

THERMAL COMPUTATIONAL MODEL TO PREDICT THERMAL NECROSIS IN BONE SARCOMAS

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KEYWORDS

• Sarcoma, bone tumor, cement, PMMA.

1. INTRODUCTION

Sarcomas are heterogeneous tumors that form from bone tissue, connective tissue, cartilaginous tissue, muscle tissue, adipose tissue, peripheral nerves, and blood vessels, usually at its extremities. These tumors occur at any age and in any region of the patient's body.

Cementation is a technique used for example in percutaneous procedures such as vertebroplasty, kyphoplasty, osteoplasty and sacroplasty. Bone cements are synthetic biomaterials composed of a polymer (powder) and a liquid component (monomer). The introduction of bone cement into the tissue is intended to treat or prevent vertebral and extra-spinal pathological fractures and alleviate pain in patients with osteoporosis and bone metastases, for example.

The most frequently used bone cements are acrylics, PMMA (polymethylmethacrylate), due to their structural, physical properties, excellent biocompatibility, easy handling and low cost. One of the disadvantages in the use of bone cements is the development of thermal necrosis in the tissues during the polymerization process.

2. OBJECTIVES

Evaluate the minimization of the bone sarcomas growing, through the injection of PMMA ampoules filling the space of the lytic tumor lesion.

This methodology allows to verify in the interface cement and adjacent tissue, the increased temperature that could minimize the growth of bone metastasis.

Results are obtained in the computational models, by the use of different commercial bone cement compositions and their polymerization curves.

