3rd Portuguese Bioengineering Meeting

20th to 22nd February, 2013
University of Minho, Braga

Book of Proceedings

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Universidade do Minho

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Campus Gualtar, University of Minho

Braga, Portugal

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Organization

Organized and Supported by:

IEEE Institute of Electrical and Electronics Engineers

IEEE Engineering in Medicine and Biology Society (EMBS) | Portugal Chapter

IEEE Women in Engineering (WIE) | Portugal Section

University of Minho

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Welcome Address

It is our pleasure to welcome you to the 3rd Portuguese Bioengineering Meeting organized by IEEE-EMBS Portuguese Chapter!

Our Annual Meeting in biomedical and bioengineering has been previously held in Lisboa and Coimbra being, this year, Braga the host city.

The primary goal of this meeting is to promote and publicize the academic, associative, industrial and medical groups and to provide conditions for successful synergies. With this purpose, the meeting is sustained in the following five pillars:

∴ Academic excellence;
∴ Applied research;
∴ Entrepreneurship;
∴ Synergies;
∴ Identification of opportunities and means.

This year we received 91 submissions, 27 abstracts, 44 full papers and 20 Master Thesis. All the submitted contributions were peer reviewed.

The three day program includes the presentation of the Portuguese PhD programs, the presentation of the three best National Master thesis, the demonstration of applied research carried out in Portuguese and International enterprises and industries and the display of recent success cases of Portuguese entrepreneurship (in the first day); the presentation of academic work by researchers and alumni (in the second and third days). The meeting ends with two up-to-date topics: a session on the use of Virtual and Remote Labs in Bio-Engineering Education; and What WiE can do - the challenges for scientists, session organized by the IEEE Portuguese affinity group Women in Engineering. Along the three days we have the pleasure to attend lecture moments from the invited keynote speakers.

We would like to thank all the Meeting supporters, namely, Centro Algoritmi, Doctoral Program in Biomedical Engineering of University of Minho, Banco Espírito Santo, Sumol+Compal and Câmara Municipal de Braga.

We hope this meeting can boost the cooperation and interplay spirit between the different Bioengineering key players and bring together Portugal, from the seashore to the interior regions and from north to south.

Welcome to Braga! Enjoy the conference!

The Organizers

Chair: Graça Minas
Co-Chair: Filomena Soares

The assessment of the thermal necrosis due a drilling dental process with or without irrigation

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***Abstract*— The main objective of this work is to present a methodology to assess the thermal necrosis in a dental model due a drilling process with and without water irrigation. An experimental methodology, using an infrared thermography camera, was used to measure the rate of temperature change during the drilling in a pig mandible. The finite element method is used with the Ansys program to compare the results with the experimental model. A simplified model was analyzed in a transient thermal process. Using appropriated boundary conditions, successful numerical results could be used as an alternative to the in-vivo models.**

***Keywords*—thermal necrosis; finite element method; water irrigation; simplified model; pig mandible.**

I. INTRODUCTION

Different studies show that if heat is generated in bone tissue, a temperature could be raised above a threshold value and bone damage could occur. For example, surgical drilling process, where cutting tools are used, produces a heat surrounding the adjacent bone. For this raison, it is important control the effect of drilling process in a dental surgery. To keep lower temperatures and control the drilling parameters are preventive rules to obtain appropriated results.

II. EXPERIMENTAL AND NUMERICAL MODEL

In order to assess the thermal necrosis in a dental model an experimental and numerical process were used, as represented in figures 1 and 2.

In the first one a pig mandible was subjected to a drilling. The initial temperature of the mandible is equal to 20ºC. The experimental results were obtained with an infrared thermography camera. In the second process a numerical model was used. An approximated geometry was considered with a finite element mesh for cortical and trabecular zone.

In both models during the drilling process were considered the effect of water irrigation or not.

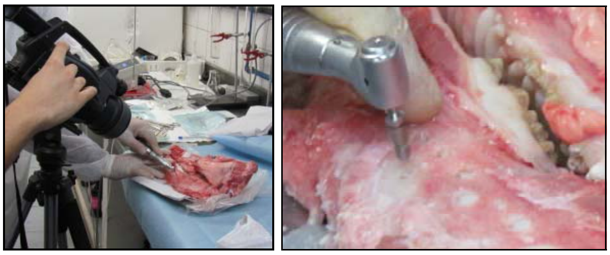

Figure 1. Experimental model.

