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# Minimally Invasive Opening Wedge Calcaneal Osteotomy Using a Titanium Structural Fusion Device

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## Abstract

Opening wedge calcaneal osteotomies are commonly used to treat tibialis posterior deformities and hindfoot varus deformities. This procedure traditionally employs the use of an autologous bone graft sourced from the iliac crest. We have explored the use of a titanium fusion plug to replace the autograft. Opening wedge calcaneal osteotomies were performed percutaneously on 18 patients over a 12-month period. Union was present in 100% of patients at 4 months. This technique is not only performed using minimally invasive techniques while providing comparable or better rates of union, it also negates complications that have been associated with autograft techniques; donor site morbidity, increased pain, increased rates of infection and graft collapse

***Keywords:*** *Calcaneal Osteotomy; Minimally Invasive; Structural Fusion Aid; Calcaneal Opening Wedge Osteotomy; Tibialis Posterior; Hindfoot Varus; Pes Planovalgus; Autograft*

## Introduction

The increasing population of overweight and obese people in society has seen increases in the prevalence of foot and ankle dysfunction and deformity. Studies have shown that obese individuals are much more likely to develop posterior tibial tendon dysfunction and associated pes planovalgus than individuals of normal weight [1]. This is commonly attributed to the increased load bearing stress placed on the ankle joint in the overweight individual [2,3]. This trend calls for simpler and more efficient treatment methods for such deformities in order to meet the increasing rates of prevalence.

Calcaneal osteotomies are a commonly performed procedure to treat a variety of conditions of the hindfoot such as posterior tibial tendon dysfunction as well as broader conditions such as flatfoot deformity (pes planovalgus) or high arch (cavus) foot pattern [4]. Challenges emerge when we try to increase the correction at the hindfoot in larger deformities. This in particular occurs in the increasing number of overweight patients who have a tibialis posterior failure [3].

Opening wedge osteotomy techniques have been used in spinal fusion surgery since the mid 1940s [5] however did not become popularized until 1996 when threaded titanium cages were approved for use by the FDA [6]. The design has now been adapted for specialized use in the foot and ankle. The use of a Fuse It (Integrant Pty Ltd, Sydney, Australia) device in calcaneal opening wedge osteotomy is explored in this paper.

Traditionally an autologous bone graft is used as a wedge however this technique comes with several complications such as donor sit morbidity, increased pain, increased rates of infection and graft collapse. Some patients have experienced pain for up to 1 year at the donor site [7]. Allografts and xenografts have also been used effectively however come with the disadvantage of increased risk of disease transmission and graft rejection as well as potential non-union [8].

The use of structural substitutes for auto- and allo- grafts has been documented with increasing frequency in recent years with further developments in surgical technique and advances in technology. The senior author has previously shown titanium prostheses coated in porous alumina as an effective substitute for allograft in the management of chondrosarcoma [9]. PolyEtherEtherKetone (PEEK) spacers have long been used in spinal surgery and have been recently adapted for use in the foot and ankle with consistent clinical results [10]. Porous wedges comprised of inert metals such as tantalum and titanium have also shown comparable efficacy to that of auto/allo-grafts. Their inert nature and high structural strength eliminate the risk of infection and graft collapse and their porosity and elasticity have high similarity to that of subchondral bone. Both have shown high levels of biocompatibility and bioactivity with bone in growth properties similar to autogenous bone [8,11].

A titanium alloy structural fusion device (Fuse It) has also been used effectively while negating the complications associated with autografts. Its fenestrated conical design allows for comparable fusion efficacy and promotes osseointegration [12,13]. Used in conjunction with compression screws, the strength of the initial macro-interlock between the device and the bone aids union of the osteotomy. The device may also be used in combination with a synthetic bone graft to further promote fusion and aid in reduction of the Osteoblast Jumping Distance (OJD).

We have used a specialized metal insert as a structural graft to increase the corrective potential of the calcaneal osteotomy when used in conjunction with minimally invasive techniques. We propose the concept of 'on-growth', 'in-growth' and 'through-growth' in the successful integration of the implant.

## Method

### Indications

Indications for the procedures discussed in this paper were tibialis posterior deformities (Valgus) and hindfoot varus deformities.

### Surgical Technique: Calcaneal Opening Wedge Osteotomy

The patient is placed supine on an operating table under general anaesthesia. 1 gm of Keflex is administered IV. The leg is exsanguinated and a pillow is placed under the ipsilateral buttock. The osteotomy is then planned with a surgical marker and the calcaneus is approached through a 3 mm minimally invasive lateral incision. A lateral to medial osteotomy is performed using a Shannon burr in an NSK drill after which a 2.5 mm K-wire wire from the 6.5 mm screw system is used as a lever to shift the osteotomy either medially or laterally depending on the deformity. Two 2.5 mm K-wires are drilled in to hold the osteotomy in place while the fusion plug is inserted.

