INTRODUCTION: Although numerous methods have been utilized to reduce interface debonding between prosthetic-Porcelian interfaces by altering the micro-mechanical interlocking across the interface, premature failure of cemented total joint replacements remains an essential issue. Despite the potential advantages of using chemical surface enhancements, few studies have attempted such techniques to improve the interfacial strength of prosthetic-Porcelian systems [1,2]. Therefore, in this study, we employ surface chemistry techniques which utilize organosilane adhesion promoters to replace weak chemical bonds with strong covalent bonds at the interface in order to enhance the bonding between the polymer and metal materials, and thus improving the debond resistance of this interface. A quantitative method to characterize the adhesion (fracture) and subcritical debond-growth rate (fatigue) behavior of two clinically relevant prosthetic surfaces in terms of an interfacial debond energy, \( G(\Delta a) \), debond extension (\( \Delta a \)) and debond extension rates, \( d\Delta a/dN (m/cycle) \), is utilized. General insights to the effects of surface roughness, chemical enhancement and the environmental effects on the thermodynamics at the interface are discussed.

METHODS: Specimen Preparation: Interfaces formed between silane treated and untreated fine polished and grit-blasted cobalt chrome alloy (Zimmer, Warsaw, IN.) and PMMA (Dough Type, Zimmer, Warsaw, IN.) were studied in a sandwiched double cantilever beam configuration (Fig. 1.).

Monotonic Loading: Interface fracture energy, \( G(\Delta a) \), was measured for each sample and resistance curves (R-curves) generated under monotonic loading. Debond lengths were monitored in situ to a resolution of better than 2 \( \mu m \), using a D.C. electrical-potential measurements across Ni-Cr metal foils bonded to the specimen surfaces and by direct optical measurements. Cyclic Loading: Cyclic fatigue debond-growth tests were adapted from ASTM Standard E647-95 [3] and performed using a computer-controlled electro-servo-hydraulic test system. The DCB specimens were loaded under a 20 Hz sinusoidal frequency (load ratio = 0.1) under decreasing fracture energy (G) loading conditions. Cyclic fatigue debond propagation rates (\( d\Delta a/dN \)) as a function of the applied debond energy range were determined for the interfaces in air and simulated physiological environments. Fractography: All fracture surfaces were evaluated using a SEM after testing to characterize the fatigue and fracture surfaces, as well as the occurrence of wear.

RESULTS: Monotonic: Characteristic adhesion and subcritical debond-growth rate values for silane treated and untreated fine polish and grit-blasted surfaces in ambient air (55% R.H., 21°C) and simulated physiological environment (Ringer’s, 37°C) are summarized in Table I. The steady-state interface debond resistance values, \( G_0 \), are increased with silane surface treatment in both air and physiological environment. Cyclic: Characteristic debond extension behavior for silane treated and untreated grit-blasted surfaces as a function of testing environment are shown in Fig. 2. Debond growth is shown to occur subcritically in both air and physiological environment. Similar to the trends depicted in the adhesion values, fatigue resistance was maintained for samples pretreated with silane and exposed to physiological environment for both the FP and GB samples. In contrast, untreated samples underwent environmental degradation, evidenced by the leftward shift of the entire fatigue curve in the case of the GB surface and spontaneous debonding in the FP surface case.

**REFERENCES:**


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**Figure 2.** Effects of silane treatment on the fatigue debond-growth rate behavior of grit-blasted-Porcelian interfaces in ambient air and simulated physiological environment.