Mechanical Evaluation of Unipolar Hip Spacer Constructs

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Abstract

The strengths of 3 hip spacer constructs—Steinmann pins, a short intramedullary nail (both cement-incorporated), and a Charnley prosthesis—were determined and compared with the strength of a commercially available hip spacer. The hip prosthesis construct was more than twice as strong as the other 2 constructs and was equivalent in strength to the commercial spacer. For spacer applications in which limited weight-bearing is anticipated, the hip prosthesis construct appears more efficacious, but its pros and cons should be compared with those of the commercial product.

Cement hip spacers are often used in 2-stage, infected prosthesis revision procedures to maintain soft-tissue spacing and allow limited patient mobility.[1-6] Typically custom-made by the surgeon, they can allow specific antibiotics to be mixed into the cement.[7-10] Various reinforcing elements (eg, pins, wires), often incorporated to increase strength, can also provide a framework for the spacer's construction. Sometimes a surface replacement head is added for improved articulation. Commercial spacers are also available.

We evaluated the strength of 3 spacer constructs that were made by adding various reinforcing elements to the cement and compared these constructs with a commercially available spacer.

Materials and Methods

Several Steinmann pins, short intramedullary nails with 2 lag screws (Trigen® TAN Nail; Smith & Nephew, Memphis, Tenn), and Charnley prostheses were obtained from pathology removals and used as endoskeletons for the hip spacer constructs. Simplex® bone cement (Stryker, Mahwah, NJ) was mixed until doughy and then hand-manipulated to surround and incorporate the selected reinforcing device. Four boxes of cement were required for the pins, 3 for the nails, and 2 for the prostheses. The cement was formed into a spacer approximating the shape of a hip endoprosthesis with a head of approximately 55 mm, a neck of 25 mm, and a length of 160 mm (Figure 1). We purchased 3 commercial spacers (InterSpace® Hip [medium size]; Exactech, Gainesville, Fla) made from bone cement containing gentamicin molded around a substantial stainless-steel central core (Figure 2).

Constructs were placed in Sawbones® composite femurs (Pacific Research Labs, Vashon, Wash) with femoral necks

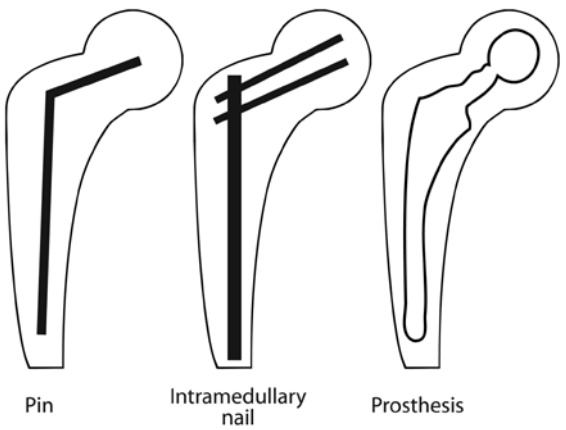

Figure 1. Schematic of construct configurations showing internal reinforcements within bone cement mantles.

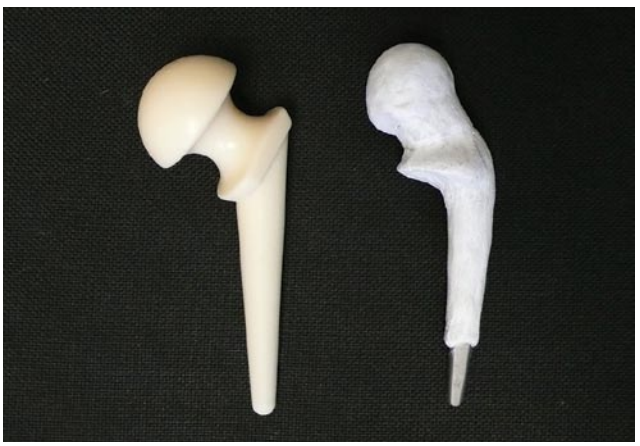

Figure 2. Commercially available spacer (on left) and handmade construct with prosthesis skeleton (on right; tip broke during testing), showing difference in surface finish.

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Table. Strengths of the 3 Constructs Compared With a Commercial Spacer

Device	Strength (N)	SD
Pin construct	832	300
Nail construct	1275	270
Prosthesis construct	3000[a]	0
Commercial spacer	3000[a]	0

[a]Maximum applied test load.

removed and canal reamed. These specimens were then held in a vise at 25° to simulate a one-legged stance and were loaded using a servohydraulic testing machine (MTS Systems, Eden Prairie, Minn) at a rate of 1 cm/min until failure or 3000 N (3-4 times body weight and the limit of the composite femurs). Eight specimens were tested for each construct, 3 for the commercial spacers.

