

AN IN-VIVO INVESTIGATION OF EXOTHERMIC REACTIONS IN POLYMERIZATION OF FOUR MATERIALS USED FOR PROVISIONAL PROSTHETIC CONSTRUCTIONS - “Tempofit®” /Detax/, “Structur 2 SC/QM” /Voco/, “Luxatemp® - Automix plus” /DMG/, “Jet Tooth Shade” /Lang Dental/.

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Summary

The “In vitro” investigations of exothermic reactions during the process of polymerizing of MMA-plastics and Bis-GMA composites report temperature changes which could lead to reversible or irreversible changes of the pulp.

The aim of this study is to be traced “in vivo” the temperature changes in the pulp during polymerization of four materials used for provisional restorations -“Jet Tooth Shade” /Lang Dental/, “Tempofit®” /Detax/, “Structur 2 SC/QM” /Voco/ and “Luxatemp® - Automix plus” /DMG/. The experimental research has been conducted on the canines of 8 dogs under total anesthesia with the help of experimental setup for recording the temperature response both in the materials for provisional restorations and in the pulp.

The results show that if the instructions of producer for intraoral stay of the materials are not obeyed strictly, there is a risk of pulpal hyperaemia during work with “Structur 2 SC/QM” /Voco/ and danger for necrosis for the materials “Tempofit®” /Detax/ and “Luxatemp® -

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Automix plus” /DMG/. In the “Jet tooth Shade” /Lang dental/ the dangerous maximal temperatures occur long after the prescribed time for intraoral stay.

Key words: *Exothermic polymerization reaction, Materials for provisional restorations, “In vivo” study*

Introduction

According to many authors [13, 15, 17, 18, 19, 26, 29, 30, 38, 40] the temperatures achieved during polymerization of MMA resins and some of Bis-GMA resins are high enough to cause reversible or irreversible changes in the pulp. Pohto and Scheinin [29] conceive that the temperature in the coronal pulp should not exceed 39°C, because in the temperature range from 39 up to 42°C it is expected a pulpal hyperaemia to be present. Schubert [32] considers that 41,5°C is the critical limit temperature for the occurrence of abnormalities in tissues. According to Zach and Cohen [40] temperatures higher than 42,5 ° C and duration of thermal effect over 20 sec lead to irreversible, necrotic changes in the pulp. Castelnuovo et al. [5] summarized that the temperature rise of 5,6°C in the pulp cavity is sufficient for the occurrence of pulp insult.

In the "in-vitro"-studies of exothermic polymerization reaction of provisional materials the exothermic reaction is monitored only in samples of test material [1, 2, 3, 4, 7, 8, 9, 25, 39]; only in pulp cavity [5, 10, 21, 22, 23, 24, 31, 33] or temperature changes are recorded simultaneously both in the material and the pulp [6, 10, 13, 21, 22]. There are numerous studies [2, 11, 16, 14, 18, 22, 28, 40] where it is established rise of pulp temperatures above the critical values for denaturation of pulp tissue. According to some authors [12, 20, 27] polymethylmethacrylates (PMMA) have higher polymerization temperatures compared to Bis-GMA composites and n-buthylmethacrylates.

Several authors [6, 5, 10, 13, 21, 22] reported that experimental settings in vitro can not fully ensure the conveying heat conditions specific for the clinic. This necessitates the need to additional “in vivo” studies on exothermic reaction to heat and its consequences.

The purpose of this study is to trace the “in vivo” temperature changes in the pulp during polymerization of four materials for provisional prosthetic restorations.

Material and methods

Material for this study is one acrylic resin “Jet Tooth Shade” /Lang Dental/ and three Bis-acrylic composites (“Tempofit®” /Detax/, “Structur 2 SC/QM” /Voco/, “Luxatemp® -

Automix plus" /DMG/). All materials are autopolymerizing and are dispensed and mixed according to manufacturer's instructions. The mass of each sample tested (average mass of material $0,36 \pm 0,13$ g) is recorded using electronic scale measuring unit "Sartorius PT 120".

