The temperature in the drilling of *ex-vivo* bovine femurs and human cadaveric tibiae

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1. INTRODUCTION

The bone drilling is common in orthopaedic surgery. The success of this surgery is dependent on many factors, namely on the heat generation control during the bone drilling. The main concern in bone drilling is the mechanical and thermal damage induced by inappropriate parameters, as drill speed and feed-rate.

Motivation: Find the best drill conditions where the increase in bone temperature would be minimal (considering the criterion of temperature, above 47º C) [1].

Objectives

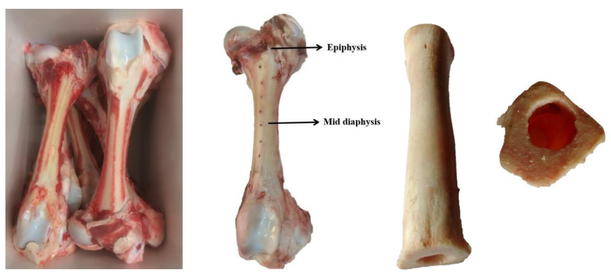
- Temperature evaluation in *ex-vivo* bovine bones and human cadaveric tibiae, during the drilling process.
- Temperature measurements were performed, considering the effect of drill speed and the temperature variation between different bone materials.

2. DRILLING IN *EX-VIVO* BOVINE BONES

- 4 samples of bovine femur were obtained from a local butchers (mechanical properties similar to human bone, [2]).
- The samples have been prepared to obtain just the cortical bone tissue (epiphysis, bone marrow and periosteum were removed leaving only the mid-diaphysis).
- To retain the properties, all samples were kept moist in saline solution with gauze swabs and stored in plastic bags at -4º C.
- The holes were made through a CNC machine with controlled parameters. Table 1 shows the list of parameters used in the drilling of *ex-vivo* bovine bones.

Table - 1 Parameters of drilling in ex-vivo bovine bones.

Parameters	
Drill diameter	4 (mm)
Drill point angle	118º
Hole depth	8 (mm)
Drill speed	**520, 900, 1370** (rpm)
Feed-rate	**18** (mm/min)



- To the temperature recorded, a thermal camera was used to measure the drill bit temperature, before and after of drilling; and 2 K-type thermocouples were used for temperature monitoring inside the bone.
- All holes were carried out at room temperature without cooling.

3. DRILLING IN HUMAN CADAVERIC TIBIAE

- 4 samples of human cadaveric tibiae were used.
- The non-embalmed sections of human cadaveric tibiae were processed in the Body Donor's Service and Dissection Room of the University of Barcelona.
- The holes were made through a drill press machine with multiple speed control.
- Different parameters were used to evaluate the influence on the drilling process.
- Each combination of machining parameters were randomly repeated four times.

Table - 2 Parameters of drilling in human cadaveric tibiae.

Parameters	
Drill diameter	4 (mm)
Drill point angle	118º
Drill speed	**520, 900, 1370** (rpm)

