

A new flexible volume DBD device for the treatment of diabetic foot ulcers

Citation for published version (APA):

Boekema, B., Ulrich, M., Smits, P., Zeper, B., Pemen, A. J. M., & Middelkoop, E. (2016). *A new flexible volume DBD device for the treatment of diabetic foot ulcers*. Abstract from 6th International Conference on Plasma Medicine (ICPM6), Bratislava, Slovakia.

Document status and date:

Published: 01/09/2016

Document Version:

Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

In vitro efficacy and safety of a new flexible volume DBD device for the treatment of diabetic foot ulcers

B. Boekema¹, M. Ulrich¹, P. Smits², B. Zeper³, G. Pemen⁴, E Middelkoop⁵

¹Association of Dutch Burn Centres, Beverwijk, The Netherlands

²Department of Applied Physics, Eindhoven University of Technology, Eindhoven, The Netherlands

³PlasmaCure, Eindhoven, The Netherlands

⁴Department of Electrical Engineering, Eindhoven University of Technology, Eindhoven, The Netherlands

⁵Department of Plastic, Reconstructive and Hand Surgery, VU Medical Center, Amsterdam, The Netherlands

e-mail: bboekema@burns.nl

Diabetic foot ulcers are common complications of diabetes mellitus and greatly increase the risk of infection or subsequent amputation. A novel method to decrease the likelihood of infection and to help cure ulcers is cold atmospheric plasma. We developed and tested a new flexible volume Dielectric Barrier Discharge (vDBD), which produces plasma in ambient air. The device is 5 cm in diameter and can be applied as a plaster following the contours of the skin. The plasma is therefore easy to apply and the plasma discharges are created at even distances to the skin, which acts as a counter electrode.

The bactericidal effect was tested on *Staphylococcus aureus* on agar, in collagen matrices and on human skin in vitro. Safety was monitored by measuring cellular activity in skin biopsies, after multiple daily treatments. To optimize treatment, the plasma parameter pulse duration (μ s), the treatment time, water content of the samples, contact area and distance between plaster and surface were varied.

The vDBD was highly efficient within 60 sec when used on bacteria on agar plates. In order to quantify the bactericidal effect in relation to the different variables, bacteria were treated in a collagen matrix. High reduction in collagen matrices was reached in 1-2 minutes of treatment and depended on the amount of liquid present and on absence of buffering. Varying pulse duration had a minimal effect on bacterial reduction. Plasma treatment of bacteria was also efficient on the epidermal side and slightly less efficient on the dermal side of skin. Plasma did not affect skin viability when used for 1-2 min, with contact or at short distance. Repeated treatments of up to 4 times slightly lowered skin viability. Optimal settings from this study will be used to treat diabetic foot ulcers for ten daily treatments with vDBD plasma. With the newly developed flexible plasma plaster we were able to kill bacteria on skin, without affecting viability of dermal cells.

This work was supported by a national grant from zonMw, no. 40-41200-98-9189 and Dutch Burns Foundation grant 14.104.