The Effect of Antibiotic on Impact Strength of Orthopedic Bone Cement

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SUMMARY
The use of antibiotic-impregnated cement for implant fixation is a known practice, particularly in revision total joint replacement (TJR) surgery with an increased risk of future joint infection. The benefit of adding antibiotics to bone cement as a method of infection prophylaxis in TJR needs to be weighed against a number of drawbacks including a drop in the mechanical properties of the bone cement. In this study we have used Simplex as the base material for bone cement and have 5 groups of samples which are antibiotic added samples (Liquid Gentamicin, Vancomycin, Erythromycin, and Tobramycin) and also control samples without antibiotics, one half of each group’s samples stored in the air and other half stored in the saline for 2 weeks. All testing was conducted in accordance with ASTM D256-06. A computer based statistical package is used to perform statistical analysis. It was demonstrated that the addition of Erythromycin antibiotics to bone cement, and aged in air, increases its impact strength. The largest drop in the impact strength was found for the samples containing liquid Gentamicin aged in the air.

METHODS
The materials used in the present study are listed in Table 1. The concentrations chosen for four antibiotics reflect those generally accepted in clinical practice. Various sample test groups have been selected using antibiotics outlined in Table 1. A control test group with no antibiotics has been also included. The components of each sample were mixed under ambient conditions (temperature 23ºC ± 2ºC, relative humidity of 50% ± 5%) according to the manufacturer’s specifications. If antibiotics were added to the sample, this was done before the addition of the liquid monomer but prior to mixing. All preparations were mixed in similar fashion and transferred to a steel casting. All testing was conducted in accordance with ASTM D256-06, the standard test methods for determining the pendulum impact resistance of notched specimens of plastics. An impact tester with the capability of delivering energy of 3J is used to perform the tests.

A computer based statistical package is used to perform statistical analysis. Data was initially analyzed with a 2-way analysis of variance (ANOVA). A Tukey’s Kramer honesty significant difference (HSD) post hoc test was used to determine significant differences among the results in each test group. A p-value of <0.05 was taken as significant.

RESULTS AND DISCUSSION
The impact strength for control group in air and in saline was measured to be 1.6 ± 0.06 and 2.05 ± 0.25 KJ/m², respectively. For liquid Gentamicin impregnated group aged in air, it was 1.27 ± 0.09 and in Saline was 2.02 ± 0.17 KJ/m². The impact strength of the Vancomycin added bone cement samples was 1.54 ± 0.18 and 1.92 ± 0.15 KJ/m², respectively, for specimens aged in air and in saline. And for Erythromycin it was 2.02 ± 0.24 in air and 2.14 ± 0.44 in Saline. At last, the impact strength for Tobramycin added bone cement samples aged in air was 1.82 ± 0.18 and for samples aged in the Saline was 2.01 ± 0.27.

Two-way ANOVA showed a significant dependence on storage condition (p < 0.05). Similarly, the effect of antibiotic addition to cement on the impact strength was also found statistically significant (p < 0.05). The Tukey’s HSD test
indicated that the liquid Gentamicin impregnated samples aged in air had significantly lower mean impact strength than all other groups (p < 0.05) as shown in Figure 1. The mean impact strength of the Tobramycin added samples aged in saline was lower than other samples aged in saline but is not statistically significant (p > 0.05). The Erythromycin added samples aged in air had higher mean impact strength than all other groups but that is not statistically significant (p > 0.05).

CONCLUSIONS

The present study used the pendulum impact resistance test method to measure the impact strength of four antibiotic-impregnated bone cement configurations. Also, the impact of storage condition (air vs. saline) on the impact strength was determined. It was reported that a change in the mechanical properties of orthopedic bone cement greater than 10% is considered unacceptable for use in total joint arthroplasty fixation [4].

The impact strength results measured for control samples in the present work is found to be in the range reported in the literature. It was demonstrated that the addition of antibiotics to bone cement reduces its impact strength except in Erythromycin impregnated bone cement samples in the air. The largest drop in the impact strength was found for the samples containing liquid Gentamicin aged in the air. Based purely on the present test results, powdered Erythromycin at clinically acceptable doses showed better biomechanical effects on cement impact strength in comparison to the other antibiotic impregnated cement configurations tested.

REFERENCES


Table 1: Materials used in the present study

<table>
<thead>
<tr>
<th>Material</th>
<th>Composition</th>
<th>Mixing ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Powder: Methyl methacrylate-styrene copolymer, Barium sulphate and Polymethyl-methacrylate</td>
<td>Liquid: Methyl methacrylate (monomer), N,N-dimethyl para toluidine, and hydroquinone, USP</td>
</tr>
<tr>
<td></td>
<td>Simplex</td>
<td>40 g/20 mL (powder/liquid)</td>
</tr>
<tr>
<td>Vancomycin</td>
<td>1.0 g</td>
<td>1.0 g/40 g cement</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>2.0 mL</td>
<td>2.0 mL/40 g cement</td>
</tr>
<tr>
<td>Tobramycin</td>
<td>1.0 g</td>
<td>1.0 g/40 g cement (pre-mixed)</td>
</tr>
<tr>
<td>Erythromycin</td>
<td>0.5 g</td>
<td>0.5 g/40 g cement (pre-mixed)</td>
</tr>
</tbody>
</table>

Figure 1: Impact strength of antibiotic-impregnated Simplex®P.

Figure 2: Percent reduction in the impact strength (compared to control: unaltered Simplex®P) due to the addition of antibiotics, aging media is Air or Saline.