Introduction

Cementing a new mantle within an existing mantle during revision hip arthroplasty is well documented, and aims to minimise the hazards associated with removing the existing mantle [1]. However, concerns remain that the resulting mantle may be more susceptible to failure as a result of the procedure.

The interfacial strength of a cement on cement mantle has been reported to be 93% of a uniform cement mantle when the existing mantle was rasped prior to insertion of new cement, and 85% when unrasped [2]. However, the effect of the cement brand used in the existing and new mantles is unknown. This study aimed to assess the shear strength of bi-laminar cement mantles using combinations of two leading cement brands. The effect of rasping the original cement mantle prior to the injection of the new cement was also assessed.

Materials and Methods

Antibiotic Simplex and Palacos R+G cements were used to produce samples in four combinations (Figure 1), where the first name represents the original mantle: Simplex-Simplex (SS); Simplex-Palacos (SP); Palacos-Simplex (PS); and Palacos-Palacos (PP). Each of these combinations was subdivided into either unrasped (U) or rasped (R), giving a total of eight groups, with ten samples in each group.

Samples were prepared using a modified version of the procedure outlined in ISO 5833:2002(E). The first cement mantle was produced with a 75 mm length, 10 mm width, and 3 mm depth. Samples were then stored in air, at a temperature of 37°C, for one week. Then a second cement mantle of 1 mm depth was added using the same cementing technique as previously. The surface of the samples in the rasped groups were prepared using 120 grit emery cloth prior to the addition of the new cement layer. Samples then were stored overnight, in air at a temperature of 37°C.

Figure 1: Cement on cement samples from left to right: Simplex-Simplex, Simplex-Palacos, Palacos-Simplex, Palacos-Palacos

On the day of shear testing, samples were cut down to 10 mm in length. Pilot tests had demonstrated that longer samples required a higher force than the capacity of the testing machine.

A 5 kN Instron testing machine was used with a custom-designed fixture to complete the shear tests (Figure 2). The samples were measured with vernier calipers and then tested quasi-statically until the failure of the sample. The maximum shear stress for each test was calculated.

Figure 2: Diagram of the shear testing apparatus. The upper block was fixed to the crosshead of the Instron testing machine. The red area represents the original cement mantle, the grey area the second cement layer

The data of each group was tested for normality using a Shapiro-Wilk test. Groups were then compared using ANOVA followed by a Bonferroni post-hoc test. Further comparisons were made in regard to whether using either Simplex or Palacos as the second layer in the cement mantle, and whether an unrasped, or rasped finish on the cement-cement interface had an effect on the shear strength irrespective of the type of cement in the original cement mantle.

Results

The shear strength varied considerably between groups both in terms of magnitude and variability (Figure 3).

Figure 3: Boxplots of the shear strength of each cement-cement group (n=10)

Six of the eight groups were normally distributed (P>0.05). A comparison of the shear strength between all eight groups using ANOVA and a Bonferroni post-hoc test showed significant differences (p<0.05) in 7 of the 28 comparisons (Table 1). The shear strength of the PPU group was significantly lower than all but the SSU and SPU groups. The only other significance was between the SSU group and the PSU and PSR groups.

Table 1: Comparison of stiffness with intact and In Motion discs for ISD specimens. Red denotes a significant difference (p<0.05)

<table>
<thead>
<tr>
<th>Group</th>
<th>SSU</th>
<th>SPU</th>
<th>PSU</th>
<th>PPU</th>
<th>SSR</th>
<th>SPR</th>
<th>SSR</th>
<th>PSR</th>
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Further comparisons were made to assess whether using either Simplex (S) or Palacos (P) as the second layer in the cement mantle, and whether an unrasped (U) or rasped (R) finish on the cement-cement interface, had an effect on the shear strength. Three of the four groups (SU, PU, PR) were non-normally distributed, therefore the groups were compared using a Kruskal-Wallis test and a Mann-Whitney post-hoc test, with a multiple comparison correction requiring P<0.0083 for significance.

The shear strength of the PU group was significantly lower than both Simplex groups (p<0.007 and p<0.001 for SU and SR respectively). The PR group was significantly lower than the SR group (p<0.001).

Discussion and Conclusions

Altering the combination and preparation of cements used in bi-laminar samples can significantly affect shear strength.

The variability of shear strength in rasped groups was higher than in unrasped groups. It was expected that the rasping procedure would provide a more suitable surface for the second cement layer to bond to, though the only cement combination for which rasping created a significant increase in shear strength was Palacos-Palacos. The curing time and chemical interaction of different types of cement may also cause alterations to the mechanical structure of the cement-cement interface.

It is recommended that cement on cement procedures in the orthopaedic environment use rasping to prepare the existing mantle prior to injection of new cement. It is also recommended that Antibiotic Simplex be used in preference to Palacos R+G for the new cement mantle. However, further research into other cement brands may provide additional understanding of the cement on cement procedure.

References:
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