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Case Report

Helical plating for a re-nonunion and a peri-implant fracture after humeral intramedullary nailing: A report of two cases

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ABSTRACT

Introduction and importance: A re-nonunion after failed intramedullary nailing for a nonunion of the humeral shaft and a peri-implant distal humeral fracture with an ununited humeral shaft are rare cases. Therefore, no consensus has been established regarding the treatment strategies.

Case presentation: Case 1: An 84-year-old woman presented with humeral shaft re-nonunion after intramedullary nailing. The images revealed callus formation and loosening of the implant, suggesting a lack of mechanical stability. Nail removal and helical plating were performed. One year postoperatively, bony union was achieved. Case 2: A 59-year-old woman presented with a peri-implant distal humeral fracture with an ununited humeral shaft after nailing. Nail removal and helical plating were performed using a minimally invasive plate osteosynthesis (MIPO) technique. The distal humeral fracture was fixed with plates. One year postoperatively, bony union was achieved.

Clinical discussion: Imaging findings in Case 1 indicated that nonunion was caused by a lack of mechanical stability. In Case 2, stabilization of the ununited humeral shaft was also needed. Helical plating provides a mechanically strong fixation and prevents damage to the radial nerve and soft tissues.

Conclusion: Evaluating the causative factors of nonunions is important. Helical plating provides mechanical stability and is associated with bony union without autologous bone grafting for a re-nonunion of humeral shaft lacking mechanical instability. For a peri-implant distal humeral fracture with an ununited humeral shaft, helical plating with the MIPO technique provides diaphyseal fracture union and enables the minimal length of distal humeral plate fixation.

1. Introduction

Nonunions of the humeral shaft occur in 0%–14% of cases after intramedullary nailing [1]. Several treatment methods for these nonunions have been described, the most suitable one being compression plating with autologous bone grafting [2]. However, treatments for re-nonunions after failed intramedullary nailing for nonunions of the humeral shaft have not been established.

With the advances in shoulder and elbow arthroplasty, periprosthetic humeral fractures have become common. However, peri-implant fractures after intramedullary nailing for humeral shaft fractures are relatively rare and difficult to treat, especially when bony union of the humeral shaft is not achieved. Regarding the management of peri-implant distal humeral fractures with an ununited humeral shaft, no consensus exists regarding whether the intramedullary nail (IMN) should be removed or not, and the implant of choice used to fix the diaphyseal and distal part of the humerus. If the IMN is not removed, distal humeral fixation is generally difficult due to the presence of the IMN, while its removal causes problems with diaphyseal union.

Helical plating for humeral shaft fractures can reduce damage to the radial nerve and complications related to intramedullary nailing for proximal and diaphyseal humeral fixations such as rotator cuff injuries [3,4]. Another advantage of helical plates is that they possess biomechanically higher torsional resistance compared with conventional straight plates [5,6].

In this paper, we present two cases of helical plate fixation: a re-nonunion after failed intramedullary nailing for a humeral shaft nonunion and a peri-implant distal humeral fracture with an ununited humeral shaft after intramedullary nailing.

This report conforms with the SCARE criteria [7].

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2. Presentation of case

2.1. Case 1

Osteosynthesis using multiple stainless wires was performed on an 84-year-old woman to treat a humeral shaft fracture at another hospital (Fig. 1A and B). She had a medical history of diabetes, but no smoking history. Eight months later, a revision surgery using an IMN was performed at the same hospital to treat a nonunion (Fig. 1C and D). However, this led to a re-nonunion. Consequently, she was referred to our hospital one year and eight months after the second operation. Plain radiographs and computed tomography (CT) revealed callus formation at the nonunion site and loosening of the nail and screws at the distal fragment (Fig. 1E). Our evaluation concluded that the primary cause of the re-nonunion in this case was the lack of mechanical stability. Therefore, we applied helical plate fixation to increase mechanical stability. First, we removed the IMN, debrided the nonunion site, and inserted an interfragmentary lag screw between the proximal and the distal fragments. The length of the plate was determined to be sufficiently long to cover almost the entire length of the humerus (from the tip of the greater tuberosity to the coronoid fossa). A helical plate was contoured by twisting a long, anatomical locking plate for proximal humeral fixation to lie on the lateral aspect of the greater tuberosity proximally and the anterior or anterolateral aspect of the distal humerus distally (Fig. 2). Finally, helical plate fixation was performed without autologous bone grafting (Fig. 1F). One year postoperatively, bony union was achieved (Fig. 1G). At the final follow-up two years after helical plate fixation, the patient resumed her daily activities without experiencing pain.

