DO CEMENT VOIDS CAUSE PREMATURE FAILURE OF CEMENT MANTLES IN TOTAL HIP ARTHROPLASTY

+*Kadakia, N; *Noble, P; *Beardsley, C; *Aberman, H; **Paravic, V
+*Baylor College of Medicine, Houston, Texas. 6565 Fannin/Suite F115/Houston, Texas 77030, 713.790.3419, Fax: 713.986.5461, pnoble@bcm.tmc

Introduction: Aseptic loosening of cemented femoral stems commonly follows mechanical failure of the cement mantle. Mantle fractures are attributed to many factors, including poor stem design, cement/stem debonding, and the presence of voids within the cement mantle: (1) As laboratory studies have shown that voids dramatically reduced the fatigue life of cement in fatigue loading, many investigators have recommended that cement be centrifuged or mixed under vacuum to reduce internal voids and prevent mantle fractures (2). However, few investigators have demonstrated that a relationship exists between cement porosity and cracks that are present in mantles surrounding hip prostheses. This study was performed to determine which factors were associated with fractures in the cement mantle and the contribution of porosity to mantle failure.

Materials and Methods: Eleven specimens consisting of cemented hip prostheses and its cement mantle (duration of implantation 3-14 years) were procured from patients ranging from 54-94 years of age. The implants were of a variety of designs including Aufranc-Turner (n=3), ATS (n=2), TR28 (n=1), Harris Precoat (n=2), and Muller (n=1). Two other prostheses were not identified. All specimens were carefully inspected to document visible cracks in the cement mantle. To ease analysis and handling the specimens were encased in red colored acrylic cement. A total of 59 sections were produced from the specimens; nine of the specimens were sectioned in the transverse plane in 4-7 locations, while the two remaining specimens were sectioned coronally. Each of the sections was then polished and stained. The sections were then divided into four zones and examined using a light stereomicroscope (WILD M7S, Heerbrugg). Visible pores, those greater than 0.5mm, as well as cracks were quantified in each section. Cracks were further qualified as complete or incomplete wall fractures. Complete wall fractures were qualified as complete or incomplete wall fractures. Complete wall fractures were defined as those cracks that extended from the prosthesis surface through the cement to the bone; incomplete wall fractures originated at either the cement/prosthesis interface or the cement bone interface and terminated in the bulk cement.

Results: A total of 111 fractures were observed throughout the 59 sections examined; only 29% (n=17) of the sections were crack-free. There was a positive correlation between the number of pores and cracks observed in each section (r = 0.93). Based on the criteria established, 43% (n=50) of the fractures observed were complete wall fractures, while 57% (n=63) were incomplete wall fractures. The complete wall fractures showed a preference towards areas of high cement stress, 96% (n=46) of complete wall fractures were found in cement mantles that were less than 2mm thick (Figures 2), while 75% (n=36) were adjacent to sharp features of the prosthesis such as corners. Also significant is that 21% (n=10) of complete wall fractures were located medially. Eighty-four voids were observed in 54% (n=33) of the sections. Non of these voids was associated with a complete wall fracture. Moreover in 5 cases, a void served as a termination site for propagating fracture (Figure 1). There was no significant difference between the distribution of sites of crack initiation and termination within the proximal, middle, or distal cement mantle (p=0.096).

Discussion: The results indicate that voids played a relatively minor role in the initiation of fractures within cement mantles. Moreover, voids that were of average size (>1mm) and shape (irregular vs. round) rarely contributed to crack initiation. The vast majority of cracks propagated from irregularities in the surface of the cement mantle, typically formed by trabeculae encapsulated by the cement or folds that remained after polymerization. Areas of thin cement were also a frequent source of mantle fractures and rarely coincided with significant cement pores. Furthermore, corners present on implants also contributed to crack initiation. Crack formation appeared to be uniformly distributed throughout the cement mantle. This study demonstrates that improvements in cement strength and fracture toughness are critically related to increased durability of cemented hip prostheses. Other factors such as mantle thickness and stem design appear to play critical roles in crack formation and subsequent loosening of the implant. Based upon our observations, elimination of voids within the cement mantle is not expected to dramatically influence the incidence of aseptic loosening in cemented hip replacements.

Figure 1. Crack terminating within a void.

Figure 2. Thin cement mantle with crack formation.

**Institute of Orthopedic Research and Education, Houston, Texas.