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Experimental Investigation of Cutting Forces and Temperature in Bone Drilling

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Abstract : Drilling of bone has been always challenging for surgeons due to the adverse effect it may impart to bone tissues. Force has to be applied manually by the surgeon while performing conventional bone drilling which may lead to permanent death of bone tissues and nerves. During bone drilling the temperature of the bone tissues increases to higher values above 47 ^{0}C that causes thermal osteonecrosis resulting into screw loosening and subsequent implant failures. An attempt has been made here to study the input drilling parameters and surgical drill bit geometry affecting bone health during bone drilling. A One Factor At a Time (OFAT) method is used to plan the experiments. Input drilling parameters studied include spindle speed and feed rate. The drill bit geometry parameter studied include point angle and helix angle. The output variables are drilling thrust force and bone temperature. The experiments were conducted on goat femur bone at room temperature 30 ^{0}C. For measurement of thrust forces KISTLER cutting force dynamometer Type 9257BA was used. For continuous data acquisition of temperature NI LabVIEW software was used. Fixture was made on RPT machine for holding the bone specimen while performing drilling operation. Bone specimen were preserved in deep freezer (LABTOP make) under -40 ^{0}C. In case of drilling parameters, it is observed that at constant feed rate when spindle speed increases, thrust force as well as temperature decreases and at constant spindle speed when feed rate increases thrust force as well as temperature increases. The effect of drill bit geometry shows that at constant helix angle when point angle increases thrust force as well as temperature increases and at constant point angle when helix angle increase thrust force as well as temperature decreases. Hence it is concluded that as the thrust force increases temperature increases. In case of drilling parameter, the lowest thrust force and temperature i.e. 35.55 N and 36.04 ^{0}C respectively were recorded at spindle speed 2000 rpm and feed rate 0.04 mm/rev. In case of drill bit geometry parameter, the lowest thrust force and temperature i.e. 40.81 N and 34 ^{0}C respectively were recorded at point angle 70^0 and helix angle 25^0 Hence to avoid thermal necrosis of bone it is recommended to use higher spindle speed, lower feed rate, low point angle and high helix angle. The hard nature of cortical bone contributes to a greater rise in temperature whereas a considerable drop in temperature is observed during cancellous bone drilling.

Keywords : bone drilling, helix angle, point angle, thrust force, temperature, thermal necrosis
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