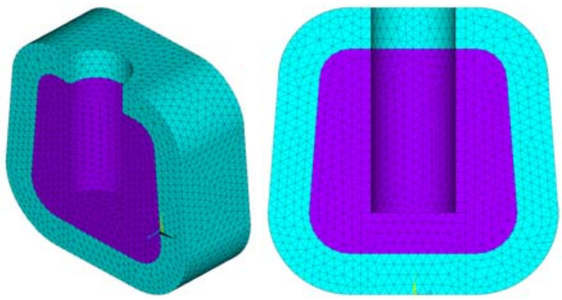

Figure 2. Simplified numerical model.

The geometry considered in the numerical simulation represents a part of a dental bone with a hollow cavity equal to the drill bit diameter and a depth equal to 10mm. Cortical bone of 2mm thickness with low density trabecular bone (Model C2) was considered, [1]. Based in the literature [2-5] the thermal properties for cortical and trabecular bone were considered and presented in table 1.

Table 1. Bone thermal properties.

Properties	Bone	Model C2
Density, kg/m^3	Cortical	2100
	Trabecular	1100
Conductivity, W/mK	Cortical	0.4
	Trabecular	0.5
Specific heat, J/kgK	Cortical	1260
	Trabecular	1490

The numerical modelling of heat propagation from drill process was described by a heat flux density received in the bone surface. The calculated heat flux value is function of the drilling parameters and was equal to $7.14 kW/m^2$, [1]. The initial temperature considered in the numerical model was assumed equal to 37ºC.

In the numerical model without irrigation only the heat flux is considered. But in the numerical model with water irrigation, in addition the convection effect is considered. The convection heat transfer coefficient is equal to $100 W/m^2K$ and the bulk temperature environment equal to 5ºC.

III. Results and Discussion

Two experimental tests were produced using water irrigation during the drilling or without water irrigation. The temperatures in the surface of the pig mandible are represented in figure 3 and 4, respectively without and with irrigation.

Figure 3. Infrared thermal image, without irrigation ΔT=14ºC.

Figure 4. Infrared thermal image, with irrigation ΔT=5ºC.

The increase of temperature is equal to almost 14ºC, relative to the initial temperature (20ºC) when the experimental test is without irrigation. With irrigation, the increase of temperature is almost equal to 5ºC, relative to the initial temperature (20ºC) of the pig mandible.

The temperature calculation in the numerical model at the end of the drilling process is represented in figure 5. The grey zone represent the bone damage according the thermal necrosis effect, on the threshold of temperature equal to 55ºC, [1]. Figure 5a represents the model without irrigation and figure 5b represents the model with irrigation.

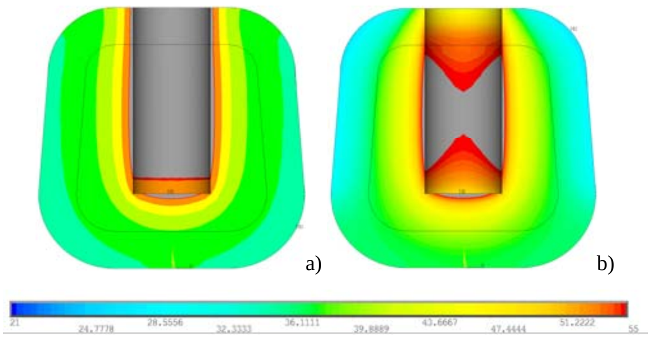

Figure 5. Numerical results at the end of the drilling process.

The numerical results through all time-temperature history are presented in different nodal positions, neighbourhood to the drill hole, figures 6 to 8. Three different positions were considered to measure the thermal necrosis, one nodal position on the surface (0C), one nodal location in cortical (1C) and one in trabecular zone (1T).

