The Journal of Foot & Ankle Surgery ■■ (2017) ■■–■■

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Case Reports and Series

Titanium Scaffolding: An Innovative Modality for Salvage of Failed First Ray Procedures

Natalie Coriaty, BA [1], Katherine Pettibone, BA [1], Nicholas Todd, DPM, FACFAS [2], Shannon Rush, DPM, FACFAS [3], Ryan Carter, DPM, AACFAS [4], Colin Zdenek, DPM, AACFAS [4]

[1]Fourth-year Student, California School of Podiatric Medicine, Oakland, CA
[2]Attending Physician, Chief of Surgical Services, Camino Division, Palo Alto Medical Foundation, Mountain View, CA
[3]Attending Physician, Chief of Foot and Ankle Surgery, Palo Alto Medical Foundation, Mountain View, CA
[4]Fellow, Palo Alto Medical Foundation, Mountain View, CA

ARTICLE INFO

Level of Evidence: 4

Keywords:
first metatarsal
graft
implant
lengthening
truss

ABSTRACT

Shortening of the first ray is a potential complication associated with first metatarsal procedures. Correction of this deformity conventionally has required the use of a tricortical bone graft to lengthen the bone. Graft complications, including donor site morbidity, poor graft stability, and graft resorption, have revealed a need for an alternative procedure. The present report shows that titanium cage scaffolding has lower extremity applications beyond its previous uses in the ankle and spine. Two patients underwent surgical correction for failed first ray procedures using a titanium cage apparatus with a calcaneal autograft and other biologic agents. The scaffolds were appropriately sized to fill the defect. Patients remained non-weightbearing until radiographic evidence of healing appeared. Success was determined by diminished pain, a return to activity, ambulation, and patient satisfaction. Patients exhibited faster-than-anticipated healing, including a return to protected weightbearing activities and increased stability within 6 weeks. Titanium cage implants provide long-term stability and resistance to stress and strain in the forefoot. The implant we have described, newly applied to the first ray, is analogous to a system used in salvage of failed ankle replacements. In addition to reducing reliance on the iliac crest bone graft, the titanium cage apparatus is advantageous because it is customized to fill a defect using computed tomography scanning, thereby reducing graft failure secondary to an improper shape. These cases demonstrate the potential beneficial applications for titanium cages in failed first ray reconstruction.

Failed arthroplasty and other first metatarsal procedures frequently result in iatrogenic shortening of the first metatarsal. These changes in length alter the natural dynamics of the metatarsal parabola, which, in turn, increases the potential for transfer metatarsalgia, lesser metatarsal stress fracture, hammertoe deformity, and collapse of the medial longitudinal arch (1,2). First metatarsal arthrodesis has historically been used as a surgical response to revise unsuccessful hallux valgus and Silastic implant arthroplasty procedures (3–5). If the metatarsal parabola exhibits shortening of the first metatarsal or inadequate viable bone stock, an arthrodesis procedure will be performed in conjunction with a metatarsophalangeal (MTP) joint distraction and bone graft to restore the first metatarsal length (5–7). Traditional techniques rely on corticocancellous autografts as the grafting material used to lengthen the metatarsal; however, these have associated with donor site morbidity and limited resources (6,8). Titanium cage implants provide an alternative: a stable, noncompressible construct in which grafts and graft adjuncts with little structural support can thrive. The present study demonstrates how the titanium truss system, previously applied to the ankle, has been successfully used in first metatarsal salvage procedures.

The use of iliac crest bone graft (ICBG) autografts with MTP joint distraction is currently accepted as the reference standard for a lengthening arthrodesis procedure, but its use comes with a cost (3,9). Donor site morbidity at the iliac crest, tibia, or calcaneus contributes to additional patient discomfort. Goulet et al (10) found that 38% of 87 patients who had received an ICBG experienced donor site pain at 6 months postoperatively and 19% experienced pain 2 years postoperatively. A comparison of intraoperative morbidities between autografts and allografts showed that patients receiving autografts had a greater than threefold increase in blood loss, lengthened operative time, and chronic pain at the donor site (11). The likeliness of associated chronic pain, nearly 1 in 5 after 2 years, and the perioperative

Financial Disclosure: None reported.
Conflict of Interest: S.R. is an SDI founder and consultant to Stryker and Zimmer.

Address correspondence to: Nicholas Todd, DPM, FACFAS, Palo Alto Medical Foundation, 701 E. El Camino Real, Mountain View, CA 94040.
E-mail address: nicholaswtodd@gmail.com (N. Todd).

1067-2516/$ - see front matter
https://doi.org/10.1053/j.jfas.2017.10.011

disadvantages related to autogenous grafting have necessitated a new avenue for grafting technology that relies less heavily on autogenous grafts. In addition to surgical donor complications, autograft resources are limited (12,13). Calcaneal grafts, for example, can be a maximum of 2.0 × 1.0 cm in dimension, and it has generally been accepted that donor morbidity increases greatly with grafts exceeding these dimensions (13,14). Furthermore, viable bone stock is subject to immense variation in the cellularity of different grafting locations.[8] Tibial and calcaneal grafts, for example, contain a greater ratio of quiescent fat to hematopoietic tissue compared with ICBGs. Therefore, the use of a slightly less invasive harvesting technique, such as in the tibia or calcaneus, will also yield a graft with more feeble osteogenic and osteoinductive qualities (8).

