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Bone drilling with internal gas cooling: Experimental and statistical investigation of the effect of cooling with CO_2 on reduction of temperature rise due to drill bit wear

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ABSTRACT

Bone drilling is a major stage in immobilization of the fracture site. During bone drilling operations, the temperature may exceed the allowable limit of 47 °C, causing irrecoverable damages of thermal necrosis and seriously threatening the fracture treatment. One of the parameters affecting the temperature rise of the drilling site is the frequency of applying the drill bit and its extent of wear. The present study attempted to mitigate the effect of drill bit wear on the bone temperature rise through the internal gas cooling method via CO_2 and to reduce the risk of incidence of thermal necrosis. To this end, drilling tests were conducted at three rotational speeds 1000, 2000, and 3000 r·min^{-1} in two states of without cooling and with internal gas cooling by CO_2 through an internal coolant carbide drill bit, along with six drill bit states (new, used 10, 20, 30, 40, and 50 times) on a bovine femur bone. The results indicated that in the internal gas cooling state, as the number of drill bit applications increased from the new state to more than 50 times, the temperature of the hole site increased on average by ΔT = 2-3 °C (n = 1000 r·min^{-1}), ΔT = 5-8 °C (n = 2000 r·min^{-1}), and ΔT = 5-7 °C (n = 3000 r·min^{-1}). Furthermore, the internal gas cooling method was able to significantly reduce the effect of the drill bit wear on the temperature rise of the drilling site and to resolve the risk of incidence of thermal necrosis regardless of the process parameters for drilling operations.

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