2.2. Case 2

Osteosynthesis using an IMN had been performed on a 59-year-old woman to treat a humeral shaft fracture at another hospital (Fig. 3A

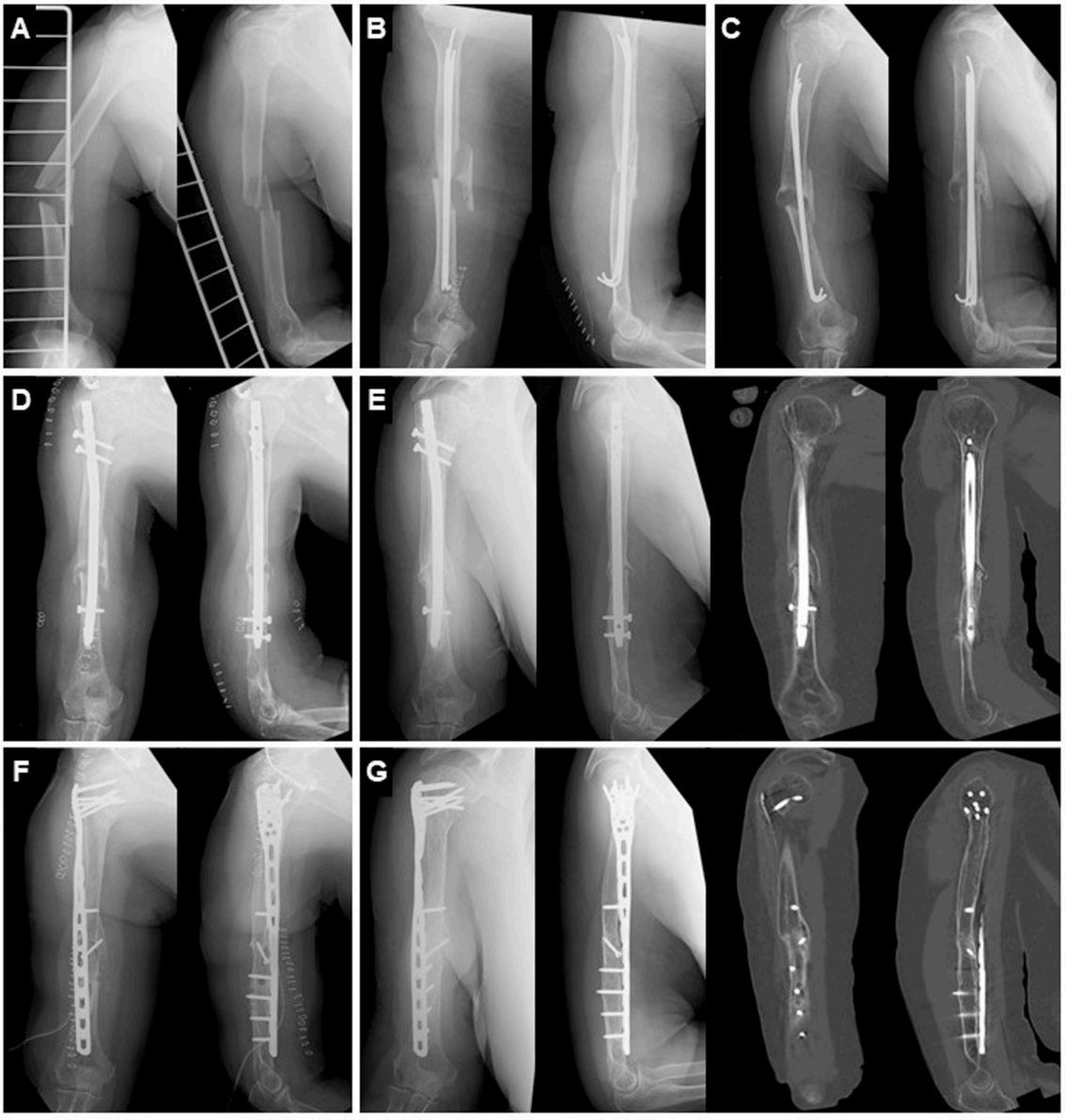

Fig. 1. Images of Case 1. (A) A humeral shaft fracture with a butterfly fragment. (B) Precisely after the first surgery with multiple stainless wires. (C) Eight months after the first surgery, bony union was not achieved. (D) After the second surgery with an intramedullary nail. (E) One year and eight months after the second surgery. Callus formation was observed, although bony union was not achieved. (F) After the third surgery using a helical plate without autologous bone grafting. (G) One year after helical plate fixation, bony union was achieved.

