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## Re-organizing inpatient care saves legs in patients with diabetic foot infections

Miska Laakso<sup>a,\*</sup>, Mikael Honkasalo<sup>a</sup>, Juha Kiiski<sup>a</sup>, Meri Ala-Houhala<sup>b</sup>, Heidi Haapasalo<sup>a</sup>, Heikki-Jussi Laine<sup>a</sup>, Tiina Luukkaala<sup>c</sup>, Jorma Lahtela<sup>d</sup>, Ilkka Kaartinen<sup>a</sup>

<sup>a</sup> Tampere University Hospital, Department of Musculoskeletal Diseases, Finland

<sup>b</sup> Tampere University Hospital, Department of Dermatology and Allergology, Finland

<sup>c</sup> Tampere University Hospital, Research and Innovation Center and University of Tampere, School of Health Sciences, Finland

<sup>d</sup> Tampere University Hospital, Department of Internal Medicine, Finland

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### ABSTRACT

**Aims:** In this study, we evaluated the effects of the re-organization of inpatient care for patients with a diabetic foot infection, and the implementation of a specialized multi-disciplinary wound department at an academic tertiary hospital.

**Methods:** This was a retrospective cohort study, comprising 272 patients treated for diabetic foot infections in 2006–2007 (Group 1,  $n = 124$ ) and 2013–2014 (Group 2,  $n = 148$ ). In 2012, inpatient care of all chronic wounds was centralized at a single wound department with a multi-disciplinary team. We assessed group outcome before and after the re-organization.

**Results:** During the 7-year study period, the incidence of hospitalized patients with a diabetic foot infection increased 19%. After initiating the re-organization, the below-the-knee amputation rate was significantly reduced (25.8% vs. 9.5%,  $p < 0.001$ ). The median time from admission to surgical intervention decreased from 5 days to 2 days,  $p < 0.001$ . The length of hospitalization also tended to decrease after the reorganization.

**Conclusions:** The findings of this study demonstrate the benefits of treating diabetic foot infections at a specialized wound department with a multi-disciplinary team. The benefits were achieved by simply distributing the workload and organizing schedules, without new investments or additional personnel. The findings of this study indicate that patients with diabetic foot infections present a challenge that is beyond the expertise of a single field of medicine. A working collaboration between disciplines and a specialized wound department are central in achieving better results.

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## 1. Introduction

Diabetes mellitus (DM) and its complications are a growing burden on the health care system. Among patients with diabetes, foot problems are the leading cause of hospitalization.

The incidence of DM is growing worldwide [1], as is the number of hospitalized patients with diabetic foot problems. DM is the number one cause of non-traumatic lower limb amputations, and infection is present in 60% of cases [2]. In the United Kingdom, the amputation rate among patients with type 1

\* Corresponding author.

E-mail address: [miska.laakso@gmail.com](mailto:miska.laakso@gmail.com) (M. Laakso).

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DM has decreased, but simultaneously the amputation rate among type 2 diabetics has rapidly increased [3]. The general consensus is that amputations should be avoided as they decrease the quality of life, prolong hospital stays, and increase mortality. In fact, the 5-year survival after a major limb amputation among diabetics is only 42% [4].

It has been suggested that diabetic foot infections (DFI) are usually preceded by chronic neuropathic ulcers [2]. Recent data, however, suggest that diabetic foot infections commonly affect patients without a prior chronic foot ulceration and can directly lead to the loss of a limb [5].

A severe DFI typically leads to hospitalization. If left untreated, the patient's limb – or in some cases, the patient's life – may be threatened [2]. Therefore, the primary aim of treatment is to save the affected limb, and to maintain ambulation and function. Previous studies demonstrated the importance of isolated interventions in the treatment of DFIs. Quick diagnosis of the vascular patency and appropriate revascularization is crucial to reduce mortality and complications [6]. Other critical interventions include early debridement, blood glucose control, antimicrobial therapy, and reconstructive surgery [7–10]. As DFIs tend to progress from superficial to deep infections without prompt management, delayed treatment may prolong inpatient care, increase morbidity, and eventually lead to the loss of a limb.

