Acta Orthop. Belg., 2016, **82**, 579-585

ORIGINAL STUDY

Use of provisional K wires instead of Poller screws for treatment of diametaphyseal fractures of the distal femur and proximal and distal tibia

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There are several important technical points that need to be observed when using an intramedullary nail to fix diametaphyseal fractures of femur and tibia. We aimed to describe a technique using 3.0-mm K wires, which act like Poller screws, in conjunction with intramedullary nails to obtain alignment of diametaphyseal fractures of the femur and tibia, and present our results. 7 distal femoral, 2 proximal tibial, and 4 distal tibial diametaphyseal fractures who were treated with this technique were identified. There was no case of nonunion at the last follow-up. In all, 12 of the 13 patients had postoperative fracture angulation that was less than 5° degrees in the coronal and sagittal planes. K wires function essentially as a Poller screw for centralization of the nail and help to ensure reduction. Locking the nail in different directions, appropriate reduction can be maintained until the bone heals and there is no need for additional fixation material.

Keywords : blocking screws ; diametaphyseal fractures; intramedullary nailing

INTRODUCTION

Intramedullary nailing is an accepted treatment method for tibial and femoral shaft fractures. However, misalignment can occur with intramedullary nailing of distal femoral and proximal and distal tibial diametaphyseal fractures (*1,6,9,12,16*). Such misalignment occurs because of technical difficulties in achieving satisfactory fracture reduction and biomechanical stability secondary to the differences between the diaphyseal and metaphyseal diameter of the intramedullary canal (*8,16*).

Several important technical points must be taken into account when using an intramedullary nail to fix distal femoral and proximal and distal tibial diametaphyseal fractures. The use of Poller screws may help to achieve satisfactory fracture reduction and biomechanical stability. Krettek *et al* (*6*) first

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No benefits or funds were received in support of this study. The authors report no conflict of interests.

described placing Poller screws around an intramedullary nail to obtain satisfactory alignment and provide additional stability. Biewener *et al* (*1*) described the "palisade method" for the treatment of distal tibial diametaphyseal fractures. They placed K wires sequentially to guide an intramedullary nail with a good central position into a distal short fragment. After proximal and distal fixation of the nail in different planes, the K wires were removed.

Because of the improvements in nails that can be locked proximally and distally in a multiplanar fashion, we believe that there is now no need to place Poller screws for the prevention of reduction loss. Indeed, modern nailing systems allow the nails to be locked in different planes to better stabilize the fracture site (*2*). We herein report a technique using provisional 3.0 K wires that similarly to Poller screws in the treatment of distal femoral and proximal and distal tibial diametaphyseal fractures and present our outcomes using this technique.

PATIENTS AND METHODS

Over the period from December 2012 to September 2014, 18 intramedullary nailings were performed for diametaphyseal fractures of femur and tibia. All postoperative images were reviewed. Five patients were lost to follow-up. Thirteen patients (7 distal femoral diametaphyseal fractures, 2 proximal tibial diametaphyseal fractures, and 4 distal tibial diametaphyseal fractures) who were treated with both a intramedullary nail and provisional K wires were identified.

Nine of the patients were men and four were woman. The mean age was 43 (20-70). The mechanisms of injury were motor vehicle accidents (n = 6), falls (n = 3), pedestrians struck by vehicles (n = 2), and gun shots (n = 2). Two femoral fractures were Gustilo-Anderson type III-B open fractures. When classified according to the Orthopaedic Trauma Association classification (*11*), one femur fracture was type 32 A1, two were type 32 A2, one was type 32 B1, one was type 32 C3 and two were type 33 A1, and two proximal tibial diametaphyseal fractures were type 42 A2 and two distal tibial diametaphyseal fractures were type 42 B1 and two were type 43 A1. One patient had been treated previously for a femur fracture with a unilateral external fixator after a gun shot and was thought to be unacceptably aligned and nonunion was established when he was examined at our institution. An other patient had been treated for a distal tibial fracture with close reduction and cast because she had refused the surgery. But nonunion was established after 6 months of follow-up and surgical intervention was accepted by patient.

Knee and ankle range of motion exercises was started at postoperative first day and weight bearing was allowed after 6 weeks of follow-up for both tibia and femur fractures.

