Endoscopic resection of scar tissues and bone graft with an intramedullary nail left in situ for distal femoral nonunion after nailing: A case report

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Abstract
Femoral shaft nonunion after the intramedullary nailing has been successfully treated with advances in surgical technique. Nonetheless, the techniques cause morbidity to periosteum at the fracture site. We report the case of a 67-year-old man who underwent endoscopic surgery for refractory nonunion following the fracture of the distal femoral shaft, despite two fixations using an interlocking nail. In addition, the patient had uncontrolled diabetic mellitus. Endoscopy allowed us to acquire a clear view of the nonunion site, in which the resection of scar tissues and the packing of the cancellous bone were performed. At the final follow-up, bone healing was observed, and the patient was able to return to normal daily and social activity.

Keywords
bone graft, endoscopic surgery, fracture, nonunion, pseudoarthrosis

Introduction
Various treatments have been performed for femoral shaft nonunion after failed intramedullary nailing including exchanging reamed nailing, augmentative plating, plating after removal of the nailing, and only bone graft. Especially the augmentative plating has shown more advantages for femoral shaft nonunion. Nevertheless, the technique need exposure of the fracture site with the morbidity to periosteum. Recently, scaphoid nonunion has been successfully treated under the arthroscopy. The femoral shaft nonunion was also endoscopically treated through the intramedullary canal. However, there existed no report of the endoscopic surgery under direct visualization for the femoral shaft nonunion after failed intramedullary nailing.

We herein report a case of distal femoral nonunion despite two surgeries, who had bony healing by an experimentally surgical technique using endoscopy.

Case report
We received written informed consent from the patient for the treatment and the publication of this case report.

A 67-year-old man, who was a fisherman, was caught between the fishing ship and the wharf during his work. He was transferred to a local hospital, where a fracture of the distal femur shaft was diagnosed by X-ray (Figure 1). The height and body weight of the patient were 166 cm and 67.9 kg, respectively. He had smoking history for 41 years. Although untreated diabetes mellitus was
discovered by blood examination with 9.1 ng/dl of the hemoglobin (Hb) A1c, the patient underwent internal fixation of the bone using an 11 mm retrograde intramedullary nail (T2 IM nailing system, Stryker Japan K.K., Tokyo, Japan), in which the tip of the nail reached the level of the lesser trochanter (Figure 2(a)). Since the findings of fracture healing including callus formation could not be identified at the fracture site, the proximal interlocking screw was removed for dynamization, 3 months after the surgery. Nonetheless, the femoral fracture was not healed (Figure 2(b)), and reoperation was consequently performed using a larger sized nail with 12-mm following 13-mm reaming, as well as a bone graft from the iliac bone at 6 months after the surgery (Figure 2(c)). Diabetes mellitus was simultaneously treated in the internal medicine department of the hospital. However, the condition did not improve due to poor compliance with the medication and the diet therapy. Unfortunately, no bone healing could be observed at 3 months after the second surgery, at which time, the dynamization, low-intensity pulsed ultrasound, and insulin for the diabetes mellitus were commenced. Furthermore, X-ray and computed tomography (CT) did not reveal bone healing at the fracture site (Figure 3). The nonunion of this patient appeared to be hypertrophic type.

Consequently, the patient was presented to our hospital for the treatment of the distal femoral nonunion at 11 months after the second nailing. At the initial visit to our hospital, the patient had range of motion with 0–120°, normal muscle power (MMT 5/5) in the knee joint, and no loosening of the nail on the imaging study. By contrast, diabetes mellitus was poorly controlled, with 7.9 ng/dl of HbA1c. We worried about further nonunion in surgical treatment due to diabetes mellitus and smoking history. Therefore, a vascularized bone graft was initially planned owing to suspicion of the mild infection at the nonunion site, even though we chose the minimally invasive technique using endoscopy with the dissection of the nonunion and the bone graft (Figure 4).

Postoperatively, the knee joint was immobilized in a brace at the position of the extension, and weight-bearing was avoided for 6 weeks. There were no complications in relation to the surgery. Pain at the recipient site of the iliac bone faded 1 week after the surgery. Postoperative CT 2 months after surgery showed that the fracture was healing.
at the anterior border of the femur (Figure 5(a)). X-Ray also showed progression of healing and absorption of the β-tricalcium phosphate (Figure 5(b)). Two years after the surgery, the healing of the femoral bone could be observed, and the patient was able to walk without assistance and return to his work (Figure 6).

**Surgical technique**

Surgery was performed under general anesthesia. Under fluoroscopy, the two portals were made at the anterior side on the site of the nonunion (Figure 7(a)). A 30° scope with a 4-mm diameter was used, similarly as during arthroscopy in large joints. The space between the femoral bone and the quadriceps muscle was arthroscopically made by water irrigation, a shaver, and a radiofrequency device, by which clear view was easily and rapidly acquired. Thereafter, the scar tissue at the site of the nonunion was removed by the shaver and punch (Figure 7(b) and (c)). In this case, we could arthroscopically see the intramedullary nail (Figure 8). The cortical and cancellous bones were also freshened by a 4.0-mm burr, and we observed bleeding from the bone after the deflation of the tourniquet (Figure 7(d)). Simultaneously, the other doctors collected the cancellous bone graft from the iliac bone. Finally, under dry conditions, the bone graft from the iliac bone mixed with β-tricalcium phosphate (OSferion®, Olympus, Tokyo, Japan) were tightly compacted into space following the resection at the site of nonunion through the metal cannula. (Figure 7(e)).

**Discussion**

Lai et al. demonstrated that union rate for the non-isthmic nonunion was significantly less in the exchanging reamed...
nailing than the augmentative plating, which appeared to be related with improper stabilization caused by the wideness of the intramedullary canal. The exchanging reamed nailing might have been unfavorable in the second surgery of these patients. Nevertheless, we hoped to avoid the invasive surgeries since the patient had untreated diabetic mellitus and smoking history which put him at risk for adverse events including infection and further nonunion. Application of osteoinductive agents were also considered including recombinant human bone morphogenetic protein 2 and parathyroid hormone.

Previous studies showed that endoscopic surgeries were successfully performed for nonunions of other sites, regardless of small incisions and small morbidity to periosteum. Based on these reports, we tried the endoscopic surgery for the nonunion at the femoral shaft. The surgery was performed with the interlocking intramedullary nail left in situ, since the preoperative imaging study showed no findings of loosening. Simultaneously, the insufficient stabilization was suspected from the hypertrophic bone formation at the fracture site. These made us carry out the postoperative immobilization and non-weight-bearing for 6 weeks. Consequently, bone healing was acquired for the femoral shaft nonunion despite two intramedullary nailing.

The experience in this patient would encourage us to further apply the endoscopic technique for the hypertrophic nonunions with relative stability at various long bones. By contrast, atrophic nonunions would be unsuitable for the treatment with endoscope, of which the maneuver was only debridement and grafting of cancellous bones. Furthermore, it is necessary to be careful about compartment syndrome due to continuous water irrigation, as reported in several joints.
Conclusion

We report a case with healing of the distal femoral shaft nonunion by a new technique using endoscopy with an intramedullary nail left in situ after nailing. The endoscopic technique is an experimental method in the treatment for the nonunion, and further investigations are needed regarding usefulness, indication, and complication.

Declaration of conflicting interests

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