A Comparison of Distal Canal Restrictors in Primary Cemented Femoral Hip Arthroplasty

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abstract

A retrospective study evaluated 75 total hip arthroplasties performed over a 4-year period using 4 different cement restrictors. A harvested bone restrictor, polyethylene restrictor (Smith & Nephew, Richards Inc, Memphis, Tenn), Biostop G (Depuy Orthopaedics, Warsaw, Ind), and polymethylmethacrylate (PMMA) (Wright Medical Technology, Arlington, Tex) were compared for the percentage of failures, the average length of the cement mantle, and the width of the femoral canal compared to the cement grade. Patient age, sex, and cement type were also evaluated for their influence on cement grade. The PMMA restrictor and bone performed better than the Richards plug and Biostop G restrictor.

A septic loosening is a common long-term complication of cemented femoral components in total hip arthroplasty (THA).\(^1,2\) Studies have shown that improved cementing technique increases cemented femoral component survival.\(^3-9\) Second-generation cement technique with preparation of the canal, occlusion of the distal femoral canal, retrograde canal fill with cement, and pressurization of the canal to allow a more reproducible cement mantle are techniques used to improve the survivability of cemented femoral components.\(^4\)

Currently, many techniques are used to obtain distal femoral occlusion to include bone harvested from the femoral head, nonabsorbable polyethylene restrictors, bioabsorbable restrictors, and polymethylmethacrylate (PMMA) restrictors. The ideal requirements of a distal femoral canal restrictor are ease and safety of use, effectiveness in withstanding pressurization, and ease of removal if the implant is revised.\(^10\)

This study compared different types of distal femoral canal occlusion, the type of cement used, and canal size compared to the cement grade. Patient age, sex, and cement type were also evaluated for their influence on cement grade. The PMMA restrictor and bone performed better than the Richards plug and Biostop G restrictor.

From December 1996 to January 2000, 75 primary cemented femoral components were implanted at our institution. Four types of cement restrictors were identified—bone restrictors fashioned from the autologous femoral head; a polyethylene nonabsorbable distal femoral cement restrictor (Smith & Nephew Richards, Memphis, Tenn); Biostop G bioabsorbable cement restrictor (Depuy Orthopaedics, Warsaw, Ind); and PMMA cement restrictors (Wright Medical Technology, Arlington, Tex).

Information on the type of cement

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restrictor used, patient age and sex, and type of cement were obtained through the patients’ records. Radiographs were independently reviewed by a single observer (E.L.S.) using the system described by Barrack et al.4 In addition, the size of the femoral canal and the distance of the restrictor to the tip of the prosthesis were measured and analyzed (Figure). A measurement >3 cm from the tip of the prosthesis was considered migration and failure of the cement restrictor secondary to pressurization.11

Statistical analysis of the data was performed using the Kruskal-Wallis one way analysis of variance, Kruskal-Wallis multiple comparison z-value, and Fisher’s LSD multiple comparison test. A \( P \) value <.05 was considered significant. Statistical analysis of the PMMA restrictors was limited secondary to insufficient numbers.

RESULTS

Seventy-five procedures were performed on 72 patients who underwent cemented femoral component placement for either a primary THA or hemiarthroplasty. Eight different surgeons performed the procedures during the review period. Four patients were excluded due to inadequate documentation or radiographs. Therefore, 71 procedures performed on 68 patients (38 men and 30 women) with an average age of 70 years (range: 33-99 years) were evaluated. Forty-two of the cemented femoral components were performed on THAs and 29 on hemiarthroplasties. Four different types of distal femoral cement restrictors were identified (Table 1). The polyethylene cement restrictor was the most common type used (n=35) with PMMA the least common (n=4).

Performance of Restrictors

Radiographs were analyzed to determine the average length of the cement mantle for each of the restrictors. The length of the cement mantle was significantly less using bone versus polyethylene, bone versus Biostop G, and polyethylene versus Biostop G (\( P < .05 \)). Each of the restrictors was analyzed to determine the percentage of failures as defined by the length of the cement mantle >3 cm (Table 2). Polymethylmethacrylate had no failures. Bone had a 22% failure rate, and Biostop G had the most failures (50%).

Cement Grade

Using the grading classification system described by Barrack et al.,4 the bone cement restrictor demonstrated overall better cement grades with 91% grade A or B with no grade D. The Biostop G demonstrated the largest percentage of grade D mantles (14%). The PMMA restrictor demonstrated 100% grade A and B mantles in all four cases (Table 3). In comparing the overall length of the cement column to the cement grade, a significant trend was found. The length of the cement column for grades A and B was significantly less compared to column lengths for grades C and D cement (\( P < .0005 \)). No statistical significance was found between grades A and B or between grades C and D.