Experimental setup has been established for recording the temperature response in materials for provisional restorations and in dental pulp using an automatic potentiometric system (Fig.1). The study of temperature is based on automatic registration (with the help of digital multimeter) the resistance of the basis where the temperature reaction is recorded. Experiments were conducted with the help of two digital thermometers "Thermometer Type K 300", equipped with appropriate microprobes registering a temperature change both in pulp and in materials for provisional restorations. Adjustment of the system is performed at temperatures from 0 °C to 100 °C compared to control resistance thermometer such as the Pt 100.

Measurements both in the pulp and in each material were conducted every 30th second and each test lasts for 10 min.



Fig.1: Experimental setup for measuring the temperatures of the exothermic reaction of polymerization of materials for provisional restorations.

Experimental animals were 8 dogs (6 males and 2 females) mean age of 4 years with a live weight between 15kg and 20kg. All dental interventions are made after general anesthesia (Atropinum Sulfuricum 0.02 mg / kg, 20 min before anesthesia, subcutaneous; Diazepam 0.2 mg / kg, 10 min before anesthesia; Xylasin "Rometa, Spofa, Czech Republic" 2% sol, 1 mg / kg, intramuscularly; Ketamin "Rhone Merieux, France" 10 mg / kg, intramuscularly) Fig.2.



Fig.2: Anesthetic drugs used for the experimental animals.



Fig.3: Prepared cavity on the vestibular surface of the canine tooth.



Fig.4: Electrodes introduced in the pulp chamber and in the material.

Upon the four canines of each experimental animal were followed the exothermic reactions to the four tested materials (each material on one canine). Consequently for each material were made respectively eight “in vivo” measurements of temperature changes both in the material and in the pulp.

For the purpose of reporting the values of exothermic reaction in the material on the vestibular surfaces of canines were prepared cubic formed cavities (Fig.3), with a depth of approximately 2 mm (1,5 -2 mm) and wall thickness above the pulp (about 1 mm).

For the purposes of device registration of the values of exothermic reaction in the pulp chamber a lingual access to pulp cavity is made with a hole corresponding to the diameter of the electrode (2 mm). The insertion of electrode in the pulp chamber and the recording of starting temperature in the pulp are carried out before the administration of material for provisional restoration.

Immediately after dosing and mixing the material for provisional restoration is applied in the cavity and in the middle of it the other thermocouple is introduced (Figure 4). Before each test the tip of the thermocouple is insulated with Vaseline in order to avoid sticking to the sample material.

Materials for provisional restorations are applied in the prepared cavities in the following sequence:

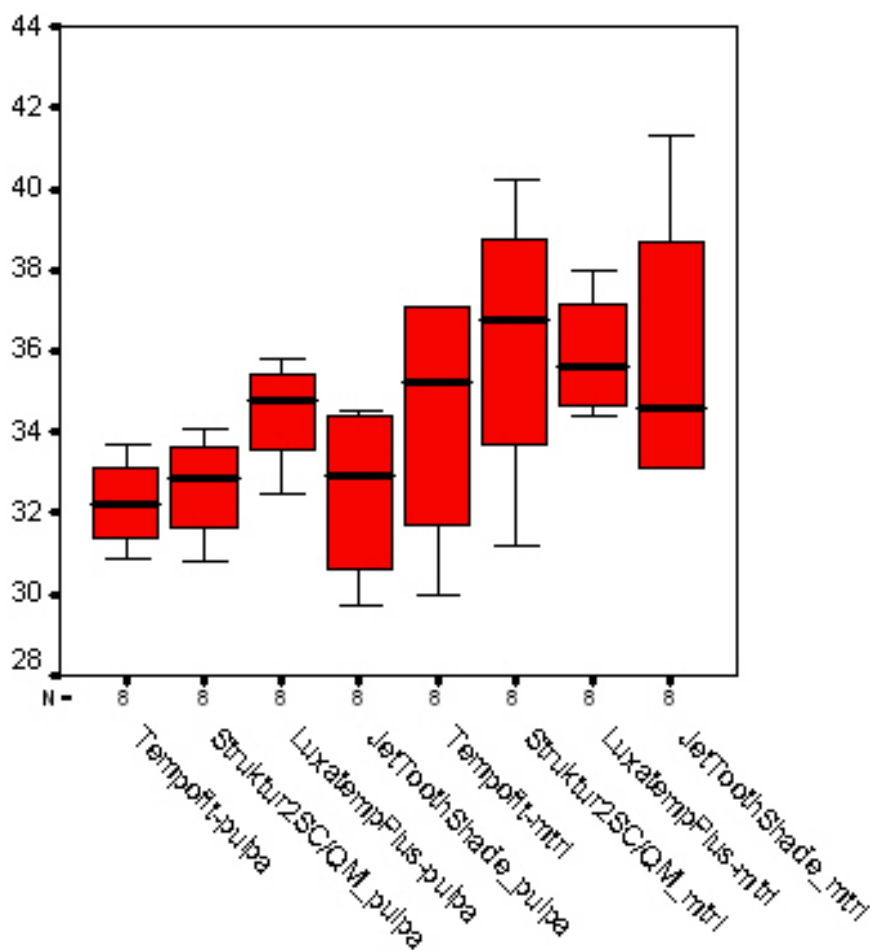
- Upper right canine with “Tempofit®” /Detax/,
- Upper left canine with “Luxatemp® - Automix plus” /DMG/,
- Lower left canine with “Jet Tooth Shade” /Lang Dental/,
- Lower right canine with “Structur 2 SC/QM” /Voco/.

