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Case Report

Minimally invasive retrieval of intramedullary broken guidewire in distal tibia: An innovative technique

Mei-Ren Zhang [a,*], Tao-Sheng Huang [b,1], Kui Zhao [a], Jiang-Long Guo [a], Xiao Zeng [a], Jian-Hui Hu [a]

[a] Guangzhou University of Traditional Chinese Medicine Second Affiliated Hospital (Guangdong Provincial Hospital of Traditional Chinese Medicine), Orthopedics Trauma Department Zhuhai Branch, Jingle Road Number 53, XiangZhou District, ZhuHai City, Guangdong Province 519015, China

[b] Department of Orthopaedics, The Second Hospital of Xiangzhou District, Nanquan Road Number 21, Xiangzhou District, ZhuHai City, Guangdong Province 519015, China

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Introduction

Cannulated guidewire breakage is common in orthopaedic surgery. The retrieval of broken hardware can be technically challenging, particularly if the fragment is embedded in bone. Every surgeon must be familiar with this problem and the different ways to tackle it. Methods for retrieval of cannulated guidewire fragments in the hip and foot have been described [1,2]; however, no specific techniques for the retrieval of intramedullary guidewire fragments embedded in the distal tibia have been described. Herein, we report an innovative technique assisted by a 3D-printed superficial template for retrieval of a broken guidewire in the medullary canal of the distal tibia during the internal fixation of a bimalleolar fracture.

Case report

A year ago, a 39-year-old man with a medial malleolus fracture underwent internal fixation with 3.5-mm cannulated screws. Unfortunately, when the second hollow screw was drilled and fixed, the guidewire broke, and the broken guidewire fragments were buried in the medulla of the distal tibia. All attempts to retrieve the broken guidewire through the fracture side of the medial malleolar had failed. In our experience, this may result in a longer duration of anaesthesia, additional surgery, increased blood loss and increased dissection of the bony structure of the distal tibial; it may even lead to complications, such as intraoperative iatrogenic fracture and nonunion after the operation. Because of the difficulty of removing the guidewire from the tibial medullary cavity during surgery, both the patient and his family agreed to have the broken guidewire removed at the same time as the implant after fracture healing. The

* Corresponding author.
E-mail address: zhangmeiren@aliyun.com (M.-R. Zhang).
[1] Co-first author.

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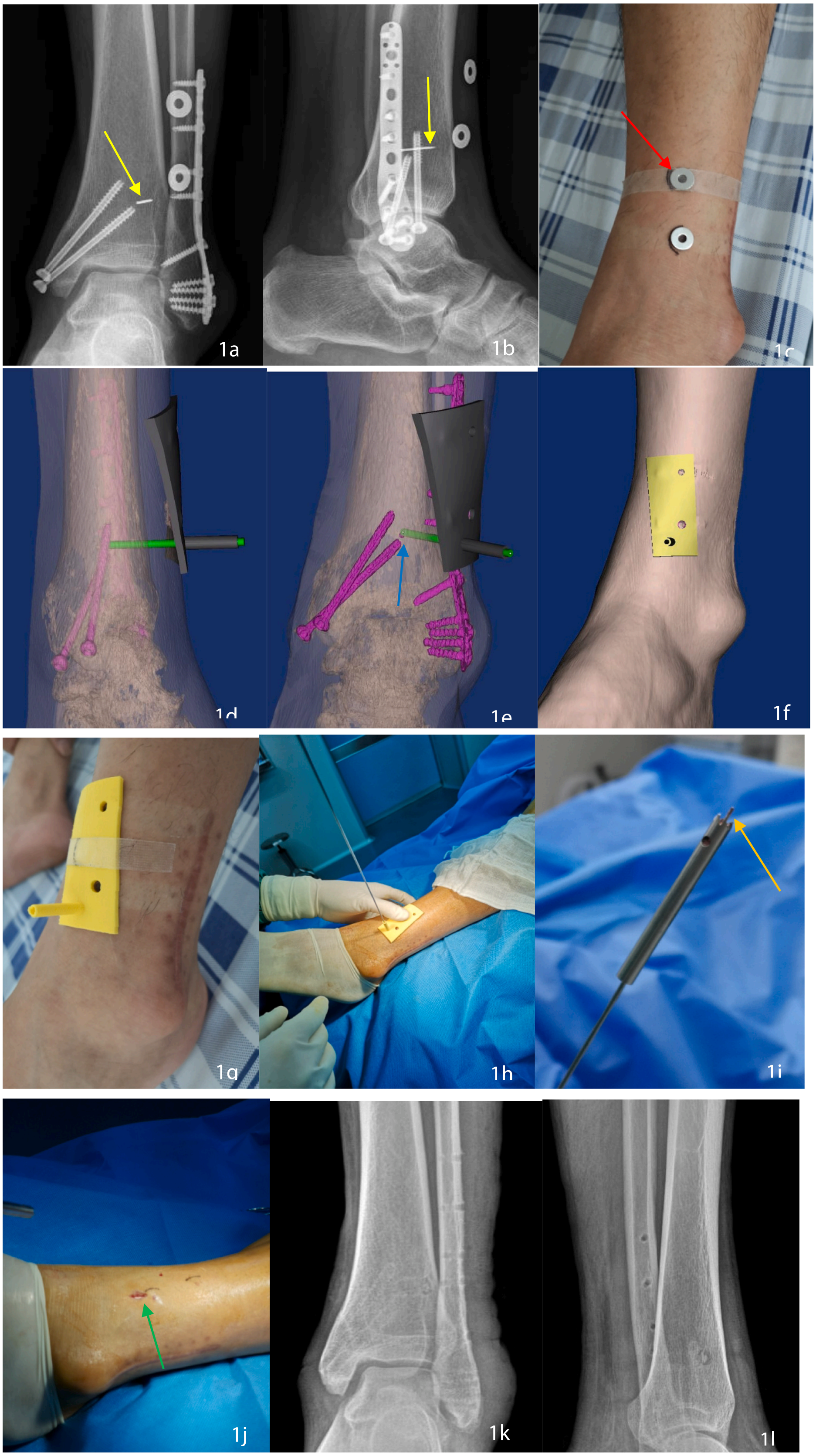