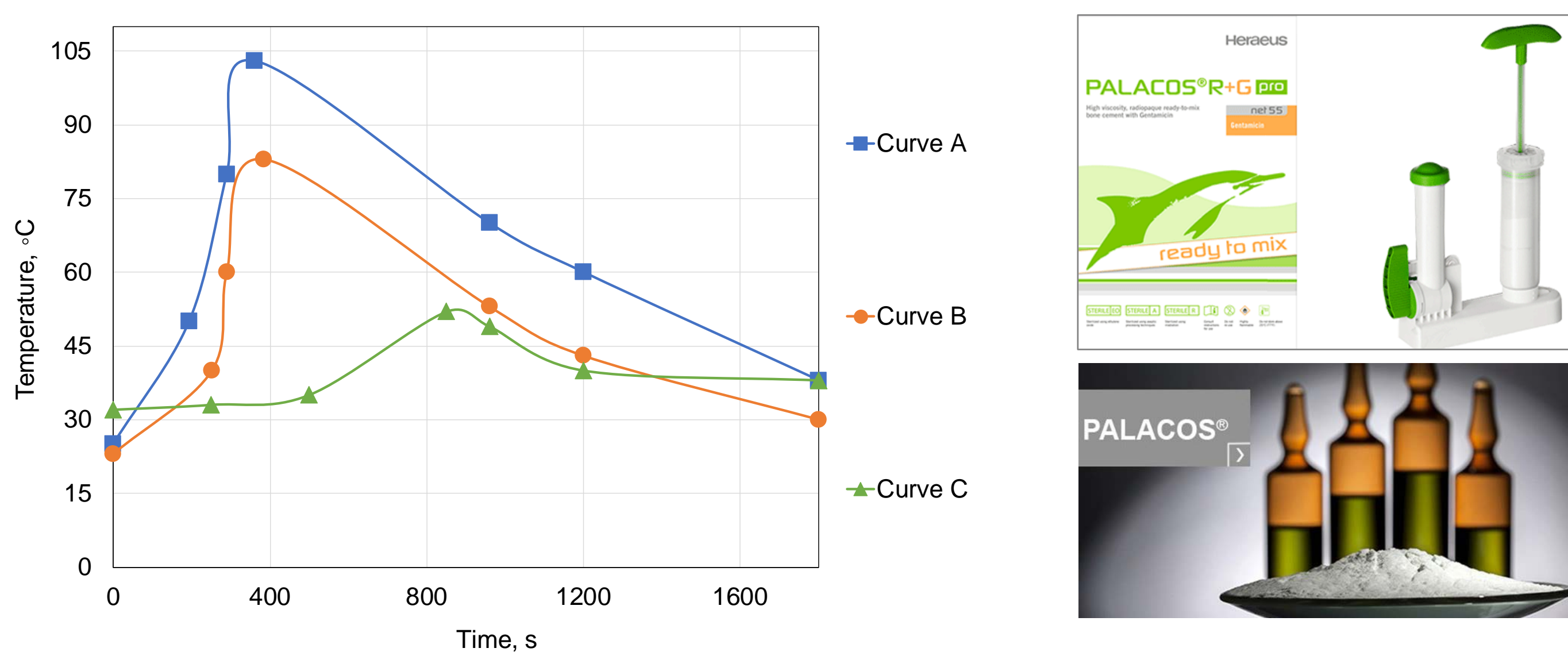


Figure 1 - Curves of polymerization

CONCLUSIONS

- The adjacent areas to PMMA have high temperature values.
- The choice of PMMA composition is important due to the produced heat effect. Curve C shows the lowest temperature peak.
- The healing process is determined by the extent area and consequent necrosis in lesion tissue, until 8mm neighbour of end cement deposition.
- For each PMMA composition, in female patients group in this study, the extended necrosis area is similar.

3. MATERIALS, METHODS AND RESULTS

Computational models were obtained through the evaluation of medical images for different groups of analysis (gender, age, affected organ and associated pathology).

The computational model represents the proximal femur zone with metastasis obtained by medical images. The patients are female gender, with age less than 70 years, mean cortical diameter 32,9mm and internal diameter 20,6mm and with age greater than 70 years, mean cortical diameter 38,3mm and internal diameter 17,5mm.

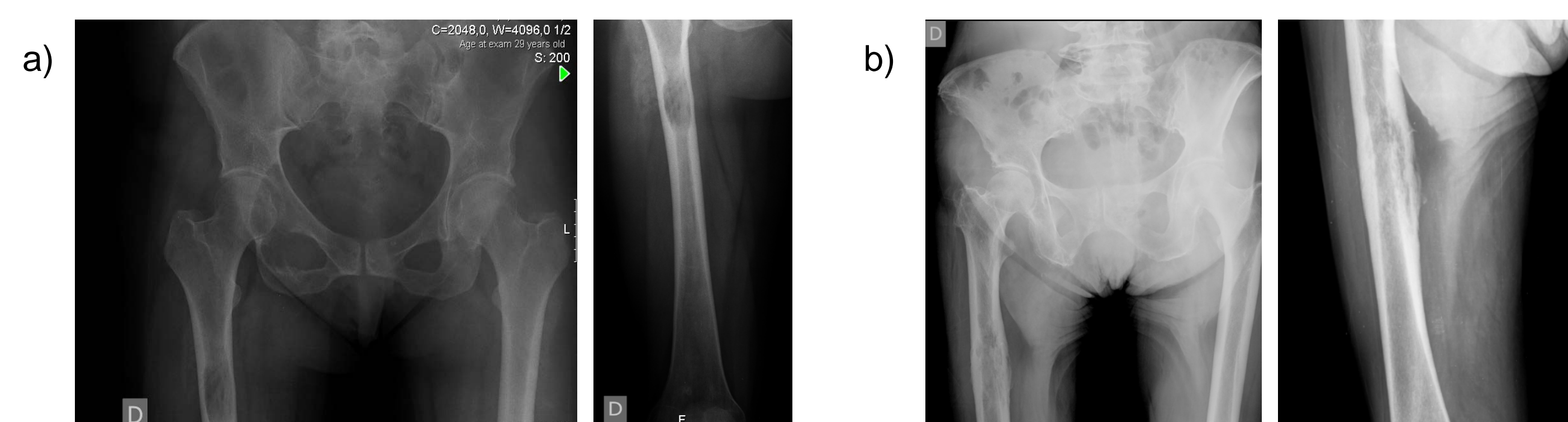


Figure 2– Medical images from X-ray: a)less than 70 years, b)greater than 70 years.

