IMPORTANCE OF WATER COOLING IN HUMAN TEETH CAVITY PREPARATION USING HIGH-SPEED BURS

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***RESUMO**: **Introdução**: A busca de solução para os problemas que afetam o homem exige, cada vez mais, o emprego de tecnologias que apresentam um alcance multidisciplinar como a Bioengenharia. A avaliação da elevação da temperatura na polpa de dentes, causada por agentes físicos, quando usados no tratamento ou diagnóstico dental, tem sido realizada por diversos autores, em diferentes modelos físicos. Alguns autores estudaram o aumento de temperatura por meio de acompanhamento clínico de pacientes. Não há, no entanto, um modelo matemático simples que descreva a variação da temperatura dos modelos em estudo durante o regime transiente, o qual ocorre antes do equilíbrio térmico, quando a temperatura está variando. **Objetivo**: Estudar a elevação de temperatura em dentes humanos extraídos e preparados com e sem refrigeração a água. **Material e métodos**: A medição de temperatura foi realizada por meio de um termopar acoplado a um termômetro digital, utilizando-se broca carbide de alta rotação. **Resultados**: Observou-se que na amostra preparada sem refrigeração à água a temperatura aumentou mais do dobro, enquanto que na amostra preparada com refrigeração à água e ar o aumento de temperatura não chegou a 1ºC. **Conclusão**: A refrigeração à água é extremamente importante para evitar o aquecimento durante o preparo de cavidade em dentes.*

***Palavras chaves**: transferência de calor, dentina, preparo da cavidade dentária.*

***Abstract**. **Introduction**: The search for the solution of the problems that affect man increasingly demands the use of technologies that present a multidisciplinary approach like Bioengineering. Assessment of intrapulpal temperature increase caused by physical agents used in dental treatment or diagnosis has been made by several authors, in different physical models. Some authors have studied temperature increase through clinical patient follow-up. There is not, however, a simple mathematic model that describes temperature variation in the study models during the transient regime, which occurs before thermal balance, when temperature is changing. **Objective**: To study temperature increase in extracted human teeth, instrumented with and without water cooling. **Materials and methods**: Temperature measurement was carried out by means of a thermocouple attached to a digital thermometer, using a high-speed carbide bur. **Results**: It was observed that temperature more than doubled in the sample prepared without water cooling, while the temperature increase in the sample prepared with water and air cooling has not reached 1ºC. **Conclusion**: Water cooling is extremely important to avoid heating during cavity preparation.*

***Keywords**: heat transfer, dentin, dental cavity preparation.*

INTRODUCTION

There has always been interest in studying the interaction between physical processes and human body structures, because the search for the solution to the problems that affect mankind requires the increasing use of technologies that present a multidisciplinary involvement among distinct areas like Dentistry, Engineering and Physics, and other like Bioengineering, Biophysics, etc.

The effects of cavity preparation in human teeth extracted with high-speed burs (HS), without water cooling and with water and air cooling is evidenced in the present study.

The assessment of intrapulpal temperature increase has been carried out in different models, such as extracted whole teeth, by several authors, namely, Stern and Sognnaes (1965); Yamamoto et al. (1988); Bahar and Tagomori (1994); Wilder-Smith et al. (1995); Mcnally et al. (1999). Hibst and Keller (1990); White et al. (1992); Niccoli-Filho (1997); Wang-Hong (1999) and Oliveira et al. (2000) assessed temperature increase using tooth fragment models. Zach and Cohen (1965); Stern et al. (1969); Adrian et al. (1971); Adrian (1977) used live animal teeth and Bassi et al. (1994); Gutknecht et al. (1997); Yamada et al. (2000) studied temperature increase through clinical patient follow-up.

However, there is not a simple mathematical model that describes temperature variation in study models during the transitory regime, which occurs before the thermal balance, when temperature is changing. There are methods that use numerical calculation (using digital computers) with the capacity of simulating the temperature in the models as a function of time (Bassi et al., 1994).

Zach and Cohen (1965) carried out a study on the pulpal response to the external application of heat and histologically assessed the pulpal responses to several surgery techniques in order to establish safety standards. Heat production was the main responsible for the pulpal changes when the teeth were prepared. The results of the study have demonstrated that the healthy pulps had not recovered from an intrapulpal temperature increase of 20^{o}F (11.1^{o}C) in about 60% of the cases. Fifteen percent of the teeth heated to 10^{o}F (5.5 ^{o}C) failed to recover. Temperature increases, below this critical level, produced severe reactions related to the heat degree - almost invariably led to pulpal recovery, but left histological sequels. Temperature increases above 20^{o}F almost invariably destroyed the pulp.

