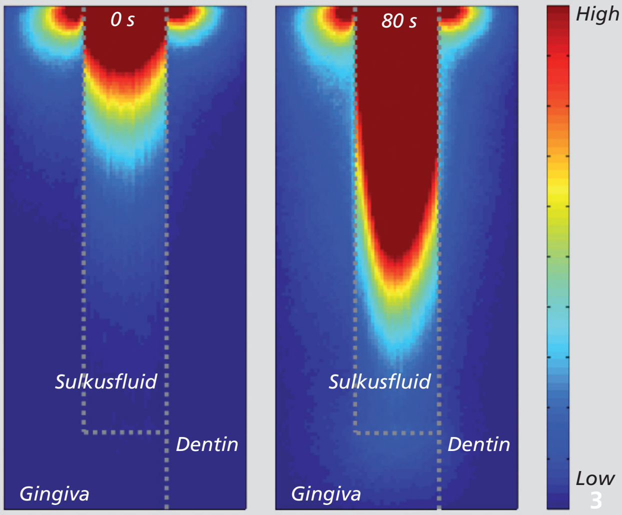

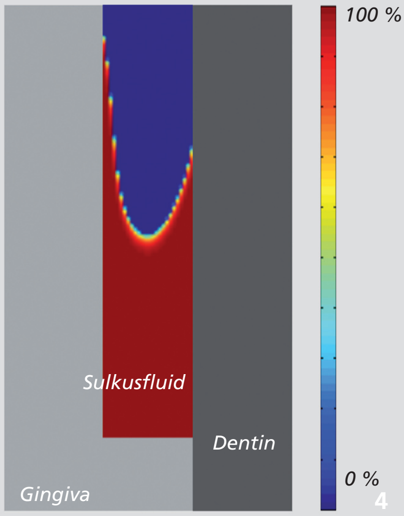

ANTIMICROBIAL PHOTO-DYNAMIC THERAPY

Task

Antimicrobial photodynamic therapy (aPDT) is used to treat bacterial infections. While this therapy becomes all the more relevant as bacterial resistance increases, its success still cannot be observed during or immediately after the treatment, which limits the benefits it could offer. To overcome such limitations, the methods of modelling and simulation are used to examine aPDT in order to identify measureable values, which, in turn, should enable the therapeutic process to be observed live.

Method

The operating principle of aPDT is based on laser-induced electronic excitation of photoactive chemicals, so-called photosensitizers, at low power (~ mW). Resonant collisions of the excited photosensitizer with molecular oxygen generate highly reactive and cytotoxic singlet oxygen. Since the singlet oxygen is close to the bacteria, the bacteria are damaged and subsequently made inactive within the short life time (~ ns) of the singlet oxygen. The spatially and temporally distributed processes (propagation, scattering and absorption of the laser radiation, progress of biochemical reactions) are depicted by a system of reaction diffusion equations.

Result

As a result, a dynamic and spatial two-dimensional mathematical model can be shown, whose resolution describes the progress of the reaction front and the successfully treated area. To resolve the model and to analyze the resolution properties, a simulation tool has been made available.

Investigations have been conducted on how dependent the therapeutic success is upon relevant parameters so that suitable treatment records can be developed. The results show that the concentrations of photosensitizers and oxygen as well as the properties of the laser radiation are all relevant. Measureable values as well as those that change with the therapeutic success will be identified and tested as to their suitability to observe the therapeutic process.

Applications

The model developed here has been designed for use with aPDT for the treatment of periodontitis. We expect that the model, when modified, can be adapted to depict the therapy of wound infections or local infections with multi-resistant germs. Another promising application of the model is a simulation to depict photodynamic therapy for tumor treatment.

Contact

Dipl.-Phys. Lisa Bürgermeister
Telephone +49 241 8906-610
lisa.buergermeister@ilt.fraunhofer.de

Prof. Wolfgang Schulz
Telephone +49 241 8906-204
wolfgang.schulz@ilt.fraunhofer.de

3 Intensity distribution in periodontium during aPDT after 0 sec. and 80 sec. radiation.

4 Survival rate of bacteria during aPDT after 80 sec. radiation.