Surgical case with technical tips for retrograde femoral nailing

The patient was positioned supine on a radiolucent table. The limb was prepared in the standard fashion.

In each case, the appropriate site for the K wire changes because of different fracture variants and the need for different reduction maneuvers. Placement of the wires was planned preoperatively. Due to fracture displacement, sometimes two or more 3.0-mm K wires can be used to achieve the proper reduction (Fig. 1C, D). To prevent anterior angulation of the distal fragment, K wires were placed posterior to the central axis of the femur so that the nail could pass anterior to them. To prevent varus or valgus angulation, the K wires were placed medial or lateral to the central axis of the femur so that the nail could pass centrally. A guide wire was placed after the K wire insertion and across the fracture. After reaming, a nail of the appropriate length and diameter was inserted over the guide wire. The nail was inserted gently. Appropriate alignment of the fracture site was confirmed by fluoroscopic imaging (Fig. 1E). If the reduction was still unsatisfactory, the nail was removed and the K wire locations were changed or additional K wires were added. The nail was fixed proximally with one screw and distally with three screws. The distal screws were placed in three different planes (Fig. 1F). After proximal and distal locking, the K wires are removed and fracture stability is tested intraoperatively.

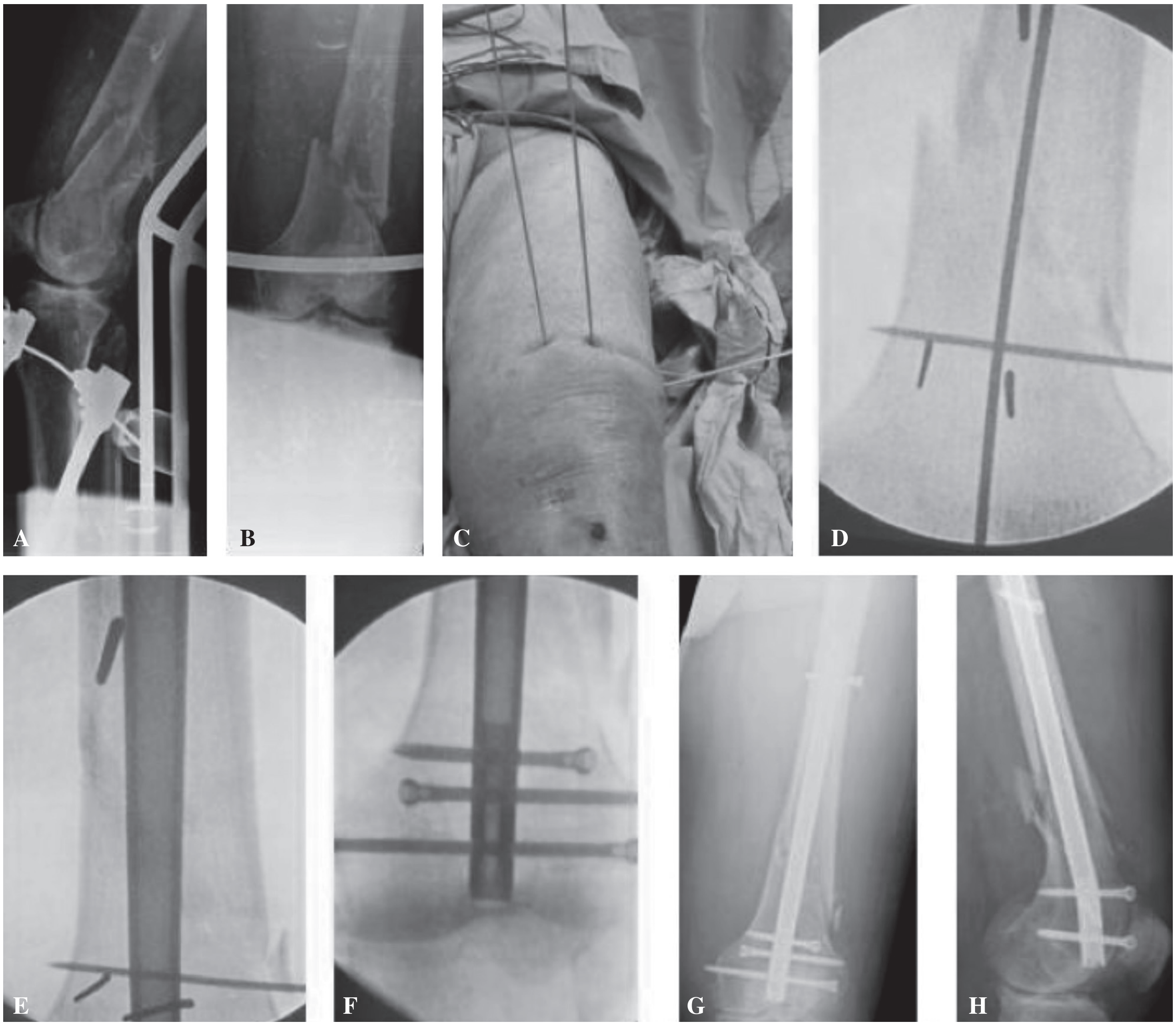

Fig. 1. — Distal femoral fracture treated with intramedullary nailing with anterior and posterior provisional K wires **A, B** : Anterior-posterior and lateral views of the fracture. **C, D** : Provisional K wire placement and guide insertion. **E** : Reduction at the fracture site after nail insertion. **F** : Nail fixed distally with three screws in three different planes. **G, H** : Postoperative radiographs.

Surgical case with technical tips for tibial nailing

The patient was positioned supine on a radiolucent table. No tourniquet was used. The patient's knee was flexed over the free end of the table.

For proximal tibial diametaphyseal fractures, a 3.0-mm K wire was placed freehand into the distal portion of the proximal fracture fragment before nail insertion. The orientation and location of the K wires depend on the fracture type. Placement of the wires was planned preoperatively. A guide wire was placed after the K wire insertion and across the fracture. To prevent anterior angulation of the apex, K wires were placed posterior to the central axis of the tibia so that the nail could pass anterior to them. To prevent varus or valgus angulation, K wire was

