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Case Report

Open reduction and Kirschner wire fixation method using a cylindrical block of unidirectional porous β-tricalcium phosphate for tongue-shaped calcaneal fracture: Report of three cases

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ABSTRACT

Background: The artificial bone grafts are performed on the defect after reduction of the calcaneal fracture. Generally, it is an artificial bone graft with an implant, and there are a few reports of an artificial bone graft without an implant.
Cases: We report three cases (42-year-old male, 67-year-old male, 21-year-old female) of a tongue-shaped calcaneal fracture treated using a cylindrical unidirectional porous β-tricalcium phosphate artificial bone (Affinos®, Kurare co Ltd., Hyougo, Japan) to surgically repair bone defects after reduction. The bone defect is often observed when fracture is reduced in calcaneal fracture. There were significant bone defects, which were then fixed using Affinos® (forming a cylindrical shape block; diameter 10 mm x height 20 mm) to support the bone fragment, an artificial β-tricalcium phosphate bone with a porosity of 57 % (pore size 25–300 μm), characterized by a novel unidirectional porous structure. Postoperative early rehabilitation started with partial load from 5 weeks after surgery and was full weight bearing at 9 weeks after surgery. There was no correction loss and good bone fusion was obtained. By 12 months postoperatively, patients were able to be walking without pain and absorption and bone fusion around the artificial bone were observed maintaining the morphology immediately after reduction. The result was a good clinical result of one excellent (92 points) and two good (81 and 84 points) 1 year after surgery in the postoperative AOFAS Ankle-Hindfoot Scale.
Conclusion: Affinos® has a frost-like structure, which endows it with good tissue invasive properties because of the capillary effect. Moreover, it has excellent osteoconduction capability. In these 3 cases, Affinos® showed good strength, affinity, absorption, and bone substitution in a tongue-shaped calcaneal fracture. Further prospective studies are required to confirm our findings.

Introduction

Calcaneal fractures represent 1–2 % of all fractures. In most cases these fractures are high-altitude falls or jumping injuries. The question of treatment choice still remains open [1–4]. The operative treatment used varies on a case-by-case basis and is influenced by surgeon preference [3–6]. Recently, lateral locking plate fixation combined with bone grafting is becoming common [7]. However,

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intra-implant fixation for calcaneal fractures carries the risk of implant infection and may require removal of the plate. Therefore, we performed reconstructive Kirschner wire fixation using an artificial β-tricalcium phosphate bone forming a cylindrical shape block, diameter 10 mm x height 20 mm (Affinos®, Kurare co Ltd., Hyougo, Japan), a new artificial bone that does not require implant fixation. We presented three cases of tongue-type calcaneus fracture according to the Essex-Lopresti classification, treated without big implant using a cylindrical shape Affinos® after reduction of the fracture under open technique.

Case presentation

Case 1

A 42 -year-old male fell from a height of 4 m during work. He felt pain in his right heels and had swelling. He was evaluated with standard lateral and axial plain x-ray of the calcaneus (Fig. 1A). Computed tomography (CT) in the sagittal, coronal, axial and 3D plane was performed. Fracture type is tongue type in Essex–Lopresti classification, and type 2B in the Sanders classification. We used external fixation and waited in an elevated position until the swelling was alleviated. The return of skin wrinkles to the lateral foot at the surgical incision site was used as a guide for timing surgery. Surgery of open reduction was performed 17 days after the injury.

