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CASE REPORT

Fixation of Intertrochanteric Fractures of the Hip With a Carbon Fiber Intramedullary Implant

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Summary: Fractures in the intertrochanteric region are among the most commonly treated operative orthopaedic injuries. Implant selection has gradually trended away from compression hip screws toward cephalomedullary nails. Carbon fiber–reinforced polyaryletheretherketone (PEEK) has been introduced as an alternative material in the construction of intramedullary nails and plates. We describe the use of a carbon fiber cephalomedullary nail to treat an intertrochanteric fracture in an 87-year-old male patient, leading to uncomplicated fracture healing.

Key Words: intertrochanteric, carbon fiber, fracture, cephalomedullary nail

INTRODUCTION

Among fractures with absolute operative indications, intertrochanteric fractures of the femur have a high incidence.[1] The majority are associated with low-energy mechanisms in elderly/osteoporotic patients,[2] whereas high-energy mechanisms cause similar patterns in younger populations.[3] With nonoperative treatment leading to protracted bedrest, persistent pain, and associated complications, operative management is the treatment of choice in all but the most debilitated patients, for whom palliative care may be a reasonable alternative. Furthermore, the incidence of intertrochanteric fractures may be expected to rise with the increasing age of the population.[4]

Goals of operation with intertrochanteric fractures are restoration of anatomy and provision of stable fixation. As many patients with these fractures have multiple medical comorbidities and increased risk of complications, minimizing the surgical time and tissue/physiologic insult are also priorities. In part due to these other considerations, the treatment of intertrochanteric fractures has evolved rapidly in the past 20 years, with a pronounced shift away from the use of compression hip screws toward the use of cephalomedullary nails.[5] Although outcomes with these 2 techniques have been shown to be equivalent in stable intertrochanteric fracture patterns,[6] investigation has also shown less shortening with the use of nails, likely due to the presence of a medullary buttress.[7]

Complications of surgical management include general surgical risks, such as infection, nonunion, and neurovascular injury. However, the incidence of these is low in intertrochanteric fractures; rather, the historically most feared complication was failure of fixation, specifically lag screw cutout, in this anatomic region subject to high load-bearing stress. Such failures are largely preventable by minimization of the tip–apex distance, defined as the sum of the distances between the tip of the lag screw and the apex of the femoral head on the anteroposterior (AP) and lateral radiographic views.[8] The importance of tip–apex distance has proven itself applicable to both compression hip screws and cephalomedullary nails.[9]

Conventional cephalomedullary nails have been composed of titanium alloy, valued for its machinability, biologic inertness, and modulus of elasticity, which is closer to bone than stainless steel.[10] More recently, implants composed of carbon fiber–reinforced polyaryletheretherketone (PEEK) implants have been introduced with similar applications as their titanium counterparts. We describe the use of a cephalomedullary nail composed of this material to treat an intertrochanteric fracture.

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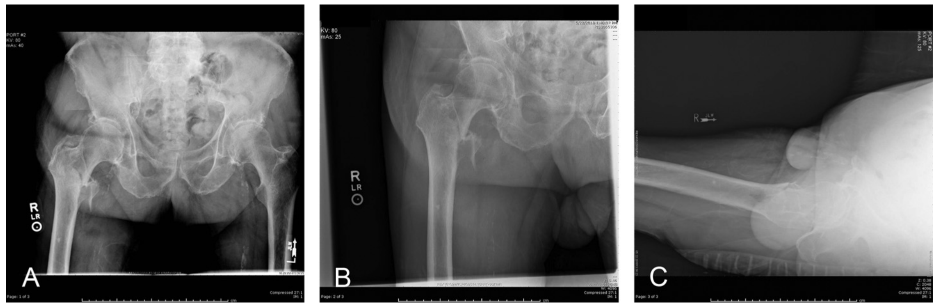

FIGURE 1. Preoperative AP pelvis (A), AP hip (B), and lateral hip (C) radiographs.

PATIENT INFORMATION

An 87-year-old man fell while bowling, sustaining an impact to his right hip. His medical history was significant for an unspecified cardiac arrhythmia requiring a pacemaker, and end-stage renal disease requiring hemodialysis. Evaluation of the patient on presentation revealed no neurovascular or other associated injury. Plain radiographs demonstrated an AO 31A2.1 intertrochanteric fracture with standard obliquity and separation of the lesser trochanter from the primary 2 fragments (Fig. 1). Additional radiographic findings included mild degenerative changes at the bilateral hips and calcification of the iliac and femoral arteries.

The patient was admitted to the trauma service and a cardiology consultation obtained, which demonstrated appropriate functioning of the patient's pacemaker. The decision was made to perform a surgical reduction with intramedullary nail stabilization. Approximately 26 hours after admission, the patient was taken to the operating room for surgical management.

