501, Norwood, MA) with the tray facing down (fig. 1). The test was stopped when the plate debonded from the cement (i.e. the tray visibly separated from the acrylic support and the load dropped substantially). Statistical analysis was performed using t-tests, Cohen's d effect size and power analysis.

**Results:** Compared to cementing under manufacturer-recommended conditions (normal), late cementing reduced the interface strength of Simplex<sup>™</sup> by 47% (p=0.004) and Palacos by 73% (p=0.034). Early cementing increased interface strength of Simplex by 48% (p=0.011) and Palacos by 72% (p=0.049). Cementing the keel increased the bond strength of Simplex<sup>™</sup> 153% (p=0.010) and Palacos<sup>™</sup> 147% (p=0.005) and over the respective normal cementing of the plateau only. **Fat contamination of the metal-cement interface reduced the interface strength to practically zero** (-99% (p=0.003) Simplex and -94% (p=0.030) Palacos). By adding cement to the underside of the tibial tray prior to an insertion with in fat contamination, this was reduced to -65% (p=0.008) in Simplex and -43% in Palacos. However, in Palacos, this was not statistically significant (p=0.133).

**Discussion:** Under laboratory conditions, regardless of cement type, a clean tibial tray-cement interface is strong, but much stronger when the keel is cemented (+150%, p<0.0001). Earlier application of the cement to metal increases bond strength (+60%, p=0.0001) while later application reduces bond strength (-147%, p=0.0006). Fat contamination of the tibial tray-cement interface dramatically reduces bond strength, but application of cement to the underside of the tibial tray prior to insertion substantially mitigates this (+1222%, p=0.006).

**Significance:** These results suggest that clinical loosening at the tibial tray-cement interface can result from too late application of cement to the tray, and/or interface contamination by marrow or other fluid (blood or saline). The surgeon should consider applying cement to the undersurface of the component soon after mixing (while tacky). To maximize tibial tray-cement bond strength, 1) thoroughly dry the entire tibial interface (plateau and keel), 2) cement the keel as well as the plateau, and 3) apply cement to the component soon after mixing (while the cement is tacky).

## Acknowledgments:

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