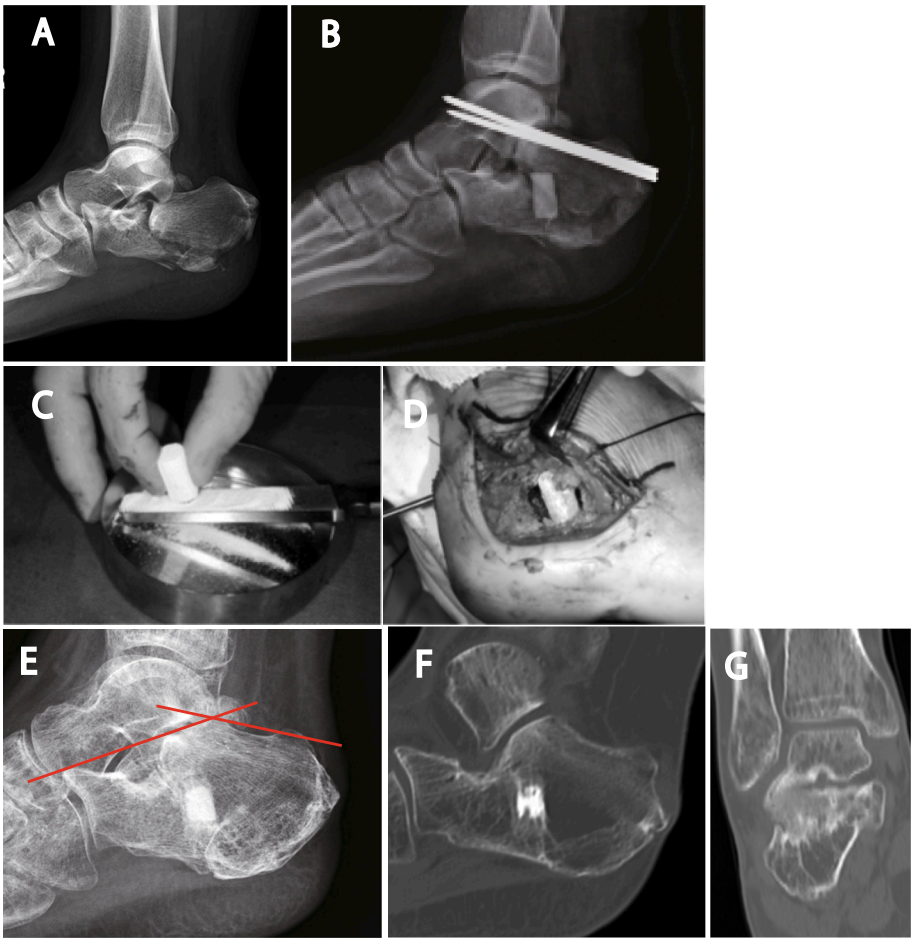

Fig. 1. Treatment method, pre- and postoperative imaging in case 1.
A, Preoperative x-ray (lateral view). Fracture type is tongue type in Essex-Lopresti classification.
B, Postoperative x-ray (lateral view). The tongue shaped bone fragment can be reduced to the anatomical position.
C, Adjusting the height of the artificial bone at the defect site.
D, Insert the artificial bone according to the height of the defect.
E, Postoperative x-ray 12 months after surgery (lateral view). The Böhler angle improved to 33°.
F, Postoperative computer tomography 12 months after surgery (sagittal view). The artificial bone did not collapse and kept its shape, and half of the artificial bone had already been absorbed.
G, Postoperative computer tomography 12 months after surgery (axial view). Bone union is complete and articular surfaces are preserved.

Operative technique

Under general anesthesia, the patient is put in the lateral decubitus position on a standard radiolucent table, with a tourniquet (300 mm Hg, under 60 min) on the upper thigh, L-shaped incision was made on the outside of the calcaneus. A subperiostal flap was created with sharp dissection, protecting the surrounding soft tissue and sural nerve. Particular care was taken to protect the soft tissue flap throughout the exposure and reduction. Next, temporary fixation of the posterior facet was performed by passing 3.0-mm Kirschner wires from the thalamic portion toward the sustentaculum. The reduction of fracture was checked by the C-arm. The bone defect was confirmed when the depressed bone fragment was lifted. The Affinos® (formed a cylindrical shape block; diameter 10 mm x height 20 mm) was inserted into the bone defect so as to support the bone fragment (Fig. 1B, C, D). The wound was closed using subcutaneous absorbable 3-0 suture material. A subcutaneous drain was inserted, and the skin was closed with 4-0 nonabsorbable sutures. A dressing was applied, followed by thick cotton wool wadding and a short leg half splint.

The Kirschner wires were removed 4 weeks after surgery. Gradually increasing weightbearing was started 5 weeks after surgery, and full weightbearing was initiated in 9 weeks after surgery.

Twelve months after surgery, there was no correction loss by x-ray (Fig. 1E) and CT (Fig. 1F, G), and the postoperative AOFAS Ankle-Hindfoot Scale was excellent of 92 points.

Case 2

A 67-year-old male fell down the stairs. He felt pain in his left heels and had swelling. His diagnosis of left calcaneal tongue type fracture (Fig. 2A) and type 3AC in the Sanders classification was made from x-ray images and CT images, and the reduction of fracture was performed 10 days after the injury after the swelling was improved by external fixation.