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Fig. 1. A 39-year-old man with a bimalleolar ankle fracture after internal fixation of left side.
a, b. AP and lateral radiographs of left ankle one year postoperatively showed a broken guidewire fragment in the medullary canal of the distal tibia (yellow arrow).
c. Two metal gaskets were used to locate the area around the surface of broken guide wire before examination of CT and X-ray (as indicated by red arrow).
d, e. Design 3D printed superficial template based on data of CT scanning (broken guidewire on designed 3D printed superficial template was entirely in the channel of guiding wire (as shown by the blue arrow)).
f. Computer simulated image.
g. Preoperative 3D printed surface template placement simulation.
h. The surface template was 3D printed, and 2.0 mm K wire was inserted into the surface of the tibial cortex as guidewire through the channel.
i. Use a small trephine to take out the broken guidewire fragment with the positioned K-wire (as shown by the orange arrow).
j. Postoperative incision less than 0.5 cm (green arrow).
k, l. Postoperative lateral radiographs of the left ankle showed broken guidewire fragment was taken out.

patient's recovery was smooth and the fracture healed without any complications. He was admitted to the hospital again for the removal of the implant and the broken guidewire fragments; the bimalleolar ankle fracture healed very well within a year (Fig. 1a–b). A technique assisted by a 3D-printed superficial template and active registration landmarks on the surface of the distal tibia was used to remove residual guidewire in the tibial medullary cavity. No complications occurred during the operation. The damage to adjacent osseous and soft tissue structures was negligible and the patient recovered well from the injury, quickly recovering his pre-injury function. The following is an outline of our technique.

Surgical technique

Step 1: active registration landmark on the body surface and computed tomography scan

Before the reconstruction of the computed tomography (CT) scan, two metal gaskets used to locate the anchor were accurately marked and adhered to the anterolateral body surface of the distal tibia near the broken guidewire (Fig. 1c). Two markers must be clearly placed before the surgery.

Step 2: design and printing of the superficial template

After CT (General Electric LightSpeed-640; GE, Milwaukee, WI, USA) examination, CT data were imported into a computer in DICOM mode. With the help of E-3D software, a 3D model of the ipsilateral left lower extremity was reconstructed. A 3D model of the left lower limb was imported into the Geomagic Wrap software in STL format to establish an original superficial template based on the left lower limb model surface around two metal gaskets (the range should include the holes of two metal gaskets). According to the position of the two 3 mm diameter metal gaskets holes, two corresponding holes were designed on the original surface template. Guide drilling holes of the original superficial template were designed in the same longitudinal direction of the broken guidewire from a 3D perspective with an inner diameter of 2.2 mm and an outer diameter of 3.5 mm (Fig. 1d–f). The original superficial template was sent to a 3D printer (CoLiDo-X3045, Tianwei Co China) for printing with PLA material (Fig. 1g) which underwent plasma disinfection before surgery.