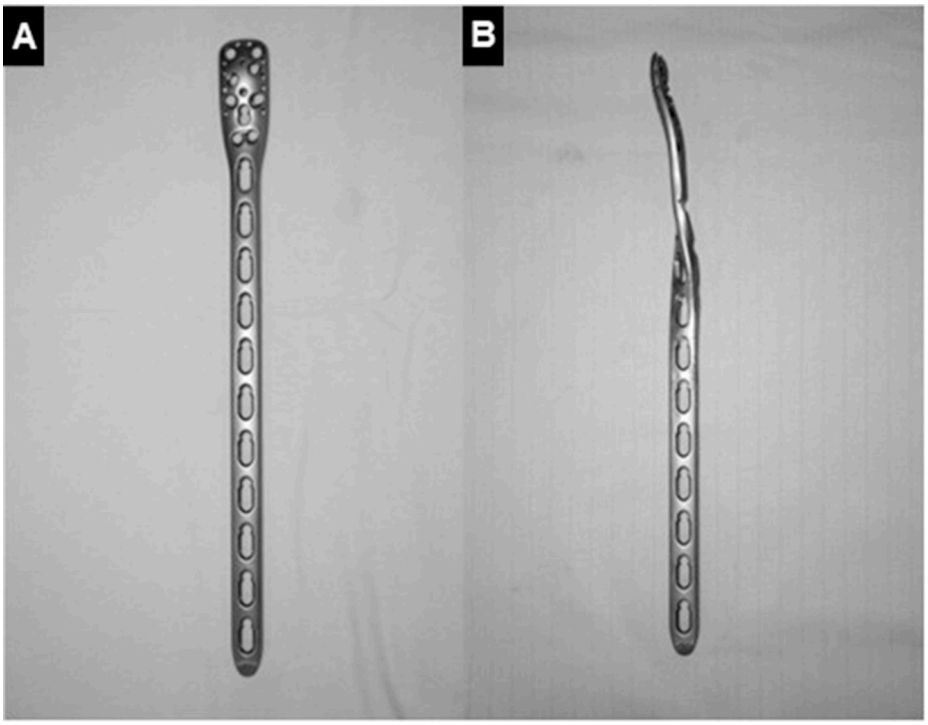

Fig. 2. Images of a pre- and post-contoured plate. (A) Pre-contoured straight shaped plate. (B) Post-contoured helical-shaped plate.

and B). She had a medical history of depression, but no smoking history. Two months after the procedure, she fell from a standing height and was re-injured by slamming her elbow on the ground. Plain radiographs and CT revealed an ununited humeral shaft and distal humeral extraarticular fracture at the tip of the IMN (Fig. 3C). Consequently, she was referred to our hospital for revision surgery. First, we removed the IMN, and a helical plate was contoured in the same manner as that in Case 1. Then, helical plating was performed using the minimally invasive plate osteosynthesis (MIPO) technique. Neither exploration of the diaphyseal fracture site nor autologous bone grafting was performed. Finally, the distal humeral fracture was reduced and fixed with locking plates using the triceps sparing posterior approach (Fig. 3D). One year post-operatively, bony union was achieved (Fig. 3E). At the final follow-up one year and six months after helical plate fixation, the patient returned to her daily activities without experiencing pain.

3. Discussion

We demonstrated that a re-nonunion after failed intramedullary nailing for a humeral shaft nonunion, and a peri-implant distal humeral fracture with an ununited humeral shaft after intramedullary nailing can be successfully treated by helical plating without bone grafting.

