Heat transfer During Intramedullary Reaming

John R. Burris M.D.; Joel M. Bach, Ph.D.; Andrew Jonassen M.D.; Todd Baldini, M.S.; Jennifer Kellogg, B.S.; Shawn Doherty
UCHSC & UCB

Purpose: To develop a practical, minimally invasive, technique for measuring the temperature of bone in vivo during reaming. This technique can then be used intraoperatively and to help establish protocols to avoid thermal injury to bone during reaming for intramedullary nail fixation.

Introduction: Kuntscher introduced the concept of intramedullary (IM) nailing for the internal fixation of long-bone fractures in 1940. He further developed the techniques of intramedullary reaming to improve stability of IM fixation in 1962. Since that time, worldwide acceptance of reamed IM nail fixation of femur and tibia fractures has spread. Despite its wide acceptance, concerns about the effects of mechanical reaming of the medullary canal persist. The focus of this study is on the increased temperature created by friction between the reamers and bone.

Numerous studies suggest intramedullary heat generation is a by-product of reaming. Thermal injury to bone has long been recognized to impair healing following prosthetic implantation. The potential for thermal necrosis with IM reaming has also been studied in vitro, though no study has been able to accurately measure the heat produced by reaming of bone in vivo. The major reason for this is the impracticality of applying contact heat measurement techniques to bone in vivo. We propose a novel approach of non-contact heat measurement in the clinical setting.

Methods: Standard temperature measurements are typically performed using thermocouples or thermistors. Although this is acceptable for in vitro bone, it is not practical for in vivo bone because it is too invasive, requiring additional holes to be drilled in the bone. This study will be performed in two phases. In the first phase, we are validating the use of an infrared thermometer and developing heat transfer equations to calculate the intermedullary canal temperature from the measured periosteal temperature. This will be done in the laboratory using a controllable heat source, cadaveric bone, and conventional heat measurement equipment. Measurements using the infrared thermometer will be correlated with the conventional, direct contact, equipment (Figure 1).

Once the infrared thermometer has been validated we will enter the second, clinical, phase of this study. In vivo bone will be minimally exposed and temperatures will be monitored, using the infrared thermometer, during the standard practice of closed IM reaming. This new technique will then be used to develop surgical protocols that reduce the risk of thermal injury to bone intraoperatively during orthopaedic procedures (e.g., reaming for intramedullary nail fixation). Use of this new system will enable the surgeon to minimize heat generation, thereby improving clinical outcomes and reducing medical costs. This technique will be fast, easy-to-use, and minimally invasive to the patient.

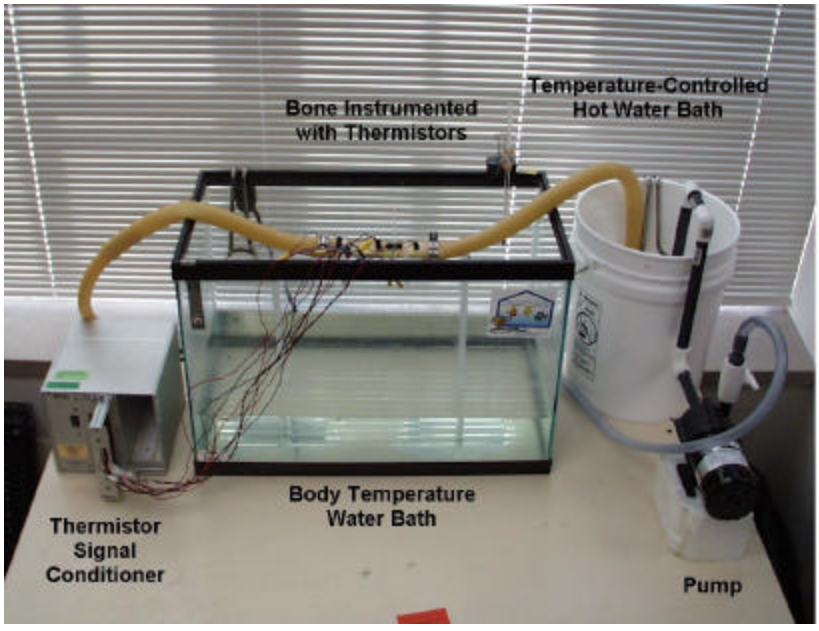

Figure 1 In Vitro Temperature Measurement Set-Up