Cement Penetration Using a Tibial Punch Cement Pressurizer in Total Knee Arthroplasty

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abstract

This study describes a new tibial cement punch pressurizer to enhance cement penetration into the metaphyseal cancellous bone of the tibial plateau. Thirty knees of 15 patients undergoing simultaneous bilateral total knee arthroplasty (TKA) were randomly selected to receive the tibial cement punch pressurizer on one side, with the opposite side serving as control. Using computerized and radiographic evaluation of both knees 2 weeks postoperatively, the punch pressurizer achieved 1.32 times better penetration of the cement. The tibial punch cement pressurizer offers a simple technique to provide reliable cement penetration and tibial component fixation in TKA.

A septic loosening of the tibial component remains a limiting factor in the long-term success of total knee arthroplasty (TKA). Since the introduction of polymethyl methacrylate bone cement in the 1960s for major joint replacements, modifications and upgrades in materials and components have enhanced the long-term outcomes for TKA and total hip arthroplasty (THA). Improvements have been made in hip cementing techniques favoring the use of cement pressurization devices of the femoral and acetabular components in THA.

Improvements in cementing techniques in TKA have been described previously. Norton and Eyres describe a technique using suction through trocars placed beneath the medial and lateral tibial plateaus. Once the bone surface is covered with cement, suction through the trocars sucks bone cement into the metaphyseal bone. Maistrelli et al demonstrated that the penetration of tibial cement is significantly increased by using pulsed lavage versus bulb syringe irrigation of the cancellous surfaces.

The goal of cement delivery is to achieve generous intrusion of cement into the trabecular bone of the prepared tibia to permit the component to be securely bonded to the tibia.

Norton and Eyres improved cement penetration into the bony trabeculae of the tibia with a combination of bone suction and pressure lavage irrigation. However, because of the knee’s anatomy, designing a cement pressurization instrument for use in TKA has not been attempted.

A new instrumented pressurizer (Symmetry Medical, Warsaw, Ind) allows a sustained and even penetration of cement into the tibial plateau bone in TKA. The goal of cement delivery is to achieve generous intrusion of cement into the trabecular bone of the prepared tibia to permit the component to be securely bonded to the tibia. To assess cement pressurization in the proximal tibia during TKA, the efficacy of the tibial punch pressurizer was compared with manual cement packing.

MATERIALS AND METHODS

All patients undergoing simultaneous bilateral TKA between July and September 2002 were evaluated for inclusion in this study. The indication for all operations was bilateral knee pain due to osteoarthritis unresponsive to medical treatment and...
that interfered with activities of daily living. The criteria for inclusion in the study were a diagnosis of osteoarthritis and bilateral TKA.

A power analysis was conducted to determine the sample size necessary to demonstrate a difference resulting from the use of a tibial punch cement pressurizer in TKA. With a one-tailed or unidirectional analysis, approximately 15 patients per group are required.11

Thirty consecutive bilateral TKAs were performed in 15 patients during the study period; all 30 procedures were included in this prospective report. Patients were evaluated 2 weeks postoperatively and a radiographic assessment was performed. No patient was lost to follow-up.

Confidentiality
To maintain patient confidentiality during the investigation, each patient was assigned a unique identification number. Patients’ names and identification numbers were kept separately, so that the analysis of the data was performed without any knowledge of the patient’s identity. Randomization was accomplished using the patient’s year of birth. Patients with an even birth year were subsequently managed with the tibial punch cement pressurizer on the right knee and those with an odd birth year were managed with the tibial punch cement pressurizer on the left knee. In either case, the opposite knee was used as a control.

Surgical Technique
All patients underwent bilateral TKA. Surgery was performed sequentially rather than simultaneously, and the most painful knee was operated first regardless of the study randomization and use of the tibial punch cement pressurizer.

Surgery was performed in a standard fashion, with tourniquet control at 100 mm Hg above systolic blood pressure.12 After the appropriate bone cuts were made, multiple fenestrations were pierced into the tibial metaphysis using a tibial punch (Figure 1). A 1/8-inch drill bit was used to make fenestrations in the patella and distal femur.

With the tibial punch, ten 15×3-mm holes were accomplished with a single mallet strike. The bone surfaces were then washed thoroughly with a pulsed pressure lavage system. Once a dry cancellous surface was achieved, the cement dam was positioned and an adequate amount of cement was poured in while still in its low-viscosity state (Figure 1). The cement punch pressurizer and a mallet were used to drive the cement into the bone (Figure 1). The tibial component was inserted. The remaining steps of the procedure, including femoral cementation and implantation, were carried out as in any other TKA.