SURGICAL TECHNIQUE

The surgical technique for the cephalomedullary nailing of intertrochanteric fractures is well described.[11] This technique was followed with several exceptions. The patient was anesthetized with a general anesthetic and positioned on a Hana fracture/arthroplasty table, with the feet secured by padded boots. The legs were scissored to allow for lateral fluoroscopic imaging, and the affected extremity adducted to ease passage of the guide pin, reamer, and implant. Traction was used to restore valgus despite the adduction, which is an effective method in standard obliquity fractures such as this. Supraphysiologic valgus was permitted to preserve leg length despite anticipated shortening during the fracture healing process. After confirmation of reduction under AP and lateral fluoroscopy (Fig. 2), the flank/buttock/thigh was prepped and draped with a "shower curtain" drape covering the remainder of the patient. A percutaneously placed guidewire was used to identify the appropriate starting point for a trochanteric nail, medial to the tip of the greater trochanter and in line with the canal on the lateral image (Figs. 3A, B). This was advanced into the femur, with oscillation mode used after entry of the pin to avoid cortical perforation and ensure central positioning of the guide pin. An incision was made around the wire and the opening reamer was used to open the proximal femur (Fig. 3C). After withdrawing the reamer and pin, a short carbon fiber cephalomedullary implant was passed along the same trajectory and inserted to a depth that would minimize tip–apex distance on the AP view. The jig-mounted guide was used to direct an incision over the lateral thigh and insertion of a guide pin from the lateral femoral cortex into the femoral neck (Fig. 4A). The lateral fluoroscopic view was then used to help guide the trajectory of this pin as to minimize tip–apex distance on the lateral view (Fig. 4B). After insertion of the guide pin to the subchondral border of the femoral head on the AP view, the screw length was measured and the reamer set to the appropriate depth. The use of a tap is recommended for preparation of the neck and head for passage of a carbon fiber lag screw (Fig. 4C). The screw of chosen length was then inserted into the subchondral bone, keeping in mind that deep placement minimizes tip–apex distance. A radiopaque marker at the tip of the screw indicated the depth of screw insertion (Fig. 4D). Compression is applied across the primary fracture line before tightening the set screw and making a fixed angle construct (Fig. 4E). The jig-mounted guide was used once again to direct placement of a titanium bicortical interlocking screw through the distal interlocking hole (Fig. 4F). Traction was taken off the extremity once this step is achieved, reducing the risk of traction-related neurovascular injury. The jig was removed and final fluoroscopic images were obtained (Fig. 5). Wounds were closed with interrupted buried dermal sutures and staples. The patient was transferred to a standard hospital ward bed and awoken from the anesthetic without incident. Postoperative plain radiographs were obtained in the recovery room (Fig. 6).

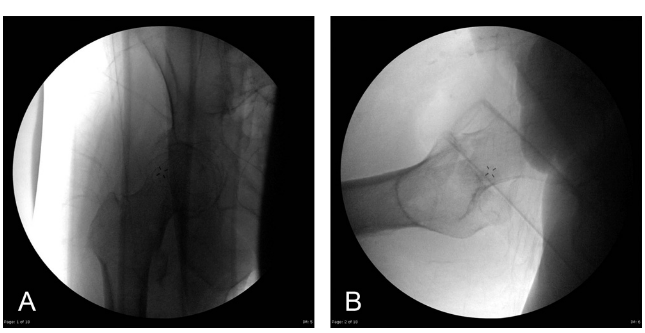

FIGURE 2. A and B, Intraoperative fluoroscopic images showing closed reduction using the Hana table.

The day after surgery, the patient began ambulation under the guidance of physical therapists, using a walker for assistance. He suffered no medical or other complications and was discharged to a skilled nursing facility on postoperative day 3. Follow-up x-rays obtained at 6 weeks postoperatively demonstrated no loss of reduction or fatigue of the construct (Fig. 7).

DISCUSSION

As stated above, goals of surgical management of intertrochanteric fractures are, fundamentally, the restoration of anatomy and provision of stable internal fixation. Secondary goals include efficiency of operation and minimization of soft tissue trauma and blood loss. Although compression hip screws have proven their

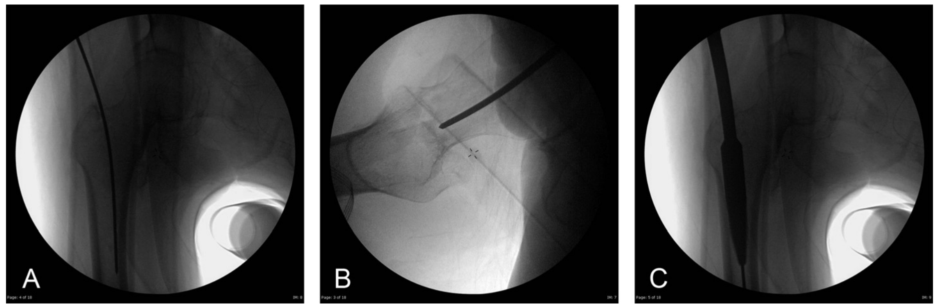

FIGURE 3. Guidewire placement (A and B) and reamer insertion (C) for placement of the cephalomedullary nail.

