ANALYZING THERMAL AND MECHANICAL EFFECTS OF PULSED LASER IRRADIATION ON TISSUES

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ABSTRACT

Pulsed lasers are known for their spatial and temporal specificity in delivering heat energy to the tissues as the duration of heat delivery is smaller than the thermal diffusion time of the tissue. This is useful in laser ablation treatment mechanism where damage to the healthy tissues is highly undesired. Pulsed laser irradiation on tissues leads to photothermal and photomechanical interactions which results in damage in the irradiated zone. Photothermal interaction is caused by the rise in temperature due to the laser irradiation. Photomechanical interaction causes the generation of pressure waves produced as a result of the pulse-laser interaction. This arises due to the thermoelastic expansion of the tissues due to heating. Photothermal and photomechanical interactions combined lead to damage in the tissues and are a potential threat to the surrounding tissues. In this paper, the effects of both the mechanisms are studied using finite element models of the skin. A three-layered model of the skin is considered which is irradiated upon by a focused Nd:YAG infrared laser beam. The finite-element solver COMSOL Multiphysics is used to simulate the thermal and mechanical interaction due to the laser irradiation. Thermal effects of the irradiation are evaluated using the equivalent thermal dose administered to the tissue. The mechanical interaction is evaluated in terms of the stress generated in the tissue during the laser ablation damage. Results obtained are useful in characterizing the laser ablation parameters such as the epetition rate, laser power and pulse width. This will enable optimizing the laser ablation process for a more effective treatment with minimum damage to surrounding tissues.