Intramedullary Plugs in Cemented Hip Arthroplasty

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Abstract: The use of intramedullary plugs in cemented total joint arthroplasty is currently considered standard practice by most surgeons. In this in vitro study, the authors evaluated the holding power, migration, and leakage of four commonly used plug types—bone, acrylic bone cement, and two polymeric plugs from different manufacturers. Only acrylic bone cement plugs prevented distal leakage of cement and did not migrate under the influences of pressurized cement injection. Key words: total hip arthroplasty, intramedullary plug, PMMA.

Each year in the United States, 200,000 total hip arthroplasties are performed (9). Long-term follow-up studies have demonstrated failure rates greater than 50% in young patients. Stauffer, in a 10-year follow-up study of 231 total hip arthroplasties, reported a 24% incidence of loosening of the femoral component at 5 years and 29.9% at 10 years (10).

New cementing techniques, such as medullary lavage, intramedullary plugs, and pressurized cement procedures (3, 4, 7), appear to have reduced the incidence of loosening. Harris et al. reported a 5-year follow-up study utilizing new cementing techniques in which the loosening rate was less than 2%. This was a marked improvement over a 24% loosening rate in 255 total hip arthroplasties reported by the same group but performed without intramedullary plugs (3).

The use of intramedullary plugs has been shown to increase the cement-bone interface pressure during prosthetic insertion (7). In present clinical practice, bone, polymeric, and methylmethacrylate plugs are used. Little basic research has been done to compare these plugs. Mallory et al. compared the behavior of three different intramedullary plugs by measuring pressure resistance after occlusion of the intramedullary canal with the various plugs. They concluded that polymeric plugs perform as well as methylmethacrylate plugs and that both were more effective than bone plugs. Mallory, also, claimed that polymeric plugs were better, due to the expedient nature of the insertion procedure (4). Wroblewski et al. claimed that cancellous bone plugs are superior due to the absence of tissue reaction (12). Still, other investigators prefer methylmethacrylate plugs over others (2, 3, 7).

The objective of this study was to assess the behavior of the clinically utilized plug systems under high sustained pressure.

Methods

Twenty human femurs were cut down to 40% of their initial length, reamed, and prepared appropriately to receive at random one of four types of intramedullary plugs. The intramedullary canal ranged in diameter from 9 mm to 14 mm. One type
of plug was produced by cutting a premeasured cylindrical section from a femoral head, as described by Miller (5), one type was made of PMMA cement, and the other two were polymeric plugs (manufactured by Dow Corning and Thackray). After the medullary canal was brushed and lavaged, a randomly selected plug type was inserted by an experienced orthopaedic surgeon. The PMMA plugs were made by introducing a bolus of PMMA cement with a syringe to the desired level of the intramedullary canal (7). The bone plugs and the Dow Corning polymeric plugs were sized 4 mm larger than the measured diameter of the intramedullary canals, as suggested by the manufacturers. The Thackray polymeric plugs are produced in one size that should fit all sizes of intramedullary canals, according to the manufacturer. A cement pressurization system designed in our laboratory was used with a specially constructed jig to apply sustained pressure to the intramedullary canals (1). The initial position of the plugs was recorded with a wire marker and the cement was pressurized at 100 psi within the canal proximal to the plug. This pressure level was selected because peak pressures greater than 100 psi have been measured in the distal aspects of medullary canals during simulated cadaver insertions (7). All of the specimens were monitored and recorded with pressure-time curves. Radiographs of the specimens were taken before and after pressurization to record any evidence of plug migration and/or leakage of cement into the intramedullary canal distal to the plug.

A score system was developed and used to assess plug migration and cement leakage to quantify the results (Tables 1, 2).

Tracings of the pressure-time curves were quantified by calculating the total time that three different pressure ranges were maintained (25–50, 50–100, >100 psi) during each pressurization.

### Results

Each of the five PMMA plug trials received a score of three. In addition, the PMMA plugs enabled the cement pressure to be maintained above 100 psi for greater than 6 minutes.

Four of the five bone plugs began to migrate as soon as pressure was introduced and continued to migrate to the bottom of the intramedullary canal. One specimen was held up due to a bone spur within the canal. All five specimens also displayed extensive cement leakage and did not maintain high intramedullary pressures, including the one specimen that had no evidence of migration.

All of the Dow Corning polymeric plugs were associated with extensive cement leakage. In addition, all the plugs migrated, with the exception of one that was held up by the large amount of cement which had quickly leaked into the distal portion of the intramedullary canal. High pressures were not maintained for a significant amount of the total time of the test (<1 minute).

The Thackray polymeric plugs were difficult to insert into the intramedullary canals that we tested. They appeared to be too large, and often there were pieces of the plug that broke off upon insertion into the canal. These plugs occasionally behaved in a similar fashion clinically. All of the five trials showed complete cement leakage. As described previously for one of the Dow Corning plugs, the cement that leaked immediately held up two of the Thackray plugs so that migration was minimal. In addition, high pressure (>100 psi) was not maintained.

### Discussion

The primary goal of plugging the intramedullary canal during total hip arthroplasty is to increase the

![Fig. 1. Relative ability to withstand >50 psi.](image-url)
penetration of cement into the cancellous bone proximal to the intramedullary plug. This results in greater penetration and may enhance prosthetic stability. It has been demonstrated that higher pressures in the intramedullary canal will produce greater cement penetration (6). Recent data on total hip arthroplasty done with contemporary cementing techniques have shown a femoral component loosening incidence of less than 2% at 5 years (3, 8). Although we cannot assume that this results solely from the plugging of the canal, these and earlier data (7) suggest that pressures of greater than 100 psi in the femoral canal should reduce the incidence of loosening. The PMMA plugs had the highest overall score and sustained pressures above 100 psi for the greatest total time, compared with all of the plug types tested. The plugs made of bone from the femoral heads and the Dow Corning polymeric plugs showed the poorest performance. The Thackray polymeric plugs demonstrated slightly better results than the Dow Corning plugs and the bone plugs, however they are not well-suited for intramedullary canal diameters less than 13 mm.

Our data does not support the concept of high or sustained pressurization of bone cement but do demonstrate the holding characteristics of the four systems evaluated. In addition, although we did not compare all of the (synthetic) plugs available, we believe that together with Noble et al. (6), we have demonstrated that plug selection is important to the clinician undertaking of cemented joint arthroplasty.

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References

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