Several surgical treatment methods for humeral shaft nonunions have been described before. According to a systematic review by Peters et al. [2], the bony union rate using compression plates and autologous bone grafting for humeral shaft nonunions was 98%, for which intramedullary nailing was not recommended due to its lower bony union rate. However, there are no established treatments for re-nonunions after failed intramedullary nailing for nonunions of the humeral shaft. Furthermore, the application of helical plates for such cases has not been previously reported. Generally, fracture healing involves several factors. Giannoudis et al. have included osteogenic cells, osteoconductive scaffolds, osteoinductive growth factors, and the mechanical environment as part of these, which they have summarized as the “diamond concept” [8,9]. This concept states that the key to the success of nonunion treatment is to consider the causative factors of nonunions—biological factors, such as cells, scaffolds, and growth factors, and biomechanical factors, such as the mechanical environment. The callus formation at the non-uinon site observed in Case 1 is a finding resulting from a lack of stability. Therefore, we inserted an interfragmentary lag screw and as many screws as possible into the proximal and the distal fragment to improve mechanical stability. No autologous bone grafting to improve the biological factors was performed because these were preserved in this case.

Peri-implant distal humeral fractures after intramedullary nailing for humeral shaft fractures are uncommon, with only a few cases having been previously described [10,11]. Additionally, if the bony union of the humeral shaft is not achieved, its treatment becomes more difficult [12]. In the previously reported case, the IMN was not removed, a locking plate was applied, and cerclage cables were added in addition to the screws. Without removing the IMN, only monocortical screws could be inserted, requiring longer plates and cerclage wiring and resulting in greater soft tissue damage. In our case, the helical plate was applied after IMN removal, which enabled plate fixation for distal humerus with the minimum required length and reduced soft tissue damage.

A benefit of applying helical plates in our cases is that it prevents damage to the radial nerve and soft tissues; radial nerve injuries are less common in helical plating than in conventional straight plating because the distal part of the helical plate is located on the anterior or anterolateral aspect of the humerus, making exploration of the radial nerve not required [3]. Conversely, the distal part in straight plating is placed at the lateral aspect of the humerus, necessitating the identification and exploration of the radial nerve when using longer plates to fix diaphyseal humeral fractures. In both of our cases, despite using sufficiently long plates to cover almost the entire length of the humerus, we did not have to explore the radial nerve by using helical plates. Moreover, helical plating was performed using a MIPO technique to preserve the blood supply at the diaphyseal fracture site, which contributed to bony union and prevention of infection. Another benefit of applying helical plates in our cases is that it provides a biomechanically strong fixation, since helical plates have demonstrated higher torsional resistance than conventional straight plates have [6]. As mentioned above, the re-nonunion in Case 1 was caused by a lack of biomechanical stability. Similarly, in Case 2, the bony union of the humeral shaft was not achieved and required a stronger fixation, for which we applied helical

Fig. 3. Images of Case 2. (A) A humeral shaft fracture with a small third fragment. (B) Precisely after the first surgery with an intramedullary nail (IMN). (C) Two months after the first surgery, a distal humeral extraarticular fracture was found at the tip of the IMN and the humeral shaft was not united. (D) After the second surgery with a helical plate and distal humeral plates. (E) One year after the second surgery, bone union was achieved.

plating in both cases.

However, whether to use contoured or pre-contoured plates is controversial. Pre-contoured helical plates are not available in our country, causing us to have to contour plates in a helical fashion by ourselves. Contouring plates may decrease the durability of the plate and increase operative time. However, plate breakage has been reported even when using pre-contoured plates [4]. Hence, using a longer plate and inserting enough numbers and appropriate length of screws into each fragment is crucial to prevent plate breakage and to obtain a mechanically strong fixation. Especially in the helical plate fixation for the humerus, inserting as many screws as possible into the proximal fragment and at least four bicortical screws into the distal fragment is necessary to resist rotation [13].

4. Conclusion

Evaluating the causative factors of nonunions is important. Helical plating provides a mechanically strong fixation and has been associated with bony union without requiring autologous bone grafting for a re-nonunion after failed intramedullary nailing to treat a humeral shaft nonunion. For a peri-implant distal humeral fracture with an ununited humeral shaft after intramedullary nailing, helical plating with the MIPO technique facilitates bony union at the diaphyseal fracture site and enables the minimal length of the distal humeral plate fixation.

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Author contribution

Shuya Nohmi: Operation of the patient, writing—original draft, Masahiro Suzuki: Writing—review and editing, Yukiko Sakamoto: Investigation, All authors read and approved the final manuscript.

Registration of research studies

1. Name of the registry:
2. Unique Identifying number or registration ID:
3. Hyperlink to your specific registration (must be publicly accessible and will be checked):

Guarantor

Shuya Nohmi.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Declaration of competing interest

The authors have no conflict of interest to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2022.104442.

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