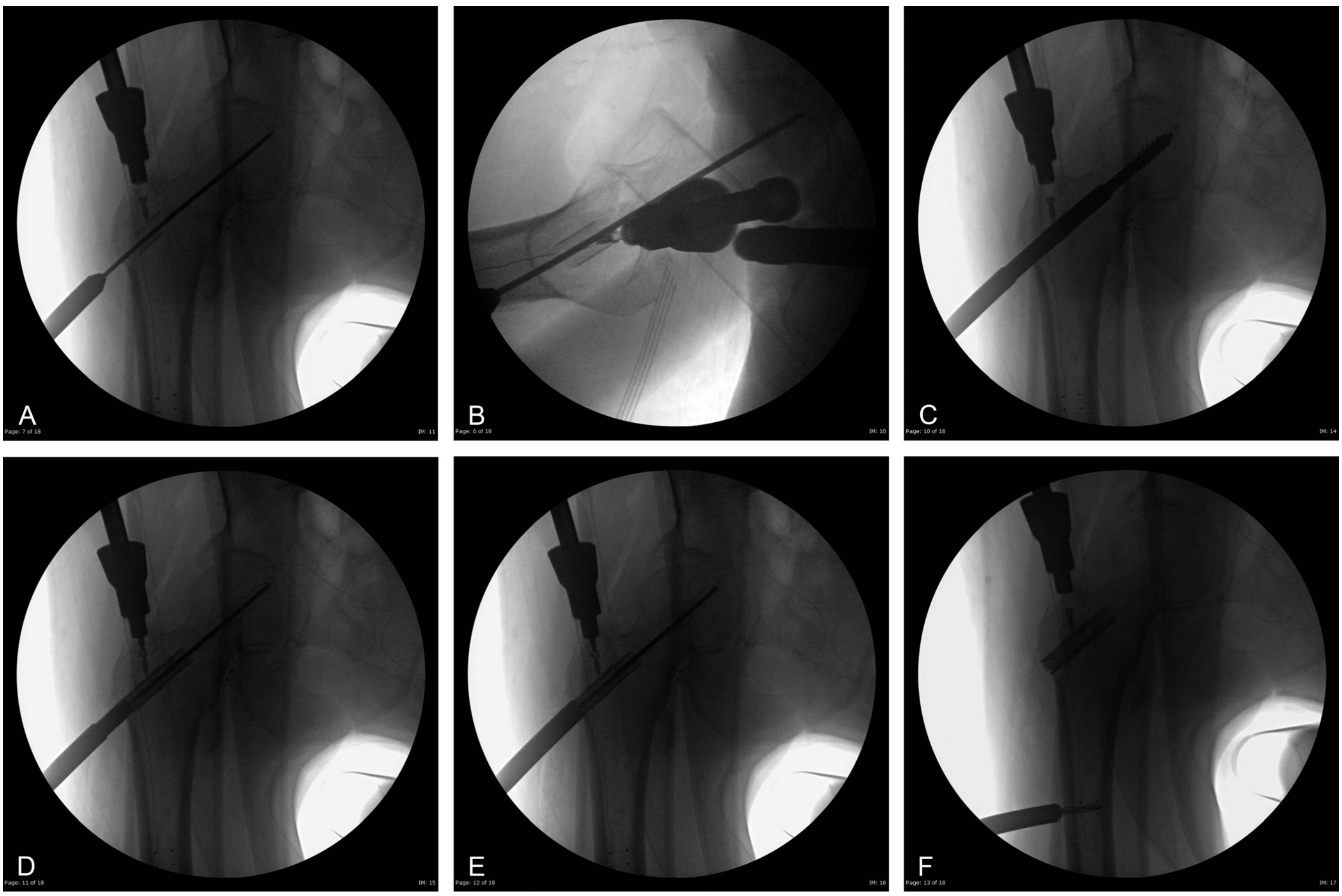

FIGURE 4. A and B, Insertion of the guidewire for the lag screw in the femoral neck. C, Use of the tap. D, Insertion of the carbon fiber lag screw (note radiodense dot marking tip of screw). E, Compression across the primary fracture line and tightening of the set screw. F, Use of the jig-mounted guide to insert the distal interlocking screw.

