Drilling of bone: Effect of drill bit geometries on thermal osteonecrosis risk regions

Mohd Faizal Ali Akhbar and Ahmad Razlan Yusoff

Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, Pekan, Malaysia

ABSTRACT

Bone-drilling operation necessitates an accurate and efficient surgical drill bit to minimize thermal damage to the bone. This article provides a methodology for predicting the bone temperature elevation during surgical bone drilling and to gain a better understanding on the influences of the point angle, helix angle and web thickness of the drill bit. The proposed approach utilized the normalized Cockroft–Latham damage criterion to predict material cracking in the drilling process. Drilling simulation software DEFORM-3D is used to approximate the bone temperature elevation corresponding to different drill bit geometries. To validate the simulation results, bone temperature elevations were evaluated by comparison with ex vivo bone-drilling process using bovine femurs. The computational results fit well with the ex vivo experiments with respect to different drill geometries. All the investigated drill bit geometries significantly affect bone temperature rise. It is discovered that the thermal osteonecrosis risk regions could be reduced with a point angle of 110° to 140°, a helix angle of 5° to 30° and a web thickness of 5% to 40%. The drilling simulation could accurately estimate the maximum bone temperature elevation for various surgical drill bit point angles, web thickness and helix angles. Looking into the future, this work will lead to the research and redesign of the optimum surgical drill bit to minimize thermal insult during bone-drilling surgeries.

KEYWORDS: Bone drilling, temperature, elevation, FEA, osteonecrosis, drill bit

DOI: https://doi.org/10.1177%2F0954411918819113