Several guidelines exist for treating DFIs. Meeting these requirements, however, demands a functioning multidisciplinary team (MDT) approach [11]. The importance of an MDT to organize diabetic foot care is widely agreed upon. The Infectious Diseases Society of America, International Working Group on the Diabetic Foot, and National Institute for Health and Care Excellence guidelines all recommend that DFI care should be provided by an MDT [12–14]. A specialized wound department with an MDT approach has been shown to improve results [15]. Although an MDT approach is strongly recommended, this recommendation is based on only moderate-quality evidence [12].

We analyzed the clinical outcome of patients with a DFI, hospitalized before and after the re-organization of inpatient diabetic foot wound care. A period of 2 years in both cases was selected to ensure a sufficient number of patients. The primary outcome measures were mortality, lower limb amputation, and length of hospital stay. Secondary outcome measures included the number of vascular and soft tissue reconstructions, and the delay to surgery in these patients.

## 2. Materials and methods

This study was conducted at Tampere University Hospital, a tertiary teaching hospital, directly serving over 0.5 million people. Before April 2012, inpatient care of patients with DFI was managed on several hospital wards, including internal medicine, infectious diseases, plastic surgery, vascular surgery, dermatology, and orthopedics. Physicians from a single discipline who consulted other specialties primarily managed the patients. A diabetic foot group served outpatient clinics, but an MDT was not implemented for inpatient care.

In April 2012, we reorganized the inpatient care of chronic wounds (including DFIs) to a specialized wound department.

In the department, an MDT, including a dermatologist, a plastic surgeon, an internist, an infectious disease specialist, an orthopedic surgeon, and a vascular surgeon, managed the patients (Fig. 1). The reorganization was done without the addition of new resources or recruitment of new personnel, and rather by simply redistributing the workload and organizing schedules.

The data in this study were obtained from two cohorts of patients, treated in 2006–2007 (Group 1) and 2013–2014 (Group 2). Group 1 constitutes the first 2 years of all the patient records being available in a digital format. Group 2 consists of patients treated during the two calendar years after the inception of the specialized wound department. During 2006–2007, the diabetic foot group operated as an outpatient clinic, while the other specialties involved in the treatment of DFIs collaborated through nonsystematic consultations. The hospitalization of patients with a DFI into various hospital wards was arbitrary, however, and followed no fixed protocol. In 2013–2014, all patients with a DFI were primarily admitted to the specialized wound department and managed with an MDT approach.

There was no registry of the inpatient care of DFIs before 2012, so study cases were collected from the medical records through a computer search. The search encompassed three groups. First, we identified all patients with a diagnosis of diabetes and C-reactive protein over 100 mg/L. Second, we identified all patients with some level of lower extremity amputation. Third, we identified the patients that underwent lower extremity wound debridement and bacterial culture sampling within 30 days of the operation. This search provided 2044 cases. This list was back-checked to the existing registry of 2013–2014 to confirm that the algorithm found all known cases. From this point, the cases were reviewed manually to include only patients with a DFI, excluding infections like pneumonia and pyelonephritis or amputation due to ischemia, but no DFI. A DFI was defined as an infection at the level at or below the ankle joint. Therefore, lower limb infections above the ankle level were excluded (Fig. 2).

This process produced two cohorts: 124 patients in 2006–2007 and 148 patients in 2013–2014. The following information was collected from each group: patient characteristics, mortality, length of hospital stay, surgical procedures, vascular investigations and interventions, and time between admission and any procedures. Patient records were reviewed from the period 2006–2014.

All statistical analyses were performed using the SPSS software package (IBM SPSS Statistics for Mac OS X, Version 22.0. Armonk, NY). The power calculation was performed with G\*Power (G\*Power for Mac OS X, Version 3.1.9.2). Analyses were planned and reviewed with a professional statistician.

## 3. Results

The number of DFIs increased 19% during the study period (from 124 to 148). The patients were predominantly men in both groups, with a mean age of 66 years (SD 13) and 68 years (SD 13) in Groups 1 and 2, respectively. Co-morbidities were

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