Intrapulpal temperature measurement is usually performed by means of thermocouples (Hibst and Keller, 1990; White et al., 1992; Wang-Hong, 1999) and thermometers (Miserandino et al., 1986; Anic et al., 1992; Glockner et al., 1998; McNally et al., 1999; Kurachi et al., 1999) while surface temperature may be measured with thermography chambers (Hibst and Keller, 1990; White et al., 1992; Wilder-Smith et al., 1995).

According to Stern and Sognnaes (1965); Yamamoto et al. (1988); Bahar and Tagomori (1994); Wilder-Smith et al. (1995); McNally et al. (1999) and Yamada et al. (2000) the assessment of intrapulpal temperature increase has been performed in different models such as extracted whole teeth or their fragments, according to Hibst and Keller (1990); White et al. (1992); Niccoli-Filho (1997); Wang-Hong (1999) and Oliveira et al. (2000). The effects of temperature increase may also be assessed through clinical patient follow-up (Bassi et al., 1994; Gutknecht et al., 1997; Yamada et al., 2000).

The thermocouple consists of two metal conductors, of distinct nature, in the form of pure metals or homogeneous alloys. The wires are welded to one of the ends which is called hot junction or measurement junction. The other end is connected to an electromotive force (EMF) measuring instrument, closing an electrical circuit through which current flows. The point where the wires that form the thermocouple are connected to the measurement instrument is called cold or reference junction.

The heating of the junction of two dissimilar metals produces an EMF. This principle known as the Seebeck effect has made the use of thermocouples for temperature measurement possible. Temperature control by a thermoelectric pair is one of the most important applications of the Seebeck effect.

The thermoelectricity phenomenon was discovered in 1821 by T. J. Seebeck when he noticed that in a closed circuit, formed by two different conductors, A and B, there is a current flow while a temperature difference ΔT exists between their junctions. The measurement junction is called Tm junction, and the other one, reference Tr junction. The existence of a AB thermal EMF in the circuit is known as the Seebeck effect. When the reference junction temperature is kept constant, it can be seen that the thermal EMF is a function of the Tm temperature at the test junction. This fact allows the use of a thermoelectric pair as a thermometer.

The Seebeck effect is produced by the fact that the metal free electrons differ from one conductor to the other and depend on temperature. When two different conductors are connected to form two junctions and these junctions are kept at different temperatures, an electron diffusion is produced at the junctions in different rhythms.

There are several combination of two metal conductors operating as thermocouples. Wire combinations must have a reasonably linear relation between temperature and EMF; they must develop an EMF per degree change in temperature, which can be detected by the usual measuring equipment.

Several combinations of metal alloy pairs have been developed, from the most simple ones for industrial use, to the most sophisticated for especial or laboratory use.

These combinations have been made in order to obtain a high thermoelectric power, additionally combining the best characteristics like wire homogeneity and resistance to corrosion, at the operating range. Therefore, each type of thermocouple has an ideal operating temperature range, which must be observed, so that it has an extended useful life. The thermocouples may be divided into three groups, namely: base metal thermocouples; noble metal thermocouples; and special thermocouples.

Base metal thermocouples are those of larger industrial use, with relative low cost wires, and its application allows a broader error margin. Noble metal thermocouples are those whose pairs are made of platinum. Though they are expensive and require high sensitivity receptor instruments, because of their low thermoelectric power, they present very high accuracy, due to the homogeneity and purity of the thermocouples wires. Special thermocouples have been developed to meet the process conditions where basic thermocouples can not be used.

The basic thermocouple used in the study is the K-type one (nomenclature adopted by ANSI Standard)

CA – Adopted by JIS Standard

Alloy: (+) Chromel - Ni (90 %) and Cr (10%)
(-) Alumel - Ni (95.4 %), Mn (1.8 %), Si (1.6 %), Al (1.2 %)

Characteristics:

Temperature range: - 200 °C to 1260 °C
EMF output: - 5.891 mV to 50.99 mV
Applications: iron and steel industries, cement and lime plants, glasses, ceramics, industries in general.

