



## Case Report

## Non-union in a neck of fifth metatarsal fracture: A case report

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## ARTICLE INFO

## Keywords:

Fracture  
 Non-union  
 Metatarsal  
 Neck  
 Augment

## Introduction

Unlike more common 5th metatarsal fractures such as those affecting the base (Zone 1 avulsion-types, Zone 2 Jones-types, or Zone 3 Stress-types) [1] or shaft (spiral “dancer’s fracture”, or stress-types) [2], neck of fifth metatarsal fractures are extremely rare [3]. In a forty-nine subject series on the incidence of 5th metatarsal fractures, only 2% (1/49) affected the metatarsal neck [4]. Distal fifth metatarsal fractures are generally treated non-operatively with good outcomes [2,5]. However, a case of non-union in a neck of 5th metatarsal fracture is yet to be reported in the literature.

As such, there is a lack of guidance relating to the treatment of this rare type of injury. We present the case of a 27 year old woman who sustained a neck of 5th metatarsal fracture leading to non-union, which was treated successfully with debridement, autologous bone graft and recombinant human platelet derived growth factor (rhPDGF) and beta-tricalcium phosphate (BTP) granules, combined with internal fixation.

## Literature review

A search of SCOPUS, Medline, and PubMed search engines using the keywords “fifth OR 5th” AND “metatarsal\*” AND “fracture\*” AND “neck” AND “non-union\* OR non-union\*” was performed on 27th of July 2017. Searches were not limited by dates. Any article reporting a case or case series of 5th metatarsal neck fracture non-union including either the presentation, management or complications were included for review. Studies were excluded if they were published in a language other than English, or duplicate publication. 15 results were identified by search, with 9 unique studies, however amongst these no case of non-union in a fifth metatarsal neck fracture was identified in the accompanying abstract or full-text publication.

## Case report

The patient gave explicit and written consent to the publication of the present report.

A 27 year old project officer presented to the office of the senior author 8 weeks after sustaining a transverse fracture to the neck

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<https://doi.org/10.1016/j.tcr.2018.11.010>

Accepted 22 November 2018

Available online 27 November 2018

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Fig. 1. Radiograph 6 weeks post-injury.

of the 5th metatarsal of her left foot. This occurred after an inversion injury of the hindfoot whilst dancing. The patient was a fit and healthy non-smoker with no previous history of injury to this foot. Her past medical history was significant for post-traumatic stress disorder, which was well controlled on a selective serotonin reuptake inhibitor (SSRI), and mild asthma managed with a standard reliever and preventer.

Management of the fracture at that point had been non-weight-bearing in a stiff-soled postoperative shoe and crutches for 1 week, followed by full-weight-bearing thereafter. At this first visit (8 weeks post injury) the patient reported considerable foot pain and had difficulty mobilising. On examination there was significant tenderness to palpation directly over the fracture site. Radiographs performed 2 weeks prior to this presentation demonstrated a clear fracture line with minimal evidence of healing (Fig. 1). She was transferred into a fracture boot to better stabilise the fracture, however, on follow up 5 weeks after this appointment, now 13 weeks post injury, she described persistent pain with clear evidence of non-union on plain radiographs and CT scan (Figs. 2, 3, 4). With clear evidence of a symptomatic, established non-union, the patient was consented for surgery.

The patient was positioned in the lateral position and a direct lateral approach was made to the foot centred over the 5th metatarsophalangeal joint. The non-union was identified and debrided back to bleeding cancellous surfaces. A 1 cm incision was made over the lateral border of the calcaneum taking care to avoid the sural nerve and cancellous bone was harvested as autologous bone graft. The autologous bone graft was then mixed with Augment © Wright Medical Group N.V.™, which consists of platelet derived growth factor (PDGF) and beta-tricalcium phosphate granules. A generous amount of this mixture was then packed into the fracture site, followed by internal fixation along the lateral border of the bone with a 1.5 mm Medartis hand module T plate with 3 screws in each fragment in compression mode (Fig. 5). The wound was then closed in layers and she was discharged in a fracture boot non-weight-bearing for 6 weeks. At 6 weeks post-operatively, there were clinical and radiological signs of healing, and she was transitioned to partial weight-bearing in the boot, starting with 25% of her weight in week 7, increasing her weight-bearing by 25% per week till she was fully weight-bearing by 10 weeks. At 4 months post-operatively, there was radiographic evidence of complete union on radiographs (Fig. 6), and there was no tenderness over the fracture site, however, she reported more global symptoms consistent with Chronic Regional Pain Syndrome (CRPS) and required a multi-modal treatment plan including input from a chronic pain clinic. At 12-months post-operatively, her CRPS had improved and she had returned to full activity including exercise.

