Introduction
Although there has been debate in THR as to whether the femoral component should be bonded to the cement mantle or not, there is no such debate in TKR. It is generally agreed that the TKR implants should stay bonded to the cement mantle. Loosening at the metal-cement interface in TKR results in osteolysis and clinical failure (1). For this reason, it is desirable to optimize the strength of the metal-cement bond in TKR. The strength of the bond between bone cement and a metallic surface is strongest when “wet” cement is applied soon after mixing, and decreases with increasing time between mixing and application as the cement becomes more “doughy” (2). However, insertion and pressurization of cement into bone is more effectively accomplished when the cement is doughy (3). One technique commonly used in TKR, is to apply wet cement to the metal surfaces, wait some time before pressurizing doughy cement into the bone, and then press the two cement surfaces together. How does the time interval influence the strength of the resultant cement-cement interface?

Materials and Methods
Surgical Simplex P (Howmedica, Rutherford, NJ) bone cement was used. A half-dose package was mixed for 60 seconds with a spatula in a 60-ml syringe at 18-19 °C and 56-65 % relative humidity and waited for 45 seconds before injecting into a mold. Control Specimens: all cement was injected immediately into a plastic molds. Delayed Specimens: half of the cement was immediately injected into the mold. At 1, 2, 4, and 6 minutes later, the remainder was injected into a second mold and packed with a gloved finger. Two cement-filled molds were brought together with a 1 Kg force forming a cement-cement interface perpendicular to the longitudinal axis of the cement block. Cement was cured in the air for an hour, then stored in a saline cement-cement interface. Two cement-filled molds were brought together with a 1 Kg force forming a cement-cement interface perpendicular to the longitudinal axis of the cement block. Cement was cured in the air for an hour, then stored in a saline solution at 37 °C. The cement block was cut into 8x5x40 mm specimens with a diamond blade saw with water irrigation. The specimens were radiographed to eliminate specimens with large voids and to localize the cement-cement interface. A 3-point bending testing to failure was performed to measure bonding strength on an MTS 10 days after mixing (9 specimens per group). The center anvil was located at the cement-cement interface and loaded at a rate of 5 mm/min (ISO5833). Fracture surface was examined with a SEM. Statistically analysis included one-way ANOVA followed by the least-significant difference method of multiple comparisons.

Results
The interface between time-delayed cements could not be seen with the naked eye but was easily identified as a dense line on radiographs. The 6-minute delayed specimens contained additional internal interfaces (laminations) from injecting and finger packing. The control group, which had no cement-cement interface, had a mean bending strength of 65.7 ± 2.5 MPa. Mean bending strength of time delayed groups decreased to 92 % (p=0.037) of the control group for 1 min. delay, 82 % (p=0.0004) for 2 min. delay, 80 % (p=0.0005) for 4 min. delay, and 58 % (p=0.0001) for 6 min. delay (Figure 1). There was no statistical difference (p=0.73) in bending strength between 2 and 4 min. delayed groups. SEM revealed that control, 1, 2, and 4 min. delayed specimens failed with brittle fracture characteristics and, in contrast, 6 min. delayed specimens failed with delamination characteristic. There was only partial bonding between two layers in 6 min. delayed cement (Figure 2).

Discussion
Although a hot topic in THR, there has been little investigation into the optimal use of bone cement in TKR. This laboratory investigation indicates that cement-cement interface strength decreases to 82 % of the cement mantle with a two-minute delay. This 80 % level of interface strength is essentially maintained with a 4-minute delay but drops substantially with further delay (58 % at 6 min.). Based on these results, the recommended surgical technique would be to insert the prosthesis (mate the two cement surfaces) by four minutes after mixing in order to get the best combination of metal-cement interface strength, cement pressurization into bone, and cement-cement interface strength.

References:
3. Insall JN, Easley ME. Surgery of the Knee, 2001

**Joint Replacement Institute at Orthopaedic Hospital, Los Angeles, CA.