Multi-objective optimization of surgical drill bit to minimize thermal damage in bone-drilling

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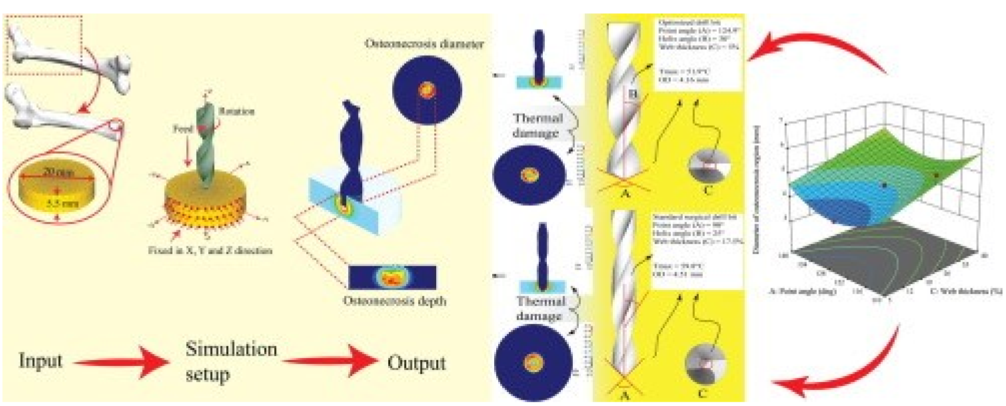
ABSTRACT

The existing surgical drill bit is not fully optimized to protect against thermal damage during the bone-drilling surgeries. In this study, the optimal drill bit design that induces minimum thermal damage is attained through rigorous drilling simulations and statistical analysis approaches. For thermal damage analysis, maximum bone temperature and osteonecrosis diameter are designated as responses, whereas drill bit point angle, helix angle and web thickness are selected as the designing parameters. These parameters and responses are evaluated and optimized using response surface methodology (RSM) coupled with desirability analysis. The optimized drill bit then is compared with the typical surgical drill bit in drilling simulation of human cortical bone. Simulation results reveal that the proposed drill bit design effectively reduces the maximum bone temperature (15.2%) and osteonecrosis diameter (10.5%). These results are validated with experimental bone-drilling and data from previous literature. This work demonstrates the feasibility of applying finite element method (FEM) to study the clinical issues in bone-drilling research and find the optimal solutions prior to clinical trial. Furthermore, this work provides an important opportunity to revise and redesign the existing surgical drill bit for a minimum thermal damage in bone surgeries.

GRAPHICAL ABSTRACT



KEYWORDS

Osteonecrosis; Bone drilling; Finite element; Temperature; Drill bit; Geometry

ACKNOWLEDGEMENTS

The authors gratefully acknowledged the financial support of Universiti Malaysia Pahang through research grant RDU 170372.