The increase of temperature in the surface model (position 0C) is equal to almost 20ºC, relative to the initial temperature (37ºC) when the numerical model is without irrigation. When irrigation is considered the increase of temperature is almost equal to 8ºC, relative to the initial temperature. Comparing the increase of the temperature obtained with the experimental process, the range is almost similar. Model without irrigation rises above 55ºC through all drill hole, while with irrigation the thermal necrosis effect vanishes.

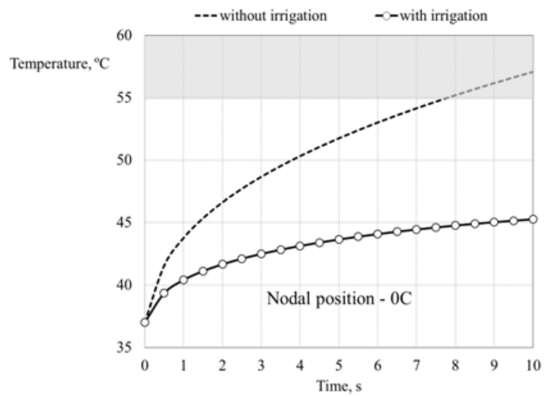

Figure 6. Time-temperature history for 0C.

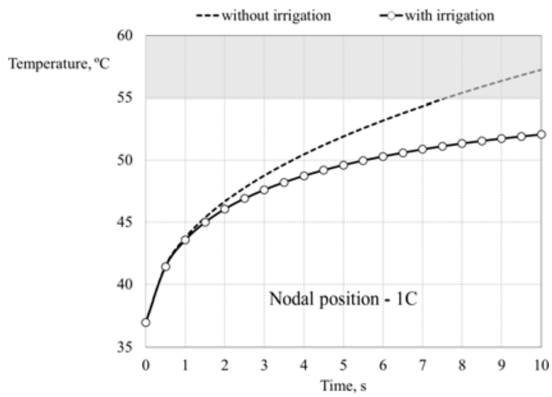

Figure 7. Time-temperature history for 1C.

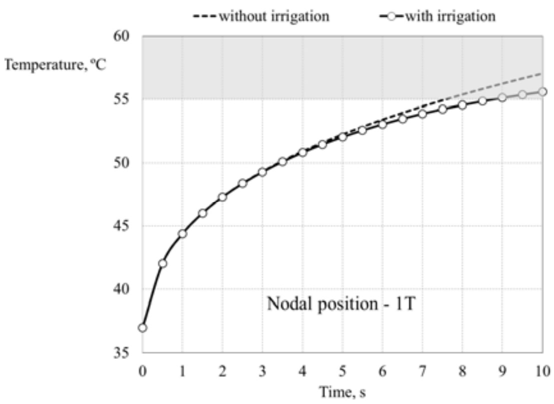

Figure 8. Time-temperature history for 1T.

IV. CONCLUSIONS

In this work two different methodologies were presented to assess the thermal necrosis due a dental drilling process with and without water irrigation. Comparing the increase of temperature between all methodologies, the range is similar. In conclusion, the numerical methodology could be one technique to induce appropriate results, without using in-vivo models.

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REFERENCES

[1] Elza Fonseca; Kelly Magalhães, Maria Fernandes, Marcos Barbosa, Gerdal Sousa; Numerical Model of Thermal Necrosis due a Dental Drilling Process, II International Conference on Biodental Engineering, Book of Abstracts, 7-8 December 2012, Porto 2012.

[2] Davidson, S.R.H. Heat transfer in bone during drilling. Applied Science Master Degree, University of Toronto, Canada, 1999.

[3] Hillery, M.T., Shuaib, I. Temperature effects in the drilling of human and bovine bone. Journal of Materials Processing Technology vol. 92-93, pp.302-308, 1999.

[4] Mazzullo, S., Paolini, M. Verdi, C. Numerical simulation of thermal bone necrosis during cementation of femoral prostheses. Journal of Mathematical Biology, vol. 29, pp.475-494, 1991.

[5] Lin, D., Li, Q., Li, W., Ichim, I., Swain, M. Evaluation of dental implant induced bone remodelling by using a 2D Finite Element model. 5th Australian Congress on Applied Mechanics, ACAM, Brisbane, Australia, 2007.