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Case Reports and Series

Large Osseous Defect Reconstruction Using a Custom Three-Dimensional Printed Titanium Truss Implant

Eric So, DPM [1], Vincent H. Mandas, DPM [2], Lee Hlad, DPM [3]

[1]*Chief Resident, Grant Medical Center, Columbus, OH*
[2]*Resident, Grant Medical Center, Columbus, OH*
[3]*Foot and Ankle Surgeon, Step Lively Foot and Ankle Centers, Columbus, OH*

A R T I C L E I N F O

Level of Clinical Evidence: 4

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A B S T R A C T

Treatment of large osseous defects remains a difficult surgical challenge. Autografts and allografts have been known to undergo late collapse, because these options are not specifically designed to withstand the high loads of the foot and ankle. The inability to achieve the correct shape for reconstruction further limits their application. Large osseous defects will result during salvage after failed Lapidus bunionectomy, explantation of failed total ankle replacements, and nonunion of Evans calcaneal osteotomy. Each of 3 patients received a 4WEB custom 3-dimensional (3D) titanium truss implant (Patient Specific Custom Implant; 4WEB Medical, Inc., Frisco, TX) for reconstruction. The mean follow-up period was 17.33 ± 3.51 months. Significant improvement was seen in pain, with a successful return to activities of daily living. The 12-month postoperative computed tomography findings demonstrated incorporation of the implant to the surrounding cortical and cancellous bone. No signs of delayed complications, such as stress shielding or implant failure, were found. This is the first case series to describe the use of a custom 3D-printed titanium truss implant to successfully contribute to reconstruction in the setting of failed elective foot and ankle surgery. This technology might play an important role in limb salvage of osseous defects that would otherwise require bone block arthrodesis with structural allograft or autograft bone.

Treatment of large osseous defects continues to be a clinical challenge for foot and ankle surgeons. Reconstruction of these injuries has been described after posttraumatic defects, avascular necrosis, severe pilon fracture, hindfoot and ankle nonunion, Charcot neuroarthropathy, failed total ankle arthroplasty, and osseous tumors (1–10). Despite advances in reconstruction techniques, complication rates have remained high, with subsequent amputation rates ≤19% in patients with revision surgery (5). Reconstruction of large osseous defects has traditionally required the use of a structural graft to fill the gaps and maintain the height, length, and/or desired correction (11). Autografts or allografts are sources of structural grafts to fill the defect space and promote consolidation. However, both structural bone graft options have associated disadvantages, including high rates of nonunion, graft infection, donor site morbidity, recalcitrant pain, and limb length discrepancies (12).

Autografts have largely been associated with donor site morbidity, a longer hospital stay, limited quantity, and concerns for quality in a compromised host (13). Allografts and autografts have been shown to undergo late collapse and structural failure, leading to either less satisfying results or failure of the procedure. Furthermore, these options are limited by an inability to achieve the precise anatomic shape for reconstruction according to the shape of the osseous defect (14–16). These grafting techniques are also not specifically designed to withstand the high loads and forces found in the foot and ankle, which predisposes these techniques to graft collapse (17). Thus, a grafting option with improved structural integrity and the ability to accommodate internal fixation is needed.

Additive manufacturing, commonly referred to as 3-dimensional (3D) printing, is the process of creating a predefined object by precise deposition of materials in a layer-by-layer fashion (18). 3D printing allows implants to be tailored to each patient's pathoanatomy. The conception of patient-specific implants was first introduced in the cutting guide instrumentation in total knee replacements (19). This technology has expanded to treat osseous defects in the foot and ankle (2,3,6). The theoretical advantage of 3D printing is the seemingly limitless customizability in size, shape, and material options, thus opening a new frontier for reconstructive efforts in patients previously relegated to complex limb salvage or amputation. To the best of our knowledge, the present report is the first to describe the versatile and durable application of a custom 3D-printed truss implant (Patient

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Address correspondence to: Eric So, DPM, Grant Medical Center, 285 East State Street, Suite 670, Columbus, OH 43215.
E-mail address: ericso70@gmail.com (E. So).