The size of the Fuse It plug is determined by the size and angle of the deformity, i.e. the larger the deformity the larger the plug. Typically speaking a 10 mm x 10 mm is used in a male and a 10 mm x 8 mm in a female.

Fixation is obtained using 2 x 6.5 mm diameter cannulated screws over the K-wires which have already been inserted. Screws are spaced widely to increase the strength of the osteotomy and to prevent metal congestion with the plug. A bone graft substitute can be used in conjunction with the fusion aid in order to maximise the fusion strength; indication is if the osteotomy gap is greater than 4 mm in size.

Portal is closed with simple 3.0 nylon suture material. DVT prophylaxis is not used unless there is a prior history of clots. It is preferred for the patient to move and engage in active weight bearing as soon as possible to limit the chance of DVT.

All procedures were performed in conjunction with secondary procedures, mostly soft tissue procedures, in order to maximise the corrective potential of the osteotomy.

### Patient Data

Over a 12-month span from 2017 - 2018, 18 percutaneous opening wedge calcaneal osteotomies were performed by the same surgeon using the Fuse it device in conjunction with cannulated screws for fixation using the above described surgical technique. The cases were performed on 7 Males and 11 Females with patient age ranging from 29 - 77 years old and were completed as day cases. Patients were in a CAM boot for 10 - 12 weeks post op and no patients required a plaster for recovery.

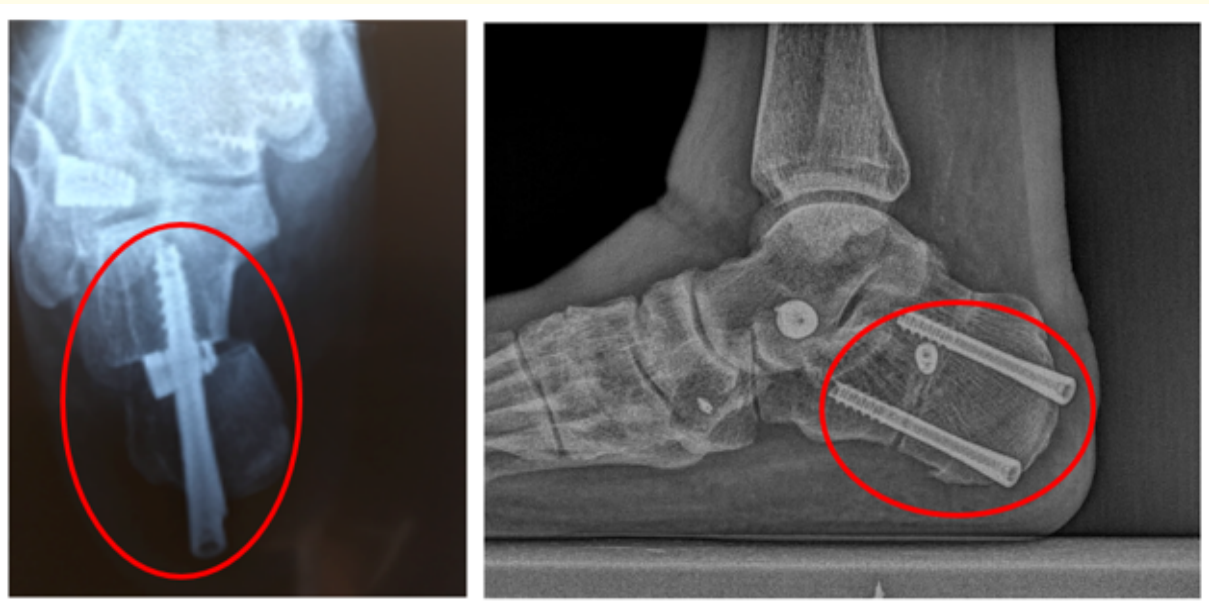

***Figure 1:*** *Post-op radiography of calcaneal opening wedge osteotomy using Fuse It device; medial and topical views.*

## Results

100% of patients showed union at a 4-month post-operation review. A total of 8 patients (2 male, 6 female) had follow-up surgery to have the fixation screws removed if they were palpable or painful (average 174 days after initial surgery). Due to the high levels of osseo-integration between the bone and fusion aid, no Fuse Its needed to be removed post-operatively. There were no signs of post-operative infection or DVT. One patient had posterior tibial nerve neuropraxia which was lost to follow-up after osteotomy union.