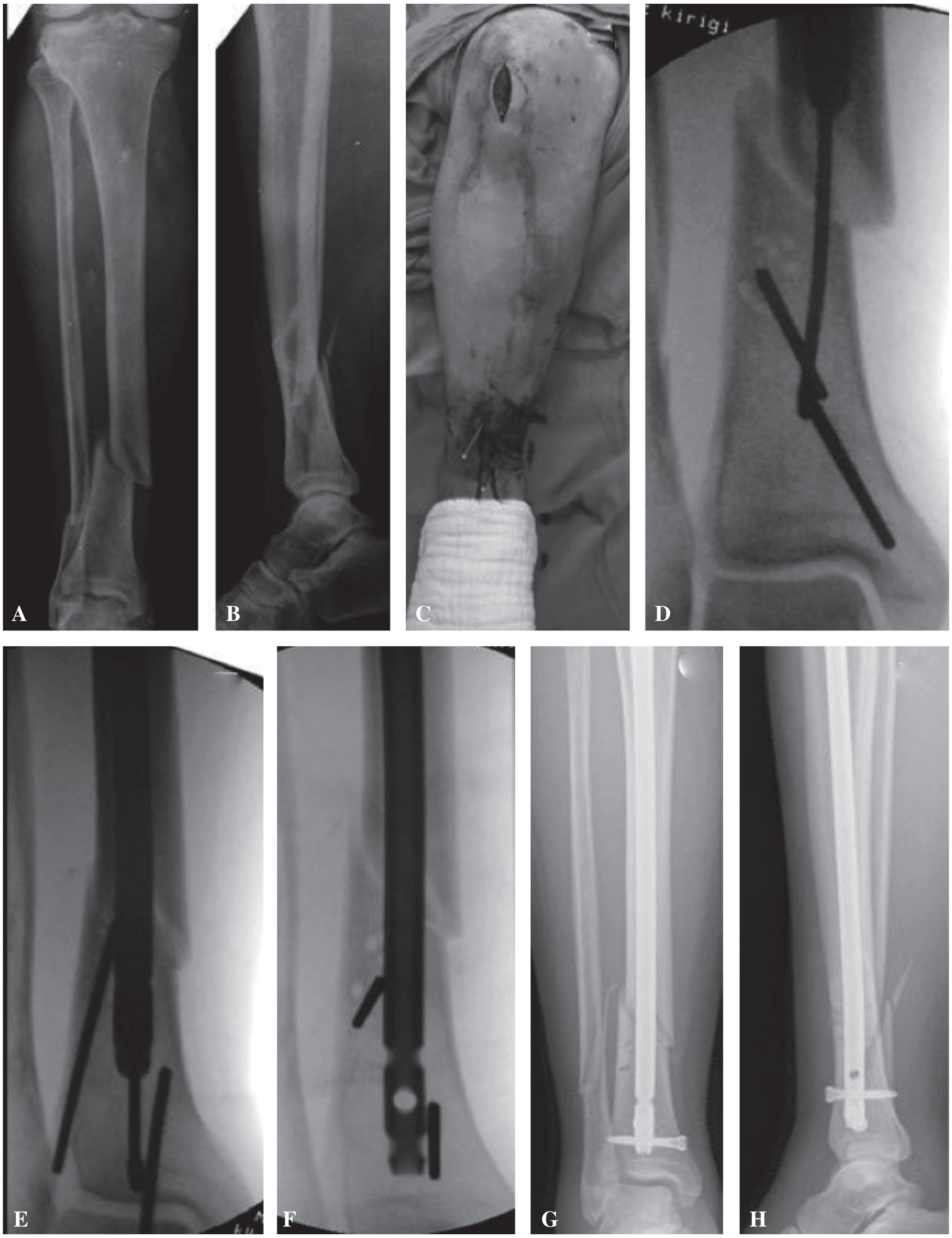

Fig. 2. — Distal tibial diametaphyseal fracture treated with intramedullary nailing with two anterior provisional K wires. **A, B** : Anterior-posterior and lateral views of the fracture. **C, D** : Provisional K wire placement and guide insertion. **E, F** : Reduction at the fracture site during the passage of the nail. **G, H** : Postoperative radiographs ; nail fixed distally with two screws in different planes.

placed into the concave side of the fracture. K wires were placed lateral to the central axis of the tibia so that the nail could pass medial to them, and medial to the central axis of the tibia so that the nail could pass lateral to them.

For distal tibial diametaphyseal fractures, 3.0-mm K wires were placed freehand into the proximal portion of the distal fracture fragment before nail insertion (Fig. 2C). Placement of the wires was planned preoperatively as for proximal fractures. A guide wire was placed after the K wire insertion and across the fracture, with the knee flexed over the end of the table. Longitudinal traction and direct force, as needed, were applied manually to the limb to obtain provisional reduction during passage of the guide wire. Reaming was performed over the guide wire. A tibial nail of the appropriate length and diameter was inserted over the guide wire. The nail was advanced gently. Fluoroscopic imaging confirmed appropriate alignment of the fracture site (Fig. 2D- F). If the reduction was still unsatisfactory, the nail was removed and the K wires were moved or additional K wires were added. Two proximal locking screws were placed from medial to lateral and from anteromedial to posterolateral. Distally, the nail was locked with two screws in coronal and sagittal plane.