Results

All constructs based on the Charnley prostheses and the commercial spacers did not fail at 3000 N; the other 2 constructs failed at significantly lower loads ($P<.001$; unpaired t test). Results are listed in the Table.

Discussion

The data showed that some constructs were significantly weaker than others and may be predisposed to catastrophic implant failure, as even the loads across the hip of a bedridden patient can be greater than body weight.[9] These constructs typically have to function for a minimum of 6 weeks and as a result are subjected to cyclic loading during ambulation that could cause fatigue failure, which was not evaluated in this study.

Handmaking a cement spacer construct in the operating room also has its costs, including those for the endoskeleton (or potential problems with device reuse), the cement, the antibiotic, and operating room time for fabrication and for waiting for the cement to cure. In addition, the hand-finished, cemented head is not ideal for articulation (Figure 2). As a result, various custom molds have been used,[10,11] including injecting cement into an irrigation bulb to form the head. A surface replacement head can be applied to a construct to improve articulation. Another option, which we did not study, is use of an endoprosthesis as a construct skeleton, which leaves the head free of cement.

Another potential problem is sizing. Spacers act as an endoprosthesis and should optimally fit both the femoral canal and the acetabulum. With a handmade construct, it is difficult to fabricate the construct spacer to an exact size based on radiographs or intraoperative measurements. A commercial spacer is limited to available sizes.

We recommend that each hospital conduct a cost analysis to determine whether a commercial spacer is cost-effective. In our case, it was approximately 20% higher in cost. Also to be considered are other factors, such as surgeon preference and possible legal liability. In addition, with commercial spacers, the cement antibiotic cannot be customized.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

References

1. Evans RP. Successful treatment of total hip and knee infection with articulating antibiotic components: a modified treatment method. *Clin Orthop*. 2004;(427):37-46.
2. Durbhakula SM, Czajka J, Fuchs MD, Uhl RL. Spacer endoprosthesis for the treatment of infected total hip arthroplasty. *J Arthroplasty*. 2004;19(6):760-767.
3. Hsieh PH, Shih CH, Chang YH, Lee MS, Shih HN, Yang WE. Two-stage revision hip arthroplasty for infection: comparison between the interim use of antibiotic-loaded cement beads and a spacer prosthesis. *J Bone Joint Surg Am*. 2004;86(9):1989-1997.
4. Hsieh PH, Chen LH, Chen CH, Lee MS, Yang WE, Shih CH. Two-stage revision hip arthroplasty for infection with a custom-made, antibiotic-loaded, cement prosthesis as an interim spacer. *J Trauma*. 2004;56(6):1247-1252.
5. Yamamoto K, Miyagawa N, Masaoka T, Katori Y, Shishido T, Imakiire A. Clinical effectiveness of antibiotic-impregnated cement spacers for the treatment of infected implants of the hip joint. *J Orthop Sci*. 2003;8(6):823-828.
6. Morimoto S, Futani H, Ogura H, Okayama A, Maruo S. Successful reimplantation of total femoral prosthesis after deep infection. *J Arthroplasty*. 2003;18(2):216-220.
7. Affatato S, Mattarozzi A, Taddei P, et al. Investigations on the wear behaviour of the temporary PMMA-based hip Spacer-G. *Proc Inst Mech Eng (H)*. 2003;217(1):1-8.
8. Takahira N, Itoman M, Higashi K, Uchiyama K, Miyabe M, Naruse K. Treatment outcome of two-stage revision total hip arthroplasty for infected hip arthroplasty using antibiotic-impregnated cement spacer. *J Orthop Sci*. 2003;8(1):26-31.
9. Brown RH, Burstein AH, Frankel VH. Telemetering in vivo loads from nail plate implants. *J Biomech*. 1982;15(11):815-823.
10. Shin SS, Della Valle CJ, Ong BC, Meere PA. A simple method for construction of an articulating antibiotic-loaded cement spacer. *J Arthroplasty*. 2002;17(6):785-787.
11. Pearle AD, Sculco TP. Technique for fabrication of an antibiotic-loaded cement hemiarthroplasty (ANTILOCH) prosthesis for infected total hip arthroplasty. *Am J Orthop*. 2002;31(7):425-427.