Technical Note

Computer-Assisted Fluoroscopic Navigation System for Removal of Distal Femoral Bone Cement in Revision Total Hip Arthroplasty

Haruhiko Akiyama, MD, PhD, Keiichi Kawanabe, MD, PhD, Koji Goto, MD, PhD, Eijiro Ohnishi, MD, and Takashi Nakamura, MD, PhD

Abstract: Removal of the femoral bone cement in revision total hip arthroplasty with a high-powered drill or burr potentially has a risk of damage to the bone, resulting in perforation and fracture of the femur. Recently, we have used a computer-assisted fluoroscopic navigation system for the revision of cemented total hip arthroplasty with a high-powered burr and completely removed the distal femoral bone cement with no complications in 6 cases. Thus, a computer-assisted fluoroscopic navigation system is a useful tool for the improvement of the surgical technique in revision total hip arthroplasty. **Key words:** computer-assisted fluoroscopic navigation system, total hip arthroplasty, high-speed burr.

Removal of the femoral bone cement is required for preparation of proper implant bed for reimplantation of a new femoral component in revision total hip arthroplasty (THA). A transfemoral approach and a femoral cortical fenestration provide good exposure and direct visualization of the cement in the femoral canal. However, these procedures induce weakness of the bone, resulting in intraoperative femoral fractures and postoperative periprosthetic fractures. Several devices and procedures have been developed for cement removal, including an extracorporeal shock wave lithotripter and yttrium-aluminum-garnet laser, as well as a high-powered drill or burr under the control of conventional fluoroscopic images and an intrafemoral endoscopy [1,2]. Ultrasonic tools are efficient for the removal of bone cement with minimal damage to the bone [3]. We use a high-powered burr to remove the deep femoral bone cement under the control of conventional fluoroscopic images, although the problem with this procedure is large exposure to x-ray and 2-dimensional viewing of burr position, which can result in perforation in the third plane [4].

A computer-assisted fluoroscopic navigation system allows the surgeons to provide positional information about surgical instrument to target bones during operations [5,6]. Two-dimensional image data are obtained using the fluoroscope with a reference frame and stored on a computer workstation. A camera interfaced with the computer then tracks the position of the patient and the

From the Department of Orthopaedics, Kyoto University, Kyoto, Japan.
Submitted September 2, 2006; accepted November 26, 2006.
No benefits or funds were received in support of this study.
Reprint requests: Haruhiko Akiyama, MD, PhD, Department of Orthopaedics, Kyoto University, 54 Kawahara-cho, Shogoin, Sakyo, Kyoto 606-8507, Japan.

0883-5403/07/1906-0004$32.00/0
doi:10.1016/j.arth.2006.11.010

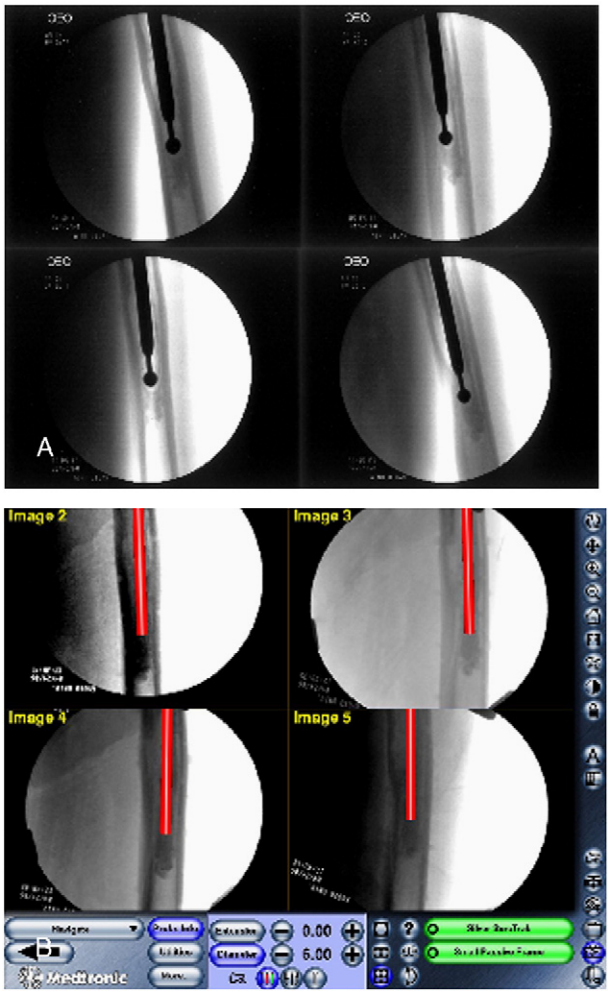

Fig. 1. Fluoroscopic images of the high-speed burr (A). Navigation removal of distal femoral cement (B). Virtual images of the high-speed burr superimposed onto the 4 femoral images on the computer workstation.

registered surgical instruments during the procedure. The predicted position and trajectory of the surgical instrument equipped with a reference frame are displayed onto the stored images on a computer workstation. Taking advantage of the real-time guidance of computer-assisted fluoroscopic navigation system, we present a technique for the removal of femoral bone cement using a fluoroscopy-based computerized navigation system.

Surgical Methods

The computer-assisted fluoroscopic navigation system (StealthStation TRIA plus, FluoroNav; Medtronic Surgical Navigation Technologies, Louisville, Colo) was used for the revision of cemented THA in 6 patients. The reference frame with light-emitting diodes was fixed at the distal femur to enable spatial tracking in relation to the patient's anatomy during the operation. C-arm images of 4 directions (anteroposterior, lateral, and bilateral oblique) were harvested with a C-arm equipped with a calibration target under the tracking infrared camera and were transferred to the computer workstation. The SureTrak2 (Medtronic Surgical Navigation Technologies) infrared-emitting active instrument tracker was attached to the high-speed burr and was calibrated against the reference frame. The position of the high-speed burr and its trajectory were superimposed onto the acquired C-arm images. Afterward, during the operation, the real-time position of the high-speed burr was overlaid onto the images on the computer workstation as the infrared camera was tracking the high-speed burr relative to the reference frame at the distal femur. Cement in the femoral canal was removed using the high-speed burr under its virtual image superimposed onto the 4 femoral images on the computer workstation (Fig. 1A and B). As a result, the new implant beds were prepared and the new stems were fixed with bone cement without any complications including femoral perforation and/or fractures in all patients.

Discussion

Computer-assisted fluoroscopic navigation system was introduced in 1999 [5]; and recently, it has come into use for a variety of orthopedic surgical procedures, including femoral intramedullary nailing, pelvic surgeries, pedicle screws in the spine, and THA in osteopetrosis [7-10]. The expansion of the indication spectrum is due to several advantages in comparison with conventional fluoroscopy and computed tomography (CT)–based navigation system. During removal of the cement from the femoral canal, we depend on conventional intraoperative fluoroscopy to observe the tip of the high-speed burr or drill for avoiding operative complications. However, the disadvantage of this technique is that the patients and the surgeons are exposed to a significant amount of radiation because of the reliance of fluoroscopy on real-time monitoring during the procedure. In addition, a high-speed burr or drill is very useful for the removal of femoral bone cement and enables the surgeons to reconstitute a femoral canal for an adequate implant bed quickly because it removes residual bone cement and reams the endosteum. However, this advantage increases the risk of femoral fenestration and/or