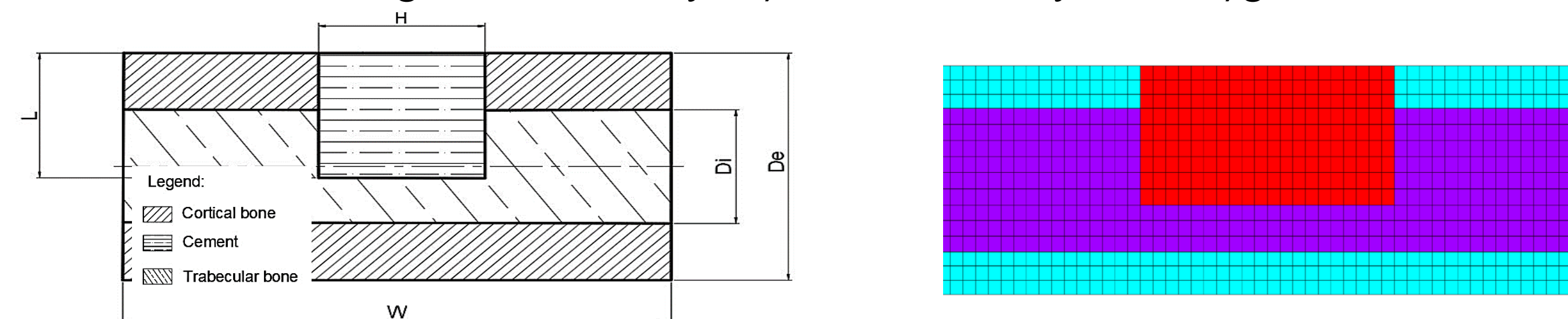


Figure 3 –Representative drawing and computational model.

The computational model includes a transient and thermal analysis, using the finite element method. The material properties (cement, bone) are according the literature.

Table 1. Thermal material properties.

Material	ρ [kg/m ³]	λ [W/K.m]	C_p [J/kgK]
Cortical Bone	2100	0.38	1260
Spongy Bone	620	0.39	4926
Cement PMMA	1100	0.20	2000

The results are temperature fields, where the cement curing process determines the extended area affected by the thermal effect.

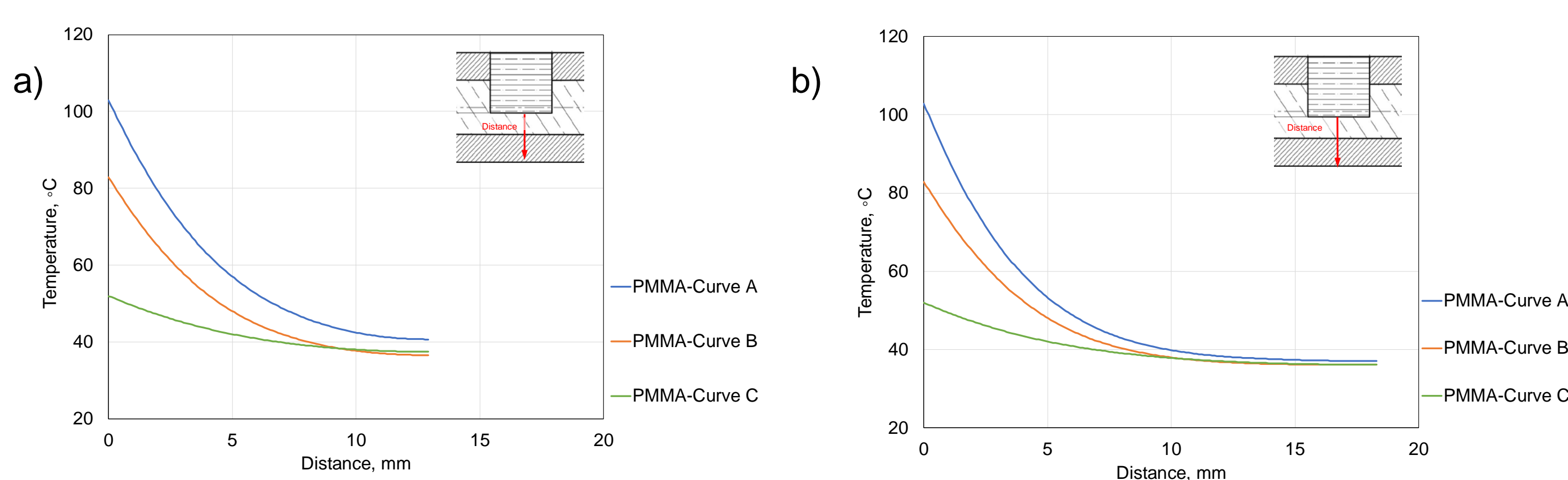


Figure 4 – Temperature function of bone distance, for high peak of PMMA polymerization: a) Age less than 70 years, b) Age greater than 70 years.