Distal Femoral Canal Width

The average width of the canal measured 16.4 mm (range: 10-26 mm). As the width of the femoral canal increased, the distance traveled by the cement restrictor increased, which was statistically significant (\( P < .0006 \)). This also correlated with the cement grade (\( P < .0007 \)).

Cement Type

Low viscosity cement (Orthoset 3 Radioopaque Bone Cement; Wright Medical Technology) was used in 37 procedures and high viscosity cement (Zimmer Bone Cement Dough Type;
Zimmer, Warsaw, Ind) in 31 procedures. No significant difference was noted when comparing the grade of the cement or the distal cement length with regard to the viscosity of cement used.

**Influence of Age and Sex**

No significant difference was noted when comparing the length of the cement mantle or the cement grade versus the age or sex of the patient. No significant difference was noted between the type of restrictor used versus the age or sex of the patient.

**Complications**

No complications such as fracture, cardiopulmonary event, or early loosening were reported.

**DISCUSSION**

The importance of establishing a superior cement mantle with second-generation cementing techniques has been established in the literature. Smith et al demonstrated a 5% femoral revision rate in long-term follow-up of 161 hips undergoing primary THA using a PMMA plug. Wroblewski and Siney demonstrated a 1% loosening rate at 14 years using bone as a restrictor. These rates are superior to the 30% loosening reported by Stauffer using first-generation cementing techniques. Katz et al reported a 29% loosening rate using first-generation techniques.

Numerous in vivo and in vitro studies in the literature compare the performance of femoral canal restrictors; however, no clear consensus has been established. To our knowledge, this is the first in vivo study comparing cement grades in primary THA and hemiarthroplasty using bone, Richards polyethylene plug, Biostop G, and PMMA restrictor. Bone performed better than the Richards plug and Biostop G restrictor. Although the numbers were too small for statistical analysis, the PMMA restrictor showed 100% cement grades A or B. Distalization of the restrictor has been advocated to deliver more antibiotic impregnated cement in a revision setting; however, most literature supports placement of the restrictor within 2 cm of the tip of the prosthesis.

Macromigration of the restrictor as defined by migration >5 mm distal to its insertion has been shown in vitro to significantly reduce pressurization and thus decrease interdigitation of the cement into the cancellous bone. The macromigration of bone was significantly less than the Richards or Biostop G restrictor. These radiographic results are consistent with the clinical results of Wroblewski and Siney. Results were different than those of Downing and Broodryk who reported a 9% distal migration rate using the Biostop G restrictor. Mallory using the Richards plug in 50 cases, reported excellent results and the ability of the plug to withstand pressurization of 100 psi.

As pressurization is lost from macromigration of the restrictor, the optimal interdigitation of 3-4 mm of the cement into the cancellous bone is lost and cement grades worsen. Excellent cement grades (A and B) were achieved in 91% of cases using bone and less when the Richards plug and Biostop G restrictor were used. Excellent cement grades were
significantly achieved when the distance traveled of the restrictor was <19.9 mm. This distance was statistically less than those distances occurring with fair or poor cement grades. Clinically, Smith et al.\textsuperscript{12} demonstrated that no femoral component loosened on long-term follow-up with a cement grade A or B. The high percentage of excellent cement grades in this study using bone are similar to the 100% A and B grades reported by Barrack et al.\textsuperscript{4} and Ballard et al.\textsuperscript{3} using PMMA restrictors. Smith et al.\textsuperscript{12} reported 33% grades A and B and 66% grades C, and suggested the decrease in excellent grades and increased accuracy was obtained when all radiographs were analyzed, not just those immediately postoperative.

Previous studies have reported no grade D cement mantles.\textsuperscript{3,4,12} Possible explanations for the large percentage of grade D cement mantles in our study are the multiple surgeons performing the operations and our lack of interobserver reliability. Other studies,\textsuperscript{28-30} however, have found only moderate interobserver reliability and high intraobserver reliability when grading cement mantles, and Kramhoft et al.\textsuperscript{30} recommended the same person perform radiographic comparisons.

The width of the femoral canal increases with age and the ability to withstand pressurization decreases as the width increases.\textsuperscript{27,31} The width of the canal significantly correlated with the distance traveled by the restrictor. As the canal width increased and the ability of the restrictor to withstand pressurization decreased, the cement grades significantly worsened. No statistical bias existed in selecting the type of restrictor used versus the size of the femoral canal, age, or sex of the patient.

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REFERENCES