Step 3: surgical techniques of minimal retrieval of broken guidewire with 3D-printed superficial template

Under spinal-epidural anaesthesia, the patient was operated on the supine position, and the left thigh tourniquet was used to assist haemostasis. After routine disinfection of the left lower limb, the 3D-printed superficial template was attached to the body surface through the two located holes in accordance to reminding marks of the surface. A-2 mm Kirschner wire was inserted through the guide hole on the accurately positioned template and penetrated the anterior medial cortex about 5 mm in (Fig. 1h), then a trephine with 4 mm diameter was manually rotated slowly through the Kirschner wire after template removal to a depth of 2.5 cm which had been measured exactly pre-operatively using E-3D software pre-operation. The trephine was withdrawn slowly from the bone; the broken guidewire was found firmly engaged with the trephine lumen, which implied that it had been dislodged from the bone completely. We packed all the bones back into their original positions (Fig. 1i); the operative procedure lasted for about 5 min with an incision of 0.5 cm (Fig. 1j) and without intraoperative fluoroscopy. Post-operative X-rays confirmed complete removal of the guide pin fragment with negligible damage to the osseous (Fig. 1k–l). Weightbearing was allowed in regular shoes after the surgery. The wound healed without complications in 2 weeks and quickly returned to the pre-injury functional level without symptoms.

Discussion

Breakage of orthopaedic instruments such as Kirschner wires and guide pins, is common and has been reported in various clinical settings [1–3]. Removal of broken Kirschner wires is difficult and depends on their anatomical location. Several techniques have been reported for the retrieval of broken Kirschner wires and guide pins; however, there had been no studies on the removal of intramedullary broken guide pins in the distal tibial. Although 3D-printed navigation templates have been widely used in clinical orthopaedics especially in the field of precise screw placement [4–6], we are not aware of any similar method in the literature for minimal retrieval of broken intramedullary guidewires from the distal tibia.

There is little evidence that a broken guidewire can cause long-term harm to the patient [7], and in some cases, it can be left in situ with no adverse effects [8]. However, If it could not be removed from the distal tibia, it could result in unnecessary litigation, Among surgeons, the challenges of and time spent to remove broken instruments and implants are well known [9]. Often, it is too difficult to accurately remove the broken segment with minimal damage to adjacent bones and joint tissues [1].

This is how a 3D-printed superficial navigation template can accurately guide a trephine to engage the broken guide pin. Firstly, the 3D-printed superficial navigation template had the same surface curvature and area as the distal tibia, and it was placed correctly by two metal gaskets that were used as artificial anatomy surface landmarks, which had been precisely marked on the surface of distal tibia before the CT scan. The 3D-printed superficial navigation template adhered to the surface of the distal tibia through the two located holes in accordance to reminding marks of the surface which was the same as satellite navigation in 3D space.

This technique has several advantages over techniques that use fluoroscopy to remove wires buried in the hip or mid-foot using a hollow drill [1,2]; firstly, this technique can significantly reduce intraoperative X-ray radiation and operation time for both the patient and the surgeon. It is also a minimally invasive technique with an incision of about 0.5 cm, minimal damage to adjacent bones, and bones are repackaged to their original position. Our approach also expands the application of 3D-printed navigation templates, because compared with traditional 3D-printed navigation templates, which are mainly located through bone protrusion, they can be positioned by actively placing metal spacers. However, in areas of the body with many muscles, such as the thighs, hips, and upper arms, the accuracy of application of a 3D-printed superficial navigation template remains to be studied; the skin is prone to displacement, which directly affects the localization accuracy. And so on, the accuracy of application for 3D-printed superficial navigation template remains to be studied as the skin is prone to displacement which directly affects the accuracy of location.

In conclusion, the method we have described in this technical report could be useful and does not damage bone and soft tissues. This technique of using a 3D-printed superficial template was precise and minimally invasive but should be used in a delayed situation.

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Consent

The authors confirm that informed consent was obtained from the patient prior to the publication of this case report.

Conflicts of interest

None.

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