In the same surgery (Fig. 2B) and rehabilitation as above, a few correction loss was observed 1 year after surgery (Fig. 2C, D, E), but AOFAS Ankle-Hindfoot Scale was good of 81 points.

Case 3

A 21-year-old female was injured by jumping from 10 m. She felt pain in hers left heels and had swelling. Her diagnosis was a

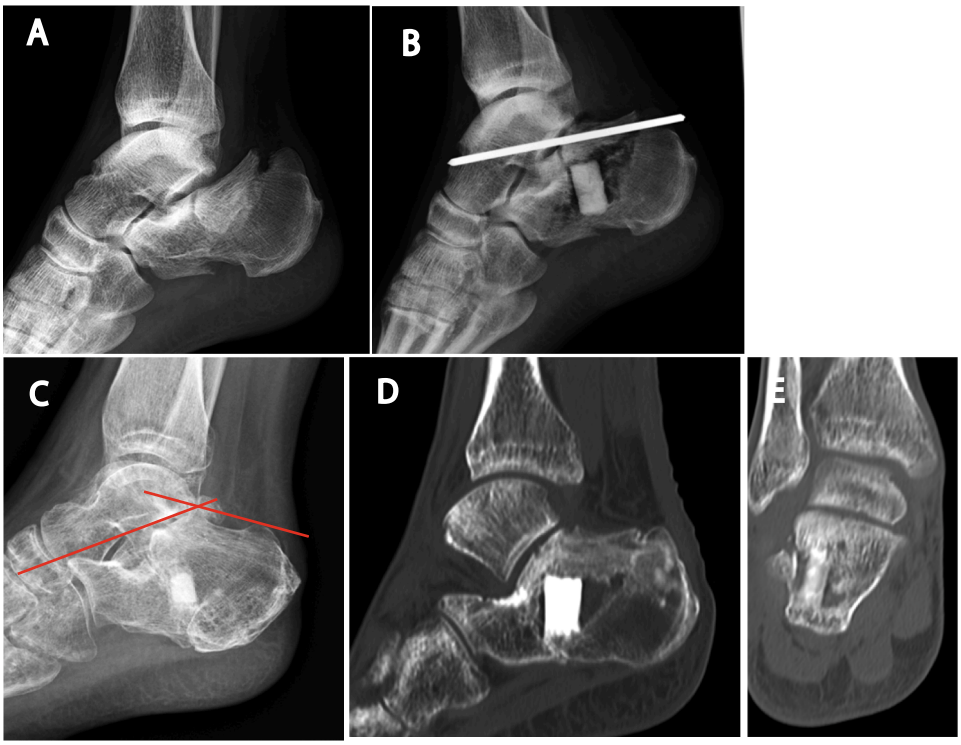

Fig. 2. Pre- and postoperative imaging in case 2.
A, Preoperative x-ray (lateral view). Fracture type is tongue type in Essex-Lopresti classification.
B, Postoperative x-ray (lateral view). The tongue shaped bone fragment can be reduced to the anatomical position.
C, Postoperative x-ray 12 months after surgery (lateral view). The Böhler angle improved to 29°.
D, Postoperative computer tomography 12 months after surgery (sagittal view). The artificial bone did not collapse and kept its shape, and 1/3 of the artificial bone had been absorbed.
E, Postoperative computer tomography 12 months after surgery (axial view). Articular surfaces are preserved and no osteoarthritis change.

tongue-shaped fracture (Fig. 3A) and type 3AC in the Sanders classification (Fig. 3B). On the day of the injury, external fixation was performed, and surgery was performed after the swelling had improved 14 days after injury (Fig. 3C).

In the same surgery and rehabilitation as above, there were no correction loss was observed 1 year after surgery (Fig. 3D, E, F), and the postoperative AOFAS Ankle-Hindfoot Scale was good of 84 points.

Discussion

Largely displaced intraarticular calcaneal fractures are more commonly treated with open reduction internal fixation than conservative treatment. The purpose of the surgery is to adjust the height, width and length of the calcaneus and perform an anatomical repair [8]. In recent years, internal fixation surgery using a locking lateral plate has become common to obtain strong stability of the fracture site. However, problems such as postoperative infection and wound skin necrosis have been reported [2,9]. Therefore, we thought that soft tissue trouble could be reduced by performing calcaneal fracture surgery without a plate.