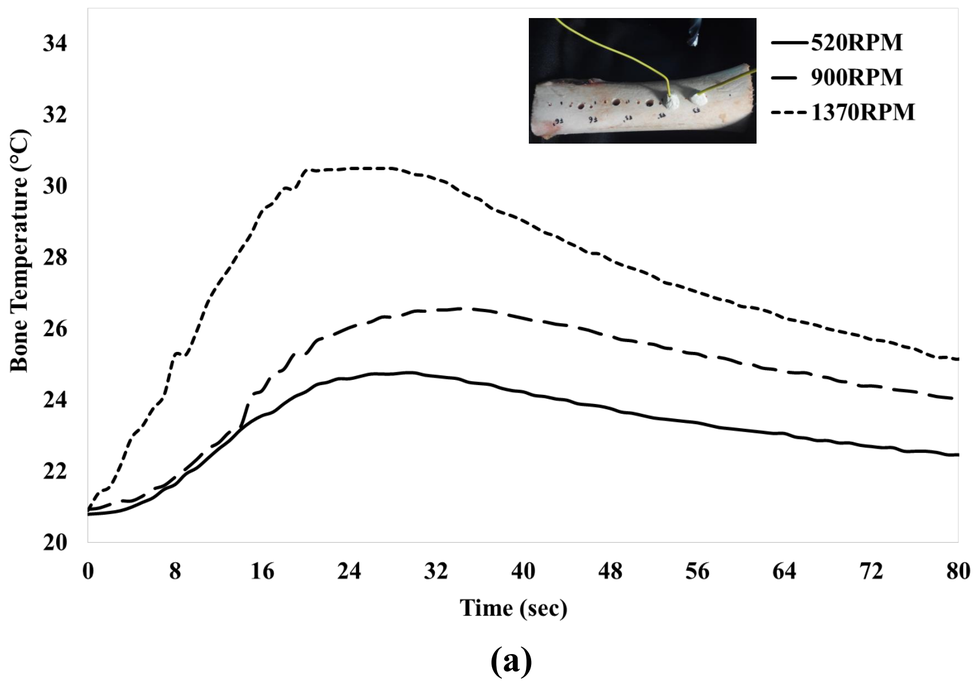
4. RESULTS AND DISCUSSION

The difficulty in measurements during bone drilling is a common knowledge due to complex nature of the bone tissue, as well as the process itself.
It is well know that there is variation of the properties from samples taken from different bones species, outcome in variations of results, although subject to identical drilling conditions.
In this way it is important to use different bone materials to ensure reliable results.

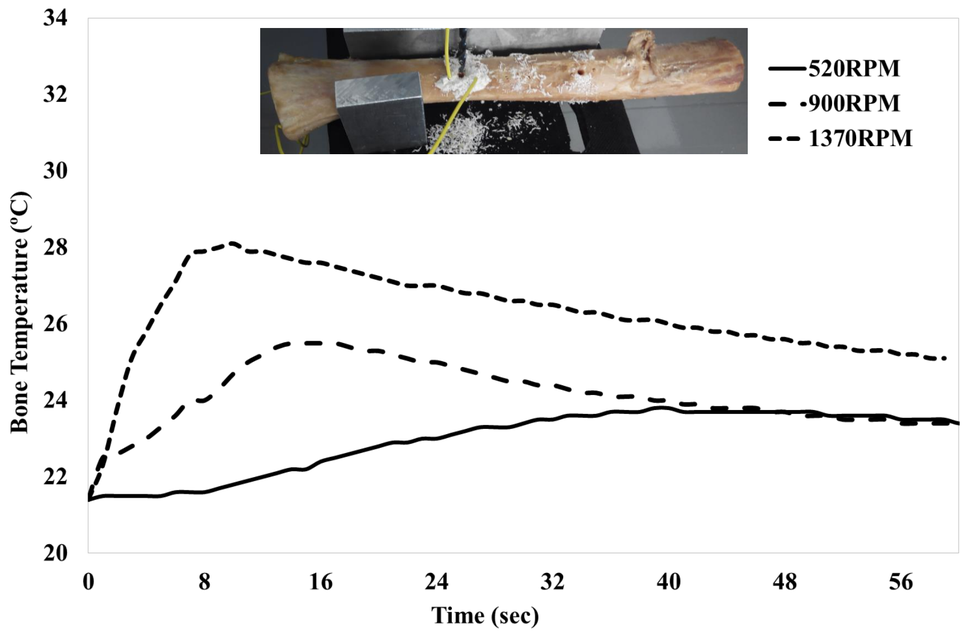
Graphs (a) and (b) represent the temperatures at different drill speeds, considering the thermocouples position (at point 4 mm deep and 2.0 from the hole wall).

Graph (a) display the temperature history for the *ex-vivo* bovine bones.

Graph (b) display the temperature history for the human cadaveric tibiae.



(a)



(b)

- In both graphs it was observed that inside of bone tissue the maximum temperature increases with the increasing of drill speed.
- In graph (a), bone temperature increased 18.8% with increased drill speed from 520 rpm to 1370 rpm.
- In graph (b), bone temperature increased 15.30% with increased drill speed from 520 rpm to 1370 rpm.
- Results showed that the bone drilling at 520 rpm generates less heat than at faster speeds.
- Results in ex-vivo bovine bones and human cadaveric tibiae are in accordance.

5. CONCLUSIONS

- The present study showed the combinations of different drill parameters producing temperatures far below the critical values.
- The application of low drill speeds reduce the heat generated during bone drilling process and decreasing the osteonecrosis in cortical bone.
- The values of temperature in the drilling process of human cadaveric tibiae were lower than the drilling in *ex-vivo* bovine bones.

[1] Eriksson RA et al. *Journal of Prosthetic Dentistry*, 50:101-107, 1983.

[2] Aerssens J et al. *Endocrinology*, 139:663-670, 1998.