The purpose of the present study was to comparatively analyze the heat produced by cavity preparation with the use of a high-speed carbide bur with and without water cooling, utilizing a contact thermocouple attached to a digital thermometer, in extracted human teeth.

MATERIALS AND METHODS

Sample characterization

Two extracted upper molar samples were selected and kept in saline in order to prevent dehydration and to reproduce a condition closer to the real oral environment, where the teeth are bathed by saliva (Fig. 1). First, the samples were washed and scaled for debris removal. Then, they were radiographed with a millimeter screen to verify pulp chamber volume and plan preparation depth (Fig. 2).

Samples with divergent roots and exposed trifurcation were preferred. An orifice with enough diameter to insert the thermocouple was prepared, ensuring a snug fit, so it could not move during the experiment (Fig. 3).

A number 56 S.S. White high-speed carbide bur, with an active 3mm-tip was selected (Fig. 4). A support apparatus was fabricated for each sample to avoid the interference of the heat of the operator’s hand (Fig. 5). At the bottom of the tube, an orifice was drilled with an acrylic cutting bur so the tooth could be inserted under pressure and stays motionless during preparation. Sample number one was attached to the black tube and prepared with the use of water and air cooling (Fig. 6), and sample number two was attached to a white tube and prepared without the use of water cooling (Fig. 7).

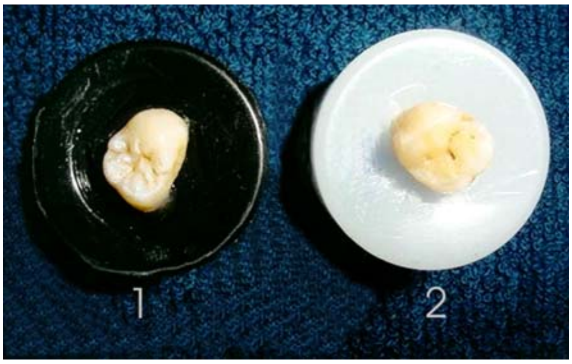

Figure 1. Teeth before preparation

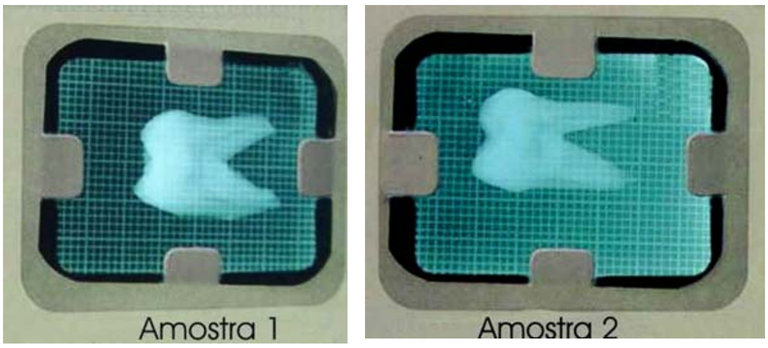

Figure 2. Radiograph of teeth with millimeter screen


Broca Carbide
FG
Nº 56

Figure 8. Digital thermometer attached to a type-K thermocouple

Figure 9. Chronometer used in the study

Preparation technique

Both preparations were performed in a continuous way and in a sweeping motion in an area of approximately 4mm^2. Preparation time was proportional to the sample volume. If the same time were used for the sample with less pulpal volume, there could be the risk of damaging the thermocouple tip. This time difference was not considered significant for result analysis.

RESULTS AND DISCUSSION

The results are shown in Tab. 1.

Table 1. Result Comparison

Parameters	**Sample 1** (with water and air cooling)	**Sample 2** (without water cooling)
Prepared area	± 4mm^2	± 4mm^2
Initial temperature	24.9ºC	24.9ºC
Final temperature	25.2ºC	52ºC
Preparation time	54 seconds	41 seconds

These results are in agreement with those by Zach and Cohen (1965), White et al. (1994) who also evidenced that the use of cooling has an influence on the reduction of tooth thermal effects.

In sample number 2, preparation time was shorter since dentin thickness was smaller (tooth with a little less volume) than that of sample number 1, and if preparation were continued the thermocouple could be damaged.

CONCLUSION

It was observed that in the sample prepared without water cooling temperature more than doubled, while in the sample prepared with water and air cooling temperature increase has not reached 1ºC.

It can be concluded that water and air cooling is extremely important to avoid tooth heating during tooth cavity preparation with high-speed burs.

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