Necrosis corresponds to the grey area in the computational models.

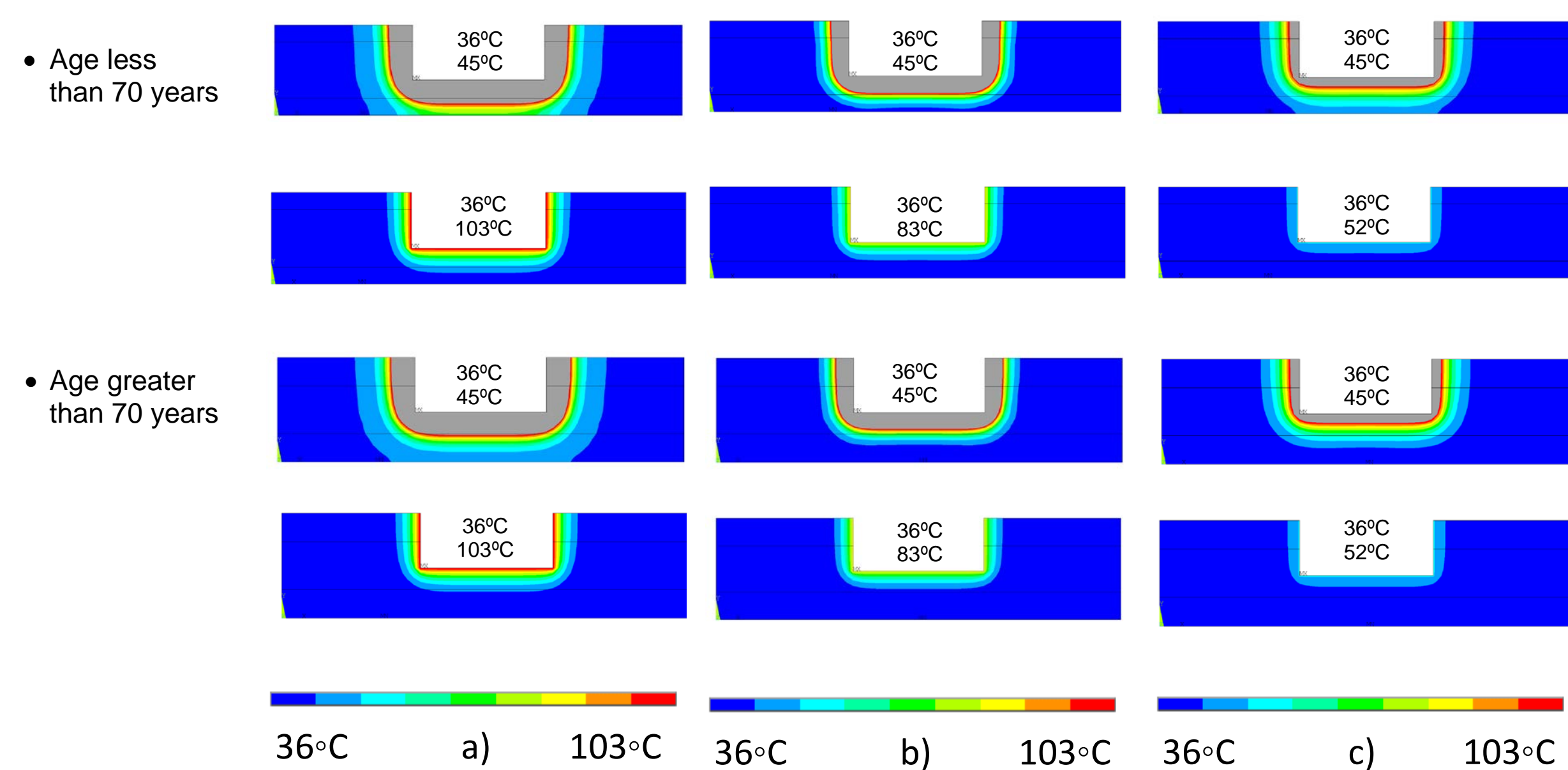


Figure 5 –Thermal analysis, function of: a) Curve A, b) Curve B, c) Curve C.

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