Female patients were able to touch weight bear immediately while men were non-weight bearing for 6 weeks. This was because women were less able to non-weight bear and the fixation was deemed strong enough to allow this. Further it was noted that the superior correction supported the medial reconstruction enough that the patients were able to mobilise quicker without the need for crutches.

The osteotomy improved overall clinical appearance and power of correction by translating the heel further and opening the lateral column effectively.

## Discussion

The Evans procedure has long been described as an effective technique for correction of hindfoot deformities [14]. More recently, calcaneal shift osteotomies have become commonplace, however these procedures, while still achieving high union rates at around 97% [15], often carry complications which are less than ideal. The use of a structural fusion aid in place of an autologous bone graft has shown consistent clinical success with comparable rates of fusion as well as the benefit of reduced comorbidities commonly associated with autografts (donor site morbidity, increased infection rates) [12,16].

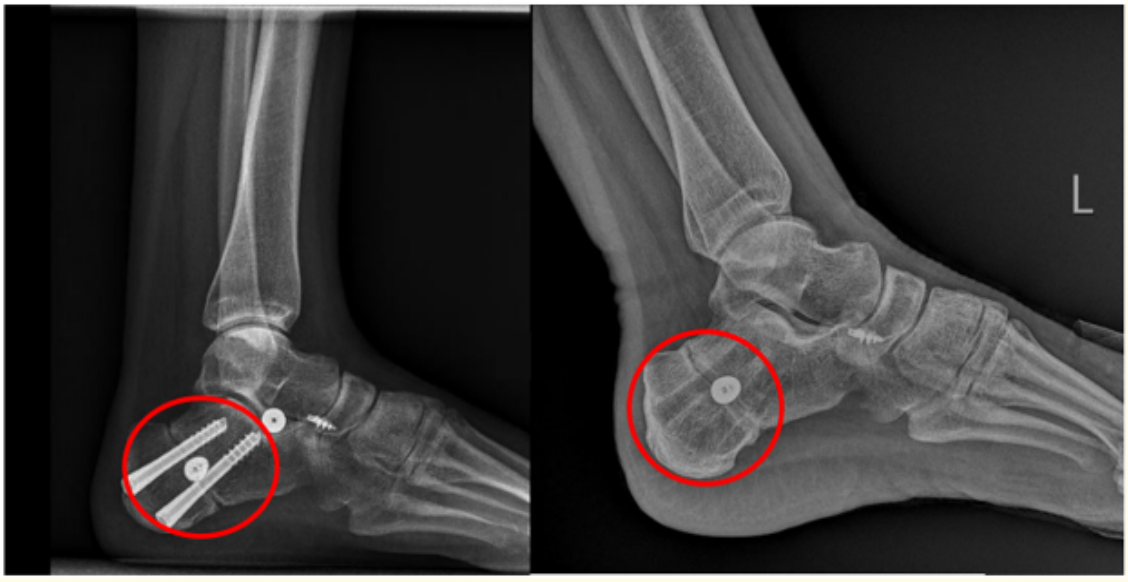


***Figure 2:*** *Radiography showing medial views of left foot of a female patient. Left image taken 2 months post-op. Right image taken 5 months post-op after removal of screws. Union is clearly present.*

In addition to this, the use of minimally invasive operating techniques as described also provide beneficial results when compared with open techniques; reductions in patient pain, recovery time post-operative infections, stiffness and scarring [17-19]. It has also been shown that minimally invasive surgery can reduce the rates of non-union in fusion surgery. This is thought to be due to reduced damage to operative-site blood vessels leading to reduced chance of hematoma [17,20].

## Conclusion

While the use of a structural fusion aid or an autologous bone graft both produce comparable results in opening wedge calcaneal osteotomies, the use of an autologous bone graft increases the rate of complications associated with the procedure (donor site morbidity, increased infection rates, graft collapse) when compared with the fusion aid [21-23].

Nonunion and overall complication rates using a structural fusion aid have been shown to be comparable or superior to what has previously been reported in the literature using allograft or autograft [16] particularly when used in conjunction with minimally invasive surgical techniques. The described technique of using a structural fusion aid such as Fuse It in opening wedge calcaneal osteotomy shows promise in its comparable or better outcomes when compared with traditional autograft techniques

## Declaration of Conflicting Interests

T. Clifton (B.Sc) declares that he is an employee of Integrant Pty. Ltd. and that no financial incentives were received by either himself or Integrant Pty Ltd for assisting in the research, authorship, and/or publication of this article.

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