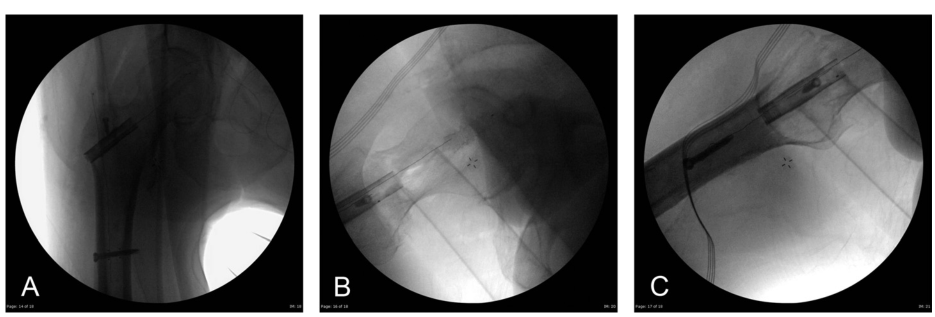

FIGURE 5. A–C, Final intraoperative fluoroscopic images.

FIGURE 6. Postoperative AP pelvis (A), AP hip (B), and lateral hip (C) radiographs.

efficacy in certain fracture patterns, cephalomedullary nails have surpassed these in popularity, particularly among a younger generation of orthopaedic surgeons. The wide variety of cephalomedullary implants available on the market is testament to this fact. Although most of these exhibit designs and material engineering similar to one another, the introduction of carbon fiber implants of similar design represents a novel solution to a common surgical problem.

The advantages of this particular carbon fiber implant are shared with other implant designs using the same material. Among these is the reduced interference with the interpretation of follow-up x-rays, as the carbon fiber implant is radiolucent. This characteristic of carbon fiber has long been used to surgical advantage in the composition of radiolucent jigs and aiming arms for both intramedullary nails and plating systems. The importance of these has only increased with the overall trend toward indirect reduction and relative stability techniques being used not only for diaphyseal injuries but also for metaphyseal injuries. With the implant now being radiolucent, union and nonunion may be more readily recognized radiographically. Furthermore, the modulus of elasticity of carbon fiber PEEK more closely mimics bone than existing titanium alloys.[12] Just as titanium intramedullary nails have largely replaced their stainless steel predecessors, carbon fiber nails may represent a step further in the improvement of such implants.

Research on carbon fiber implants in peer-reviewed literature is limited. In biomechanical studies, Bagheri et al[13] demonstrated less stress shielding of bone fixed with a carbon fiber plate than with a conventional metal plate. Additionally, the biomechanical properties of carbon fiber medullary implants may be optimized for fracture healing, reducing axial stiffness while maximizing torsional rigidity.[14] In clinical studies, Pinter et al[15] and Guzzini et al[16] demonstrated similar outcomes with carbon fiber plate fixation of ankle fractures as with conventional implants in retrospective and prospective studies, respectively.

FIGURE 7. Follow-up x-rays at 6 weeks postoperatively: AP (A) and lateral (B).

Further investigation is necessary to delineate the efficacy and role that carbon fiber implants play in fracture fixation. It is important to note that no theoretical or experimental evidence suggests that the accepted principles of cephalomedullary nailing of intertrochanteric fractures do not apply to the use of implants composed of carbon fiber. Therefore, it is recommended that tip–apex distance be minimized to reduce the risk of screw cutout. For fractures of an intrinsically unstable pattern (AO 31A2.2 and above), a long rather than short implant is recommended to reduce the risk of implant failure and loss of reduction.

A primary challenge to the surgeon unaccustomed to the use of these implants is the radiographic understanding of the implant itself. Part of the purported benefit of carbon fiber is its radiolucency, which allows for greater appreciation for bony healing or lack thereof; however, this can make understanding of the intraoperative implant positioning difficult. A thin radiolucent line is present along the length of the nail, and metallic components are present in the barrel of the lag screw, which allows for assessment of anticipated lag screw position when initially implanting the nail. The set screw and interlocking screws are metallic and relatively easily visualized on fluoroscopy. Perhaps, most challenging is understanding the depth of the lag screw insertion; here, a radiopaque punctate marker may be seen when the insertion handle is parallel to the floor. This requires the most careful attention, both because of its small size and because of the importance of deep insertion to minimize tip–apex distance.

CONCLUSIONS

The treatment of intertrochanteric fractures has undergone a tremendous evolution in the past 2 decades. The once-universal utilization of the compression hip screw has to a large measure given way to cephalomedullary nailing. We present a case illustrating the use of a carbon fiber cephalomedullary nail to treat a common fracture pattern, with a successful short-term outcome. However, challenges exist for the unfamiliar surgeon using such implants, and further research is necessary to demonstrate their efficacy and risk profile.

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