The influence of cement viscosity on cement mantle in total knee arthroplasty

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INTRODUCTION:

The cement viscosity at the time of application to the bone is critical in ensuring a long-term success of the arthroplasty, as it influences the cement penetration and stability of the prosthesis. Currently, there are number of cements available with a wide range of viscosities and set times. High viscosity faster-setting cements may significantly reduce operating room times. However, the concern is that this positive feature may be at the expense of decreased penetration into the bone, and hence reduced stability of the construct.

This study evaluates and compares the use of four cement types (DePuy II (DePuy Inc. Warsaw, IN), Endurance (DePuy Inc. Warsaw, IN), Simplex-P (Stryker Corp Kalamazoo, MI) and Palacos (Zimmer, Inc, Warsaw, IN)) during TKA, with respect to radiolucency, and depth of cement penetration under identical surgical conditions.

METHODS:

Twelve (12) sawbone open cell blocks (Pacific Research Laboratories, Inc., Vashon Island, WA) simulating tibial cancellous bone, were used for the study. The sawbone chosen has a subsurface quality and an open cell texture very closely matching the structure of proximal tibial cancellous bone. The ease of availability, consistency, and control in the variables like bone porosity, and quality of the bones influenced the choice of using the surrogate tibiae for the experiment. The tibiae were divided into four groups of three, with each group receiving the treatment with one cement type. The four bone cement types of varying viscosities which were used for comparison were DePuy II (DePuy Inc. Warsaw, IN), Endurance (DePuy Inc. Warsaw, IN), Simplex-P (Stryker Corp Kalamazoo, MI) and Palacos (Zimmer, Inc, Warsaw, IN). Standard arthroplasty cuts were performed on each proximal tibia utilizing the same surgical approach, prosthetic components (Zimmer NexGen LPS), and cementation technique. The Zimmer NexGen LPS tibial plate design includes cement wells on all component surfaces to facilitate cement pressurization. All surgical procedures were performed by the senior orthopaedic surgeon.

Cement preparation

The cement was prepared in a hand-mixing bowl and was allowed to cure until it no longer adheres to a Biogel powderfree latex glove in accordance with ASTM F 451-99a and ISO 5833:1992(E). The preparation time for each of the cements was recorded using a stopwatch. Guidelines for preparation time were used as provided by cement manufacturers. The operating room temperature and humidity set points were controlled and maintained at 65 F and 55% respectively for all the procedures.

Cement application

The cement was applied under digital pressure in the cement wells of the tibial component . As per the standard surgical procedures, prosthetic surgical components were used to ream the cavities to seat the tibial plate stem. Cylindrical shaped bone cement dough was inserted in the cavity and then the tibial plate was seated on the surrogate tibia. Finally, the tibial plate was pressed down by the surgeon using surgical components. An additional sample was prepared with a randomly picked bone cement, and quarter section of the tibial plate was cut using a water-cooled diamond saw (Buehler Ltd., Lake Bluff, IL), to verify the uniformity of the construct, and consistency of the open cell structure of the surrogate cancellous bone.

Radiographic analysis

All specimens were evaluated radiographically for radiolucency. All the specimens were placed on a radiography plate to capture lateral and antero-posterior (AP) characteristics of the cement penetration in the twelve sample constructs. The radiographs were digitized, scaled, and the mean cement penetration depth was determined for the seven zones in AP and lateral views.

Statistical Analysis Student t-test was performed to assess the statistical significance of penetration depth with different cements;

RSEULTS:

On radiographic analysis of the implanted surrogate tibiae, it was found that Simplex had the maximum commulative penetration of 19.2 mm in seven zones in Mediolateral view, and 12.7 mm in three zones in anteroposterior view. In zone seven, the difference was statistically significant when comparing Simplex with Palacos (11 mm vs 4.6 mm, two-tailed P value = 0.035), somewhat significant with Depuy 2 (11 mm vs 6 mm, two tailed P value = 0.08), but the different was not significant when compared with Endurance (11 mm vs 10 mm, two-tailed P value = 0.6345). In Zone 5, the difference was statistically significant with Simplex vs Endurance (0.3 mm vs 2.2 mm, P = 0.028), and with Simplex vs Depuy 2 (0.3 mm vs 2.17 mm, P = 0.012).

DISCUSSION:

Simplex is considered as gold standard when evaluating bone cement performance. In the present study, simplex had the maximum cumulative penetration in all seven zones, followed by Endurance, Depuy 2, and Palacos, respectively in AP as well as lateral view. Relative higher viscosities of Endurance, Depuy 2, and Placos may attribute to lower penetration in zone 7 (AP view), and zone 3 (lateral view). This study enhances the understanding of the relation between cement viscosities and cement penetration into cancellous bone during TKA.