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CASE REPORT

Case Report

Femoral Shaft Fracture Resulting From Femoral Tracker Placement in Navigated TKA

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Abstract Computer-assisted navigation is a surgical tool that may decrease malalignment outliers in TKA. With any new surgical technique, there is the possibility of unexpected complications that raise caution. We report two patients with displaced femoral fractures at optical tracker pin placement sites created for routine performance of navigated TKA. Our experience suggests single bicortical 5-mm pins placed in the femoral shaft have the added risk of creating a stress riser leading to the potential for fracture. Females may have a higher risk for this complication. We believe bicortical pin fixation in the femur or tibia no longer is indicated.

Introduction

Computer-assisted navigation offers considerable improvement for more reliably achieving lower extremity alignment than conventional instrumented TKA techniques [1, 4, 5, 7, 12, 17, 19, 21]. The importance of this new technique is underscored by the potential for early TKA failure if the surgeon does not create neutral alignment within 3° of the mechanical axis [9, 16].

Potential problems from application of computer-assisted navigation may include pin site infections, referencing mistakes made by the surgeon, tracking errors, soft tissue morbidity from tracker placement, and fracture of the tibia or femur from pin placement. Others have reported the occurrence of femoral shaft fractures after use of surgical navigation in TKA [8, 11, 15].

We report two patients with displaced femoral fractures resulting from the usual placement of a bicortical 5-mm threaded pin into the distal femoral shaft from a consecutive sequential series of 70 patients operated on during a 5-month period in which computer-assisted navigation was used in TKA. Both patients had a complicated clinical course with retrograde intramedullary nailing to treat the periprosthetic fracture.

Case Reports

Patient 1

A 71-year-old woman underwent bilateral TKAs performed with adjunct computer navigation using the Stryker 3.2 system (Stryker Orthopaedics, Mahwah, NJ) with the imageless total knee referencing protocol. The patient was 160 cm in height and weighed 106 kg with a body mass index of 42 kg/m^2. Preoperative bone density studies had not been obtained in this patient. A bicortical 5-mm threaded pin was used for tracker placement and was placed anterior to posterior approximately 10 cm above the joint line. The surgical procedure and postoperative

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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recovery were uneventful and the patient was walking normally at the 6-week followup. While rising from a chair 9 weeks postoperatively, the patient sustained a displaced distal femoral fracture at the site of the prior pin placement (Fig. 1). The patient was asymptomatic at the time of the fracture. The periprosthetic fracture was treated with a retrograde femoral nail. The patient was diagnosed with occult infection of the TKA 7 months postoperatively after biopsy revealed inflammatory cytology with greater than 10 leukocytes per high-powered field, although cultures were negative. This patient underwent successful two-stage débridement and reimplantation revision TKA.

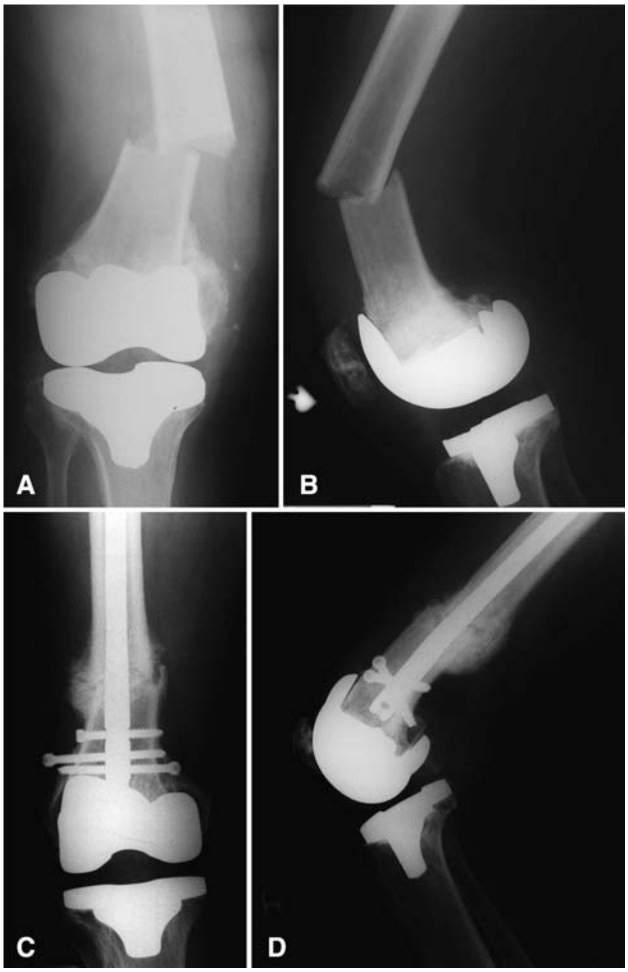

Fig. 1A–D (**A**) Anteroposterior and (**B**) lateral radiographs of a 71-year-old woman show a displaced distal femoral fracture at the optical tracker pin placement site 9 weeks postoperatively. (**C**) Anteroposterior and (**D**) lateral radiographs show the fracture after retrograde intramedullary nailing.

Patient 2

A 77-year-old woman underwent a right TKA in June 2006. She was 162 cm in height and weighed 70 kg with a body mass index of 27 kg/m^2. Bone density studies had not been obtained to determine the presence of osteoporosis. The procedure was performed using the Stryker 3.2 system with the imageless total knee referencing protocol. A 5-mm threaded bicortical pin was placed approximately 12 cm above the joint line for femoral tracker placement (Fig. 2). However, because of difficulty achieving rigid stability of the femoral pin, several passes were made with the pin. The surgical procedure and postoperative recovery were satisfactory and the patient had excellent range of motion and walking ability at 6 weeks followup. While rising from a chair 3 months postoperatively, a displaced femoral fracture occurred through the prior femoral pin placement site. The patient had been asymptomatic. The patient underwent retrograde femoral nail placement and had an uneventful recovery.