The operative treatment of intraarticular calcaneal fractures with or without bone grafting is still a topic of debate. The practice of using a bone graft to fill the "empty core" of the calcaneus during surgery has become increasingly popular. The bone grafting for calcaneal fractures has been used for bone defects after reduction, and is reported to be performed in 2.2 million people annually in the United States, and is clinically used in many facilities [10,11]. In recent years, artificial bone (hydroxyapatite, β-tricalcium phosphate, etc.) graft has become the mainstream for autologous bone graft due to the problems of the harvested site (pain, bleeding, infection, amount of bleeding, etc.) [12]. There are reports that postoperative correction loss is reduced by bone grafting [13], and excellent

Fig. 3. Pre- and postoperative imaging in case 3.
A, Preoperative x-ray (lateral view). Fracture type is tongue type in Essex-Lopresti classification.
B, Preoperative computer tomography (coronal view). Fracture type is type 3AB in the Sanders classification.
C, Postoperative x-ray (lateral view). The tongue shaped bone fragment can be reduced to the anatomical position.
D, Postoperative x-ray 12 months after surgery (lateral view). The Böhler angle improved to 31°.
E, Postoperative computer tomography 12 months after surgery (sagittal view). The artificial bone did not collapse and kept its shape, and the artificial bone had been mostly absorbed.
F, Postoperative computer tomography 12 months after surgery (axial view). Articular surface is partially irregular.

postoperative results have been reported in prospective clinical trials [14]. There are many useful reports in bone grafting. Therefore, bone grafting for calcaneal fractures is effective in retaining depressed bone fragments, and clinically useful therapeutic method.

In recent years, various artificial bones have been developed and used, and the artificial bone that we used this time has Affinos® (a cylindrical shape block; diameter 10 mm × height 20 mm), an artificial β-tricalcium phosphate bone with a porosity of 57 % (pore size: 25–300 μm), characterized by a novel unidirectional porous structure. Affinos® has the characteristic that bone formation can be seen at an early stage compared to other artificial bones [15]. In addition, the compressive strength after transplantation of the femur of a beagle dog was similar to that of normal bone 3 weeks after transplantation (unpublished data). Based on these data, we thought that it would be possible to perform Kirschner wire removal and load-bearing training early after surgery. As a result, there was no loss of Böhler angle correction with temporary Kirschner wire fixation for 4 weeks after surgery. Therefore, we thought that the Affinos® had performed their functions satisfactorily.

In this time, we report three cases in which cylindrical Affinos® were used for post-reduction bone defects in calcaneal fractures. I don't know if it's better to fill (many artificial bones of various shapes) the whole depression or just one artificial bone, but considering the medical economy, I think it's better to treat it at a lower cost. In recent years, there have been reports of the use of balloons to reduce depressions and the use of liquid-based artificial bones [16], which may lead to calcaneal fracture treatment that does not use implants [17,18]. Perhaps in the future, a minimally invasive treatment for intra-articular calcaneal fractures that does not use implants may be developed.

Conclusion

A prospective trial with a large sample of patients would be required to assess these options. Treatment of tongue-shaped calcaneal fractures with a single cylindrical artificial bone (Affinos®) graft does not cause correction loss and is a safe surgical method. In addition, it is considered to be a useful surgical method that can be treated at a low cost. In the future, we would like to increase the number of cases and examine the usefulness of this surgical method.

Ethical approval

The work was conducted in accordance with the Declaration of Helsinki (1964).

Informed consent

Informed consent was obtained from all patients.

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Declaration of competing interest

The authors declare that they have no conflicts of interest.