Implant Characteristics

A titanium tibial nail (Smith and Nephew) was used in 6 tibial fractures and in four femoral fractures. A titanium retrograde femoral nail (Smith and Nephew) was used in three femoral fractures. K wires were 3.0 mm stainless steel.

RESULTS

The average follow-up was 21,4 (10-30) months. There was no case of nonunion at the last follow-up. In all, 12 of the 13 patients had postoperative fracture angulation that was less than 5° degrees in the coronal and sagittal planes. One patient who was treated for a distal femoral diametaphyseal type 33 A1 fracture had postoperative malalignment of 7° recurvatum. Her postoperative fracture alignment was neutral in the coronal plane. This patient was too osteoporotic and the retrograde intramedullary nail was locked with two short screws distally. This patient progressed from 7° recurvatum after surgery to 10° recurvatum at union. Twelve patients achieved union and maintained the alignment of their fractures.

DISCUSSION

Although improvements in surgical techniques and implant designs have extended the indications for nailing to metaphyseal fractures of the proximal tibia, distal tibia, and distal femur, concerns about the nailing of these fractures remain. The reported incidence of malalignment is 58% for proximal tibial fractures and 8.0% to 16.2% for distal tibial fractures (*4,17*). Ricci *et al* (*13*) reported a 10% malalignment rate after treatment of distal-third femoral fractures with retrograde nailing.