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Table
Patient demographics, failed index procedure, implant characteristics, fixation methods, and limb salvage

Variable	Patient Number		
	1	2	3
Age (y)	38	29	64
Gender	Female	Female	Female
Failed procedure	Total ankle replacement implant failure	Evans calcaneal osteotomy, septic nonunion	Lapidus bunionectomy, septic nonunion
Dimensions (mm)			
Height		NA	NA
Overall	25.4		
Superiorly	43.8 × 35.5		
Inferiorly	43.8 × 44.6		
Length	NA		
Overall		24.5	70
Anteriorly		18.5 × 25.6	14.5 × 13.5
Posteriorly		24.4 × 27.0	28.7 × 19.5
Orthobiologics	Trinity ELITE DBM (Orthofix, Lewisville, TX) and autogenous fibular bone graft	5 mL Paragon V92 MSCs (Paragon28 Inc., Englewood, CO) and 40 mL of BMA from right tibia	Trinity ELITE DBM (Orthofix) and 40 mL of bone graft major from left femur by reamer-irrigator-aspirator
Follow-up (mo)	21	14	17
Limb salvage	Yes	Yes	Yes
Complications	Superficial wound dehiscence	None	None
Fixation	13 × 200-mm retrograde nail with 6 interlocking screws (Orthofix)	7.0-mm screw (Paragon28 Inc.)	6.5-mm beaming screw with two 4.0-mm interlocking screws (Wright Medical Technologies, Memphis, TN)

Abbreviations: BMA, bone marrow aspirate; MSCs, mesenchymal stem cells; NA, not applicable.

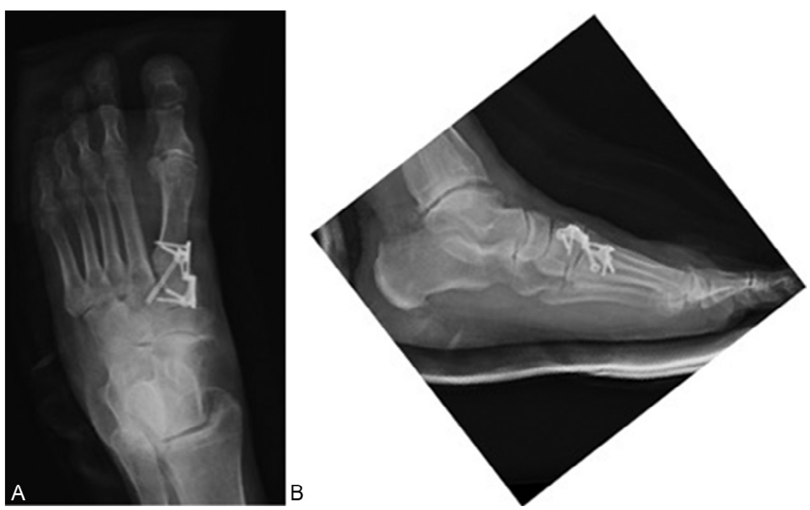

Fig. 1. *(A)* Anteroposterior and *(B)* lateral views of Lapidus bunionectomy as index procedure.

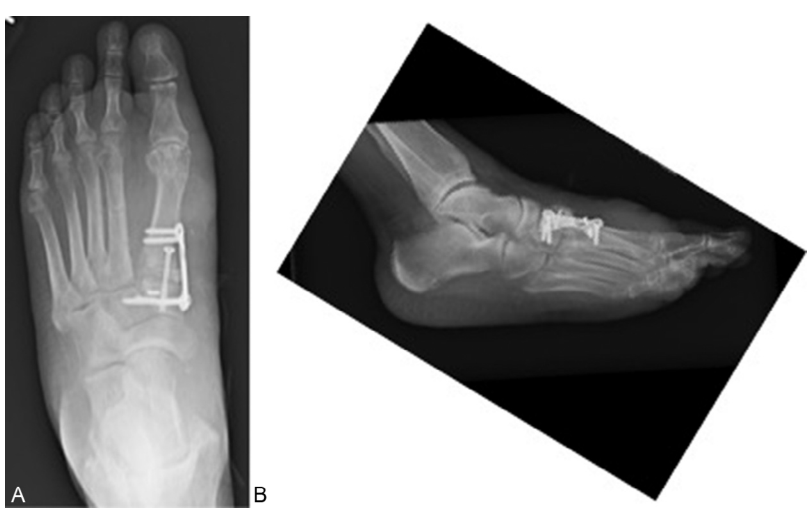

Fig. 2. *(A)* Anteroposterior and *(B)* lateral views of revision of nonunion of Lapidus bunionectomy.