Although autografts embody osteogenic, osteoinductive, and osteoconductive qualities, manufactured and allogeneic-harvested graft materials might ultimately yield a more satisfied patient because of the reduced donor site discomfort. A combination of synthetic scaffolds, growth factors, stem cells, and allografts has the potential to yield the positive outcomes of an autograft but with the reduced graft resorption and donor site drawbacks (12,15). Titanium cage implants supply the necessary structure to support amorphic bio-manufactured graft adjunctive materials or delicate cancellous graft chips, which have all 3 of the obligatory components of bone growth. The inert qualities of titanium make its use ideal in a highly inflamed region and its strength provides long-term stability and appropriate resistance to stress and strain in a highly used region of the foot (16).

The titanium truss system has only recently been applied to the first ray. The system described in the present study is analogous to the titanium cage spacer that has been successfully used in the salvage of failed ankle replacements (17). According to Mulhern et al (17), the titanium cage spacer is advantageous because it can be customized to fill a defect using computed tomography (CT) scanning. The coarse texture of the titanium cage allows for osteointegration and the ability to 3-dimensionally print a custom scaffold addresses the challenges associated with autografts and allografts, including graft failure secondary to an improper shape (18). The present report indicates that the titanium scaffold has beneficial applications in the first metatarsal after a failed first MTP joint Silastic implant and failed first metatarsal lengthening procedure with a calcaneal autograft.

Case Report

Patient 1

An active 55-year-old male nonsmoking patient presented with a history of a right foot first MTP joint arthroplasty and neuroma excision at his third interspace >6 years previously. His initial physical examination revealed an intact neurovascular status and a drooping right hallux with an inability to dorsiflex. The patient had an iatrogenic laceration of the extensor hallucis longus (EHL) at the right first MTP joint from the original surgery. This was confirmed by ultrasound imaging. Passive range of motion at the right first MTP joint was severely limited and revealed notable crepitus. The patient had an antalgic gait with circumduction on the right side. Radiographs and CT imaging (Figs. 1–4) revealed a subluxed Silastic implant with local osteophytes and heterotrophic bone formation. The distal end of the implant abutted the proximal medial cortex of the right proximal hallux with clear signs of cortical erosion in that area. Ultrasound studies showed a 6-cm diastasis between the EHL tendon stumps extending from the first metatarsal cuneiform to the first MTP joint. The combination of the patient's EHL tendon laceration, dysfunction of the first MTP joint, and bony erosion at the first MTP joint, indicated an arthrodesis with an EHL tendon repair.

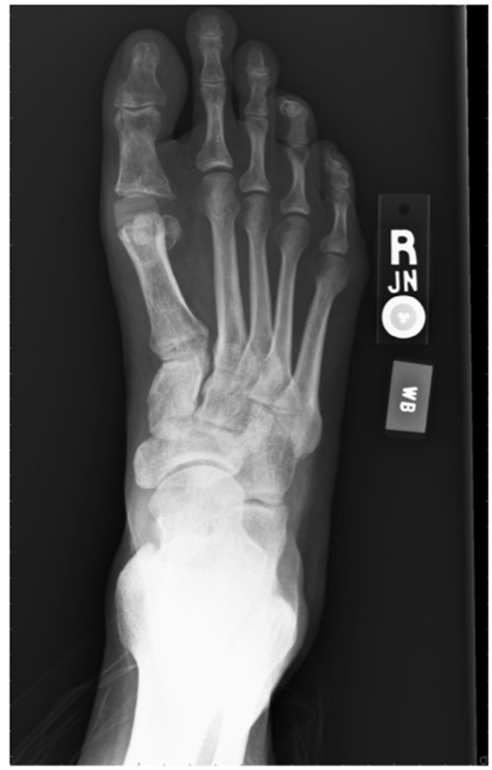

Fig. 1. Preoperative anteroposterior radiograph of right foot showing subluxed Silastic implant with local osteophytes and heterotrophic bone formation.

Before surgical treatment, the patient attempted nonoperative care, including stiff-soled shoes and orthotics, without success. Eight months after his first appointment, he underwent preoperative CT scans, which confirmed subluxation of the Silastic implant and local osteolysis. An

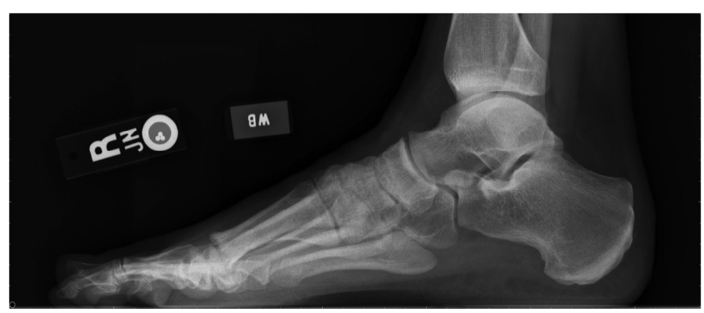

Fig. 2. Preoperative lateral radiograph of right foot showing subluxed Silastic implant with local osteophytes and heterotrophic bone formation.

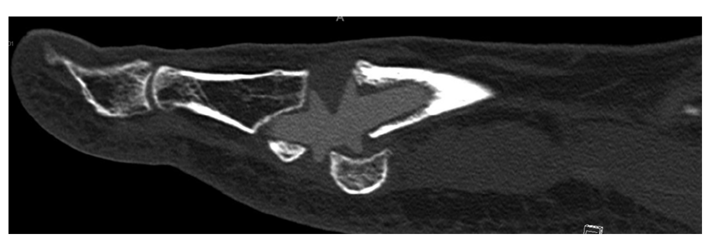

Fig. 3. Preoperative sagittal computed tomography of right foot showing subluxed Silastic implant with local osteophytes and heterotrophic bone formation.