The use of intramedullary nails alone for the treatment of diametaphyseal fractures is insufficient. Thus, many other reduction techniques have been described together with the use of intramedullary nails to ensure fracture reduction. Donalds and Seligson(*3*) used "block screws" adjacent to the Küntscher nail to treat tibial fractures, which are predisposed to bending. Krettek *et al* (*7-9*) described block screws in their clinical application of tibial and femoral fracture treatment, calling the block screws "Poller screws," as a tool to prevent axial deformities during intramedullary nailing.

Treatment of diametaphyseal fractures requires careful preoperative assessment. Regardless of the intraoperative technique used for treatment, the cause of the deformity should be well understood and the surgery planned accordingly (*14*). Stedtfeld *et al* (*16*) designed a model to show the causes of angulation and reduction loss in diametaphyseal fractures and to determine the precise placement for Poller screws, which they termed "transmedullary support screws." They showed that nailing at the diametaphyseal junction produced malalignment of the short fragment. If not well understood, incorrect placement of a Poller screw can worsen the alignment of the fracture. In such a situation, changing the position of the screw can be challenging because of additional bone and soft tissue damage, and it may prolong the surgery.

Because the location of the K wires can be readily changed if the location is disliked and quickly replaced in another location, we did not use Poller screws. K wires were placed as indicated by Stedtfeld *et al* (16). The K wires essentially function as Poller screws for centralization of the nail and help to ensure reduction. In this way, we can avoid potential damage and the risks of iatrogenic fractures with Poller screws, including increased stress on the fracture line, screw breakage, reamer damage, and unnecessary soft tissue dissection (1,14). Shahulhameed *et al* (15) recently presented their technique using a Steinman pin as an initial step in Poller screw placement for the treatment of tibial and femoral metaphyseal fractures. The authors used Steinman pins for centralization of the nail and replaced them with Poller screws during the last step of the surgery, after locking the nail. Biewener *et al* (1) described the "palisade method" for treatment of distal tibial diametaphyseal fractures. They placed the K wires sequentially to guide an intramedullary nail with a good central position into a distal short fragment. After proximal and distal fixation of the nail, the K wires were removed to prevent loss of reduction. The authors concluded that the K wires could act as a guide to position the nail in a central position and that reduction could be prevented by locking the screws even in the most distal tibial fractures.

Currently available nailing techniques allow for distal locking, even with a short metaphyseal fragment or intra-articular extension. In our experience, appropriate reduction can be achieved and maintained by locking the nail in different directions. In our series of distal femoral diametaphyseal fractures, if the nail was fixed distally in at least three directions after anatomical reduction, no displacement was observed at the postoperative follow-up. In the same way, angulation did not develop after reduction of diametaphyseal fractures of the tibia with proximal and distal fixation of the nail into two planes with two screws. Işık *et al* (5) recently reported the results of 34 distal tibial diametaphyseal fractures treated with intramedullary nails. They showed that when fixation was performed in distal-third tibial fractures by placing two static screws distal and proximal to the intramedullary nail following adequate reduction, the angulations that developed during the period until union were not significant in terms of causing deformity. We treated 12 of 13 patients with < 5° angulation, and 10° recurvatum was observed in 1 patient with a distal diametaphyseal femoral fracture after union. That patient had severe osteoporosis, and the nail was fixed distally with two short screws. However, multiple distal fixation may not be sufficient for primary stabilization of distal osteoporotic, small-fragment fractures and for patients with poor bone quality. Poller screws may be needed in these patients to improve primary stability.

Our study was limited by the small number of patients and by the fact that it was not a controlled prospective study. The absence of data on the effects of multidirectional distal locking on primary stability is another issue. Larger-scale studies with patient and control groups are needed to address this.

According to our study, the location of the K wires can be readily changed if the location is disliked and quickly replaced in any location. They essentially function as Poller screws for centralization of the nail and help to ensure reduction. In our experience, by locking the nail in at least two different directions for tibial proximal and distal diametaphyseal fractures and in three different directions for distal femoral diametaphyseal fractures, appropriate reduction can be maintained until the bone heals. There is no need for additional fixation material.

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