## Discussion

Fractures of the base and shaft of the 5th metatarsal are common, however, isolated fractures of the neck of the 5th metatarsal are extremely rare. [3]. Furthermore, a non-union of this rare fracture has not been reported in the literature.



Fig. 2. Radiograph non-union 13 weeks post-injury.



Fig. 3. CT Axial non-union 13 weeks post-injury.



Fig. 4. CT sagittal non-union 13 weeks post-injury.

Non-union is defined as the cessation of the reparative processes of healing without bone union, diagnosed on the basis of both radiographic and clinical findings. In particular, there is an emphasis on a failure of progression of healing on serial radiographs [6,7]. A number of risk factors have been implicated which can be divided into patient factors (age, gender, medical comorbidities e.g. anaemia, diabetes), environmental factors (smoking, medications e.g. steroids) and injury factors (high or low energy trauma, vascular supply of fracture, presence of infection) [8,9]. In this case report, the patient was of good health with no patient,



Fig. 5. Preliminary intraoperative fixation.



Fig. 6. Radiograph 4 months post-operative demonstrating complete healing.

environmental or injury risk factors for non-union. However, treatment factors such as a failure to adequately immobilise a fracture, can also lead to non-union. In this particular case, the patient had been weightbearing from 1 week after the time of injury, an approach that has been advocated in the literature for distal shaft and neck fractures [1]. This early weightbearing protocol is appropriate for most base and shaft fractures of the 5th metatarsal, but may not provide adequate immobilisation for fractures of the neck of the 5th metatarsal, which is an area subject to different stresses. It is possible that an initial period of immobilisation and nonweightbearing in either a cast or fracture boot may have resulted in fracture union, obviating the need for surgery.

Treatment options for established non-union can be either non-operative or operative. The evidence supporting many non-operative modalities is relatively weak in non-long bones and foot and ankle surgery, such as in electrical stimulation [10], ultrasound [11] and extracorporeal shockwave therapy [12].

Operative management of non-union can involve the use of biological enhancements and mechanical processes. The “gold standard” in biological techniques is autologous bone graft, however there are many other options including allograft implantation,

bone graft substitutes, use of growth factors including bone morphogenic proteins (BMP) and platelet derived growth factor (PDGF), osteoconductive scaffolds and osteoprogenitor “stem” cells. These can be combined with mechanical methods such as debridement, distraction and fixation strategies [13].

In the case we have presented, we have used Augment mixed with calcaneal autograft, combined with rigid internal fixation and a period of non-weight-bearing in the post-operative period, to address the issues of biology and mechanical stability or lack thereof. Augment (© Wright Medical Group N.V.™), is a completely synthetic, liquid injectable bone graft substitute composed of recombinant human platelet-derived growth factor BB (rhPDGF-BB) and beta-tricalcium phosphate (BTP) granules. RhPDGF-BB, also known as becaplermin, is a potent recruiter of, and strong mitogenic factor for, cells crucial to musculoskeletal tissue repair, including mesenchymal stem cells (MSCs), osteogenic cells and tenocytes [14]. It has been proven to be safe for human use and approved in Australia and New Zealand, the United States, Canada and a number of other countries worldwide [15,16]. Additionally, rhPDGF-BB has recently been found to represent a safe and efficacious treatment alternative to autologous bone graft in various foot and ankle procedures including various ankle and hindfoot arthrodesis procedures [16].

In this case, we combined autologous bone graft from the calcaneum with Augment. The manufacturer of Augment neither encourages nor discourages the addition of autograft bone to the preparation, however, this is routinely done at our institution as we believe the patient's own bone is still the best scaffold to promote bone healing, and the combination with Augment might offer the optimal circumstances for osteogenesis, osteoinduction and osteoconduction. Given the success of healing in this case, the authors propose the use of Augment as a potential adjunctive treatment for non-union of the 5th metatarsal neck, and this may be applicable to non-unions elsewhere.

Ultimately, this case illustrates that early weightbearing, may lead to non-union in neck of 5th metatarsal fractures, in contrast to most base and shaft fractures of the 5th metatarsal, where early weightbearing is entirely appropriate. As such, an initial period of non-weightbearing in a cast or fracture boot may be best initial management for this rare fracture. If faced with the problem of non-union in this fracture, we have shown that a combination of debridement, biologic enhancement with autologous bone graft mixed with a commercial preparation of PDGF, and rigid stabilisation, can achieve successful union.

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