Discussion

Femoral shaft fracture is an uncommon event but has been recognized in certain cases in which there has been compromise of the bone through biologic processes such as chronic osteoporosis or mechanical issues such as surgical bone window or drill hole placement [3, 6, 18]. Cortical

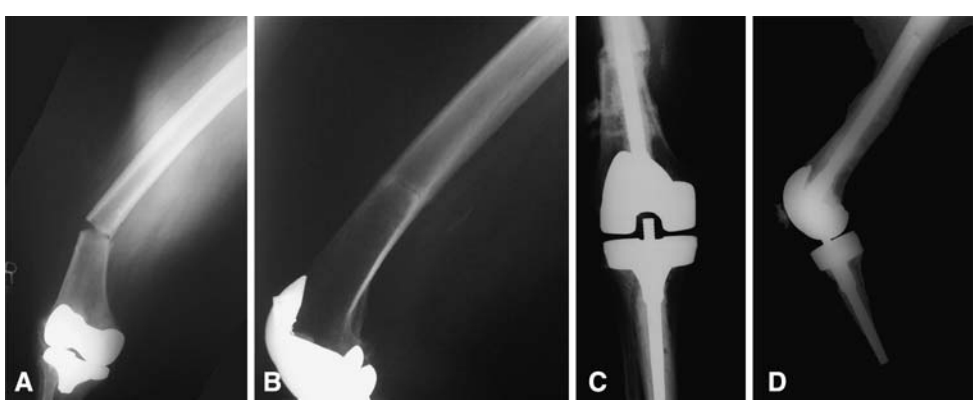

Fig. 2A–D (**A**) Anteroposterior and (**B**) lateral radiographs of a 77-year-old woman show a displaced distal femoral fracture at the optical tracker pin placement site 3 months postoperatively. (**C**) Anteroposterior and (**D**) lateral radiographs show the fracture after retrograde intramedullary nailing.

bone, being an anisotropic structure, has lower torsional strength across the axis of the bone. Biomechanical studies have shown the potential of screw or drill holes to diminish the bending strength and energy absorption potential of cortical bone by as much as 40% [2, 10]. Torsional stress is proportional to the load force divided by the unit cross-sectional area of the loaded structure. In the simple calculation of the amount of cylindrical bone removal from unicortical pin sites, the hole of a 5-mm pin would remove 2.78 times more bone than a 3-mm pin. Obviously, this number doubles in the transverse plane of the femoral shaft with bicortical pin placement causing higher torsional stress for a given load. Bicortical pin placement in diaphyseal cortical bone should be avoided if possible.

Other cases of anecdotal fracture have been reported after placement of navigation tracker pins. Ossendorf et al. [15] first described a femoral fracture after navigation tracker pin placement. They noted repeated violations of the femoral cortex trying to secure the femoral tracker pin. Li et al. [8] reported a supracondylar femoral fracture that occurred 1 month after TKA in which three 3-mm pins had been used for optical tracker anchorage. The initial fracture was only splinted and the patient subsequently had a completely displaced distal shaft fracture treated with intramedullary rod fixation. Jung et al. [11] reported two patients in whom 2.8-mm pins caused a displaced distal femoral shaft fracture at 5 weeks and a nondisplaced midshaft tibial fracture at 6 weeks postoperatively. They noted transcortical pin placement with eccentric drilling through the cortex might create a more detrimental scenario for fracture. As all four of these reported fractures occurred in females and combined with our experience, we question whether females are at higher risk for fracture.

Marchant et al. emphasized specific issues regarding placement of navigation tracker pins in the distal femur. In one anatomic study, the findings indicated the close proximity of the popliteal vessels to potential injury with bicortical placement of tracker pins in the anteroposterior direction in typical total knee approaches [13]. They reported that 100% of pins placed in the distal femur from anterolateral to posterior medial were within 5 mm of the popliteal artery and vein. Mihalko et al. investigated multiple scenarios for computer-assisted surgery tracker pin fixation including unicortical and bicortical pins of 3- or 5-mm dimension and cortical or metaphyseal bone placement [14]. They suggested two-pin placement is optimal for dynamic reference base tracker anchorage, and they could find no difference when two pins were used in cortical or metaphyseal bone [14]. This implies effective pin placement for navigation trackers could be placed distally in the metaphyseal bone, avoiding creating stress risers in the femoral shaft. Using percutaneous transepicondylar placement for femoral tracker pins, Stiehl reported no clinical complications in 86 patients [20]. Cited advantages of the method included easy access to the intramedullary canal for rod placement of femoral cutting instruments, avoidance of the normal cut surfaces for a typical femoral implant, the ability to perform a minimally invasive incision without binding or interfering with the quadriceps mechanism, and placing the trackers in the medial sagittal plane away from the usual surgical field.

Our experience has led us to avoid single 5-mm bicortical pins placed in the distal femoral shaft in favor of two-pin tracker jigs placed in a unicortical fashion and transversely or obliquely in the metaphyseal bone of the distal femur. The manufacturer of the system no longer sells 5-mm pins for this purpose and the current protocol avoids pin placement in the femoral shaft. We have now followed 130 subsequent patients in whom two 3-mm pins have been used with no additional fractures reported to date.

The use of smaller pins with double pin-fixated trackers placed in the metaphyseal areas of the distal femur appears to be the safest method for tracker anchorage. Based on the limited anecdotal experience, females may be at greater risk. Any patient who presents with unexpected pain at the site of a tracker pin during the early postoperative period should be evaluated for a potential fracture and treated with appropriate followup care.

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