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Precise Spatially Selective Photothermolysis Skin Treatment by Multiphoton Absorption

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Abstract : Conventional laser treatment of skin diseases and cosmetic surgery is based on the principle of one-photon absorption selective photothermolysis which relies strongly on the difference in the light absorption between the therapeutic target and its surrounding tissue. However, when the difference in one-photon absorption is not sufficient, collateral damage would occur due to indiscriminate and nonspecific tissue heating. To overcome this problem, we developed a spatially selective photothermolysis method based on multiphoton absorption in which the heat generation is restricted to the focal point of a tightly focused near-infrared femtosecond laser beam aligned with the target of interest. A multimodal optical microscope with co-registered reflectance confocal imaging (RCM), two-photon fluorescence imaging (TPF), and second harmonic generation imaging (SHG) capabilities was used to perform and monitor the spatially selective photothermolysis. Skin samples excised from the shaved backs of euthanized NODSCID mice were used in this study. Treatments were performed by focusing and scaning the laser beam in the dermis with a 50μm×50μm target area. Treatment power levels of 200 mW to 400 mW and modulated pulse trains of different duration and period were experimented. Different treatment parameters achieved different degrees of spatial confinement of tissue alterations as visualized by 3-D RCM/TPF/SHG imaging. At 200 mW power level, 0.1 s pulse train duration, 4.1 s pulse train period, the tissue damage was found to be restricted precisely to the 50μm×50μm×10μm volume, where the laser focus spot had scanned through. The overlying epidermis/dermis tissue and the underneath dermis tissue were intact although there was light passing through these regions.

Keywords : multiphoton absorption photothermolysis, reflectance confocal microscopy, second harmonic generation microscopy, spatially selective photothermolysis, two-photon fluorescence microscopy
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