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Modeling the thermal conditions around sites of microwave drilling in bone

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A new method for orthopaedic drilling was developed, based on microwave energy that is localized at a ``hot spot'' to penetrate bone tissue [1,2]. However, the heat generated during microwave drilling was shown to cause some tissue carbonization and collagen denaturation in vitro [2]. The goal of this study was to develop a model of time-dependent temperature distribution around the drilling site, in order to optimize the drilling process. A finite-difference time-domain (FDTD) model [3] was employed. The model calculates the temperature fields around the drilling site for a given drill bit diameter, microwave drilling power, and bone geometry (e.g. cortical thickness and presence of underlying marrow). The model allows determination of the size of tissue regions exceeding critical temperature and the time exposure to temperature. Generally, we found that the radius and depth of bone that exceeded a 50°C threshold (for osteocyte cell death) increased with the drilling depth, and damage area was wider when bone marrow was considered. Overall, the model emerged as an essential engineering tool for improving the technology and design of orthopaedic microwave drills.

Reference:

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