Studies are conducted at room temperature $20,14 \pm 1,26$ ° C and humidity $57,50 \pm 0,88\%$. Statistical data processing is made using the program SPSS for Windows version 11.0.1.

Results

We conducted eight tests of each material so as a result we obtained sixteen temperature curves (eight temperature curves for the material and eight for the pulp), corresponding to the change of values with the increase of time. Thus, 8 reached maximum temperatures for each material were reported and 8 maximum temperatures in the pulp. Figure 5 presents box plot of the distribution of maximum temperatures both in the pulp and in each tested material. In the X-axis are presented the studied materials and Y-axis indicates the temperature change in °C.

Fig.5: Box plot of the distribution of maximum temperatures both in the pulp and in each tested material.



Legend:

...._pulpa – distribution of maximum temperatures recorded in the pulp

..._mtrl - distribution of maximum temperatures recorded in the material

Based on these data for each of the tested materials were derived 95% confidence intervals of maximum temperatures during the exothermic reaction in the material and in the pulp. (Figures 6, 7).

Fig.6: Confidence limits of the maximum temperatures in the materials.

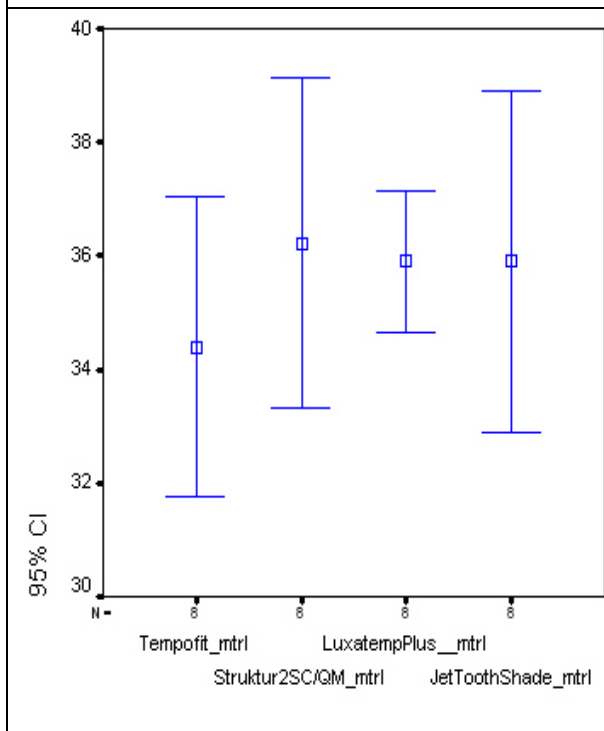
