Experimental investigation of temperature rise in bone drilling with cooling: A comparison between modes of without cooling, internal gas cooling, and external liquid cooling

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Abstract

Bones fracture due to accident, old age, and disease. To treat bone fracture, bones should be immobilized in the proper place. In complex fractures, to immobilize the fracture location, internal and external immobilization tools and equipment are used. For connecting immobilizing equipment, drilling into bone should be done. During this operation, the forces required for chip formation cause elevation of temperature. If the generated temperature exceeds 47ºC, it results in thermal necrosis in the bone. Thermal necrosis causes failure in immobilization and in turn improper fusion of bones. In this research, attempts have been made to detect changes in the temperature of bone and drill bits during drilling process using infrared thermography. Drilling tests have been performed on bone samples of bovine femur and the thermal changes of the drilling bit and bone have been measured. The results indicated that at the feed rate of 50 mm/min, the only allowable rate for drilling has been 1500 rpm and at feed rates of 100 and 150 mm/min, application of rates of 2000-3000 rpm can be useful to prevent thermal necrosis.

Keywords

Bone, Internal Fixation, Drilling, Temperature Rise, Thermal Necrosis, Infrared Thermography

Introduction

One of the most important stages of internal fixation of bone in the site of fracture is drilling. In the next stage, a self-tapering screw is closed for fixation of plug and cord at the site of the created hole. This process is influenced by different factors including plastic deformation of chips, friction between the drilling bit and chips, as well as friction between the chips and the hole wall. These result in heat generation in the drilling site. Part of the heat generated during bone drilling process can be transferred by blood stream and interstitial fluids. Some parts can also be transferred by the chips towards outside the hole. However, part of the generated heat is transferred to the bone through conduction heat transfer. On the other hand, heat conductivity coefficient of bone is poor. According to research, the heat conductivity coefficient of human bone in the cortical bone has been reported to be 0.38-2.3 W/mK [1]. This means that due to the poor heat conductivity of bones, the heat generated during the process is not able to be transferred rapidly from the bone to the surrounding environment, thereby causing localized temperature rise at the site of hole. Temperature rise at the site of drilling causes alteration of the nature of Alkaline phosphatase of the bone, which is a precursor for incidence of thermal necrosis, cell death, death of bone tissue, and diminished mechanical strength of the drilling site [2]. The bone strength is of importance in orthopedic surgery,