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References

[1] J. Bruce, A. Sutherland, Surgical versus conservative interventions for displaced intra-articular calcaneal fractures, Cochrane Database Syst. Rev. 1 (Jan 31 2013), CD008628, https://doi.org/10.1002/14651858.CD008628.pub2.
[2] R. Sanders, Z.M. Vaupel, M. Erdogan, K. Downes, Operative treatment of displaced intraarticular calcaneal fractures: long-term (10-20 years) results in 108 fractures using a prognostic CT classification, J. Orthop. Trauma 28 (2014) 551–563.
[3] K. Palmersheim, B. Hines, B.L. Olsen, Calcaneal fractures: update on current treatments, Clin. Podiatr. Med. Surg. 29 (2012) 205–220.
[4] Z. Wu, Y. Su, W. Chen, Q. Zhang, Y. Liu, M. Li, W. Haili, Z. Yingze, Functional outcome of displaced intra-articular calcaneal fractures: a comparison between open reduction/ internal fixation and a minimally invasive approach featured an anatomical plate and compression bolts, J. Trauma Acute Care Surg. 73 (2012) 743–751.
[5] M. Goldzak, P. Simon, T. Mittlmeier, M. Chaussmier, R. Chiergatti, Primary stability of an intramedullary calcaneal nail and an angular stable calcaneal plate in a biomechanical testing model of intraarticular calcaneal fracture, Injury 45 (2014) S49–S53.
[6] N. Jiang, Q.R. Lin, X.C. Diao, L. Wu, B. Yu, Surgical versus nonsurgical treatment of displaced intra-articular calcaneal fracture: a meta-analysis of current evidence base, Int. Orthop. 36 (2012) 1615–1622.
[7] P. Zeman, J. Zeman, J. Matejka, K. Koudela, Long-term results of calcaneal fracture treatment by open reduction and internal fixation using a calcaneal locking compression plate from an extended lateral approach, Acta Chir. Orthop. Traumatol. Cechoslov. 75 (2008) 457–464.
[8] R. Buckley, S. Tough, R. McCormack, G. Pate, R. Leighton, D. Petrie, G. Robert, Operative compared with nonoperative treatment of displaced intra-articular calcaneal fractures: a prospective, randomized, controlled multicenter trial, J. Bone Joint Surg. Am. 84 (2002) 1733–1744.
[9] D. Makki, H.M. Alnajjar, S. Walkay, U. Ramkumar, A.J. Watson, P.W. Allen, Osteosynthesis of displaced intra-articular fractures of the calcaneum, J. Bone Joint Surg. (Br.) 92 (2010) 693–700.

[10] K.U. Lewandrowski, J.D. Gresser, D.L. Wise, D.J. Trantol, Bioresorbable bone graft substitutes of different osteoconductivities: a histologic evaluation of osteointegration of poly (propylene glycol-co-fumaric acid)-based cement implants in rats, Biomaterials 21 (2000) 757–764.
[11] A.K. Singh, K. Vinay, Surgical treatment of displaced intra-articular calcaneal fractures: is bone grafting necessary? J. Orthop. Traumatol. 14 (2013) 299–305.
[12] J.A. Rihn, K. Kirkpatrick, T.J. Albert, Graft options in posterolateral and posterior interbody lumbar fusion, Spine (Phila Pa 1976) 35 (2010) 1629–1639.
[13] T.M. Duymus, S. Mutlu, H. Mutlu, O. Omer, G. Olcay, M. Mahir, Need for bone grafts in the surgical treatment of displaced intra-articular calcaneal fractures, J. Foot Ankle Surg. 56 (2017) 54–58.
[14] D. Longino, R.E. Buckley, Bone graft in the operative treatment of displaced intraarticular calcaneal fractures: is it helpful, J. Orthop. Trauma 15 (2001) 280–286.
[15] M. Iwasashi, M. Sakane, H. Saito, T. Taguchi, T. Tateishi, N. Ochiai, In vivo evaluation of bonding ability and biocompatibility of a novel biodegradable glue consisting of tartaric acid derivative and human serum albumin, J. Biomed. Mater. Res. A 50 (2009) 543–548.
[16] M. Prod'homme, S.P. Jafar, P. Zogakis, P. Stutz, A novel minimally invasive reduction technique by balloon and distractor for intra-articular calcaneal fractures: a report of 2 cases, Case Rep. Orthop. 26 (2018), 7909184.
[17] D. Vittore, G. Vicenti, G. Caizzi, A. Abate, B. Moretti, Balloon-assisted reduction, pin fixation and tricalcium phosphate augmentation for calcanear fracture, Injury 45 (2014) S72–S79.
[18] F. Biggi, S. Di Fabio, C. D'Antimo, F. Isoni, C. Salfi, S. Trevisani, Percutaneous calcaneoplasty in displaced intraarticular calcaneal fractures, J. Orthop. Traumatol. 14 (2013) 307–310.