Surgery on the control knees was performed following the same steps, but the cement dam and punch pressurizer were not used. Standard bone cement (Osteobond; Zimmer, Warsaw, Ind) was mixed for 1 minute and applied at 2 minutes in all cases.

Radiographic Findings
Routine radiographs included weight-bearing anteroposterior, lateral, and skyline views of both knees. Radiographs were reviewed by an investigator (K.Y.) who was blinded to the surgical technique and cementing method. All radiographs were analyzed by zones as suggested by the Knee Society.13

To achieve optimum flow and mechanical interdigitation, the cement should be injected and pressurized while its viscosity is relatively low to obtain maximum penetration into cancellous bone.
Jose, Calif). The fibular head was used for density control as the photographic qualities (ie, radiograph technique, camera exposure, amount of light, etc) vary from patient to patient. Side-to-side ratio (pressurized/control) was calculated, and 95% confidence interval (CI) was estimated.

RESULTS

Radiographic assessment showed a remarkable difference of cement intrusion when the tibial cement pressurizer device was used (Figure 2). Radiographs revealed the cement within the invaginated zones in the pinholes on both study groups and control groups. However, the cement showed a more amorphous pattern and diffuse penetration on the non-pressurized side, whereas the cement was more delineated and advanced further distally on the pressurized side, and a prominent radiopaque layer was consistently present.

The radiographic density results for all patients are summarized in the Table. All 15 patients achieved a better cement intrusion in the study knee with an average 1.32 density ratio (range: 1.01-1.89). The knees prepared with pressurized cement impaction showed a better intrusion than those processed without the cement pressurizer. The average density of cement intrusion in the study group was 1.32 times higher than the control group. This difference was statistically significant (95% CI, 1.2-1.5). When Knee Society score zones were evaluated in sections, zones 3 and 4 achieved the best cement intrusion possible for a 1.38 density ratio (95% CI, 1.2-1.6); whereas zones 1 and 2 accomplished 1.27 (95% CI, 1.2-1.4).

DISCUSSION

Specific measures that seem to have the greatest impact on the longevity of cemented THA are better cementing techniques, including pressurization of cement and better control of mantle thickness. The strength of the cement-bone interface is related to cement intrusion into the bone. The depth of cement intrusion, in turn, is correlated with the cement-intrusion pressure. Thus, adding cement pressurization to the tibial component of cemented TKA may further increase the long-term durability of fixation.

During polymerization, polymethyl methacrylate bone cements have complex viscoelastic characteristics. Within a short working time, they transform from dough-like consistencies to solid cement. Therefore, the time at which the cement is introduced into cancellous bone surfaces and subjected to pressure is important. To achieve optimum flow and mechanical interdigitation, the cement should be injected and pressurized while its viscosity is relatively low to obtain maximum penetration into cancellous bone. Achieving adequate mechanical interlock increases the area for load transfer and

Cement penetration achieved with this technique gives an optimal depth of intrusion (2-6 mm) for adequate strength of the bone-cement composite.
What is already known on this topic

- Better cement intrusion provides better component fixation.

What this article adds

- This article shows a means of improving tibial component fixation.

reduces localized bone-cement interface stresses.\textsuperscript{15}

The authors have used tobramycin-impregnated Osteobond cement for the past 7 years without any perceptible change in the polymethyl methacrylate polymerization properties. However, because of national shortage of tobramycin, we have been forced to mix vancomycin into the cement powder, detecting a significant reduction in the viscoelasticity and a more doughy consistency is achieved faster, thus the time the bone cement is manageable shortens. We predict a better cement penetration when using tobramycin in the cement powder and a forthcoming study is planned. Mixing the acrylic for /H11088\textsuperscript{3} minutes prior to manual packing or pressurization into bone prepared by pulsating lavage is also suggested.

Clinical use of this technique has improved intrusion, as evidenced by post-operative radiographs. Cement penetration achieved with this technique gives an optimal depth of intrusion (2-6 mm) for adequate strength of the bone-cement composite. Finally, bilateral TKA represents the ideal setting for this study, as all variable differences are minimized and a homogeneous group is achieved.

Conclusion

The results of this study demonstrate that cement impaction using a pressurizing instrument provided a significant increase in cement-bone intrusion over conventional manual cement packing in TKA. Cementing techniques that use higher pressurization of cement are recommended; in this setting, the tibial punch-cement pressurizer allowed a 1.32 times better cement intrusion than manual packing.\textsuperscript{12}

References