Optimization of drilling parameters for thermal bone necrosis prevention

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ABSTRACT

BACKGROUND: Bone drilling is a mandatory process in orthopedic surgery to fix the fractured bones. Excessive heat is generated due to the shear deformation of bone and friction energy during the drilling process. OBJECTIVE: This paper is carried out to optimize the bone drilling parameters to prevent thermal bone necrosis. The main contribution of this work is instead of only consider the influence of rotational speed and feed rate, the effect of tool diameter and drilling hole depth are also incorporated for optimization study. METHODS: Response surface methodology (RSM) was used to develop a temperature prediction model. Drilling experiments were performed using finite element software DEFORM-3D. Analysis of variance (ANOVA) was conducted to investigate the drilling parameters' effect. Desirability function in RSM was used to determine the optimum combination of drilling parameters. RESULTS: Results indicated that one applicable combination of drilling parameters could increase the bone temperature by less than 0.03%. To avoid thermal bone necrosis, eight reasonable combinations of drilling parameters were proposed. 3.3∘C residuals between in-vitro experiments and predicted values were demonstrated. CONCLUSIONS: It is envisaged that finite element simulation with RSM can simplify tedious experimental works and useful in the clinical application to avoid bone necrosis.

KEYWORDS: Drilling parameters, osteonecrosis, temperature, response surface methodology, optimization

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