Infection is one of the most disturbing and frightening complications of total knee arthroplasty (TKA) being one of the most feared complications in orthopaedic surgery. The treatment of periprosthetic infections (PPI) after TKA associated with bone destruction and massive loss, severe instability, recurrent infection usually includes removal of all prosthetic components, debridement of the joint, and insertion of an antibiotic-impregnated cement spacer. This spacer offers no adequate mechanical support. To improve the mechanical stability, we present an alternative for filling the joint space and linked bones with a stable antibiotic-impregnated cement rod-spacer. This rod-spacer can be custom-made at the time of surgery using Steinmann pins, any intramedullary nail, Rush rods, Harrington spine rods, bone cement (polymethylmethacrylate), and antibiotics. The technique, its advantages, and the results of clinical use over a 7-year period are described.

MATERIALS AND METHODS
This technique was used in 9 cases over a 6-year period. All cases have been followed clinically. There were 7 cases of chronic PPI and 2 cases of acute PPI. Eight patients have had multiple surgeries (from 3 to 16, on average 7) with recurrent infection, bone destruction and loss, severe instability or deformity. Medical history was aggravated by morbid obesity (4 cases), diabetes mellitus (2 cases), chronic lymphoma (1 case), vascular injury with insufficiency (1 case), and hypothyroidism (1 case). After all prosthetic components are removed, a meticulous debridement of all infected and nonviable tissues is performed, and extensive pulse lavage irrigation with antibiotic solution is done. The femoral and tibial intramedullary canals are reamed with flexible reamers. Then the canals are also irrigated with pulse lavage. Three to six 40-gram packs of Palacos bone cement (Heraeus Kulzer GmbH, 61273 Wehrheim, Germany) with 2 grams of vancomycin and 2.4 grams of tobramycin per pack of cement are usually used. The Steinmann pins, any intramedullary nails, Rush rods, or Harrington spine rods are chosen depending on the anatomy encountered. A cylinder of antibiotic-impregnated cement is placed over the chosen rod and well molded to completely coat the rod with 1-2 mm of cement. With the femoral and tibial intramedullary canals exposed, the cement-coated rod is placed into the canals to ensure that there would be no difficulties with inserting the rod. While the cement is in the final stage of curing, the antibiotic-impregnated cement rod is placed within the intramedullary canals. The most used way to insert the rod within the canal is the insertion of the rod retrograde up in the femur with the knee in flexion, then knee is extended and the rod is inserted antegrade down within the tibia. While traction is maintained across the knee, extra antibiotic-impregnated cement is used to fill the space between the tibia and femur forming an antibiotic-impregnated cement rod-spacer in order to preserve length and improve stability (Figure 1). Adequately molding the antibiotic-impregnated cement rod-spacer allows a good soft tissue closure. A knee immobilizer is used for additional protection. Postoperatively, the patients are allowed toe-touch weight bearing immediately ambulating with crutches or a walker. The patients are advanced to partial weight bearing with support over the ensuing 6 weeks. The patients undergo appropriate intravenous antibiotic therapy based on the culture reports for 6-8 weeks or more as needed.

RESULTS
All patients presented with pain, swelling, elevated erythrocyte sedimentation rate and C-reactive protein. Four patients underwent a second stage TKA reimplantation with long stem femoral and tibial components. No bone graft was used in these patients. The reimplantation was done at approximately 3 months in three patients, and at 20 months in one patient. Patients were able to ambulate with crutches or a walker and were household or community ambulators in the time between the first and second stage. They received 6-8 weeks of intravenous antibiotics after antibiotic-impregnated cement rod-spacer implantation. All four patients are doing well at an average follow up of 4 (2 to 7) years. Four patients ended up with a knee arthrodesis using long intramedullary nails. All these patients have a fusion confirmed radiologically. They are doing well an average follow up of 3 (2-4) years follow up. An eighty-five years old patient has chosen the antibiotic-impregnated cement rod-spacer as definitive treatment option.

DISCUSSION
For the staged management of infected total knee arthroplasty, antibiotic laden polymethylmethacrylate spacers have been recommended. Antibiotic-impregnated cement spacers target drug delivery, achieving high local levels while limiting the potential for host toxicity associated with parenteral antimicrobial therapy.
However, most proposed antibiotic-impregnated cement spacers do not provide adequate mechanical support. Antibiotic cement nails are used to treat infected tibial fractures, septic tibial nonunions, and intramedullary infections. We have extended the concept of antibiotic cement nails and developed an alternative for filling the collapsible joint space and linked intramedullary non-collapsible dead space with a stable antibiotic-impregnated cement rod-spacer. The antibiotic-impregnated cement rod-spacer has the advantages of having a large surface area, a high antibiotic concentration, and an adequate porosity of the cement maximizing antibiotic elution. The resourcefulness in choosing the endoskeleton for the rod-spacer makes this a versatile technique applicable to the wide range of anatomy encountered.
In cases with infected knee arthroplasty having bone destruction, severe instability or deformity, resection arthroplasty with insertion of an antibiotic-impregnated cement rod-spacer for fixation and stabilization could be an effective resource. It is easy to use. The cement can be loaded with antibiotics according to the culture results and sensitivity. This rod-spacer does not only provide stable fixation across the knee and local antibiotic delivery, but it has also a beneficial role in maintaining the joint space and preservation of soft tissue tension around the joint due to enhanced stability and length maintaining advantage. The antibiotic-impregnated cement rod-spacer maintains limb length and knee joint space making subsequent reimplantation technically easier. It gives immediate stability making patient rehabilitation and management much comfortable. The rod-spacer allows rapid mobilization, a higher functional level, and less pain than the use of a simple antibiotic-impregnated spacer. Based on our experience, we believe that the antibiotic-impregnated cement rod-spacer is a valuable technique in treating difficult cases of total knee PPI. While our experience is limited to a small group of patients, future controlled prospective trial or multicenter study for determining the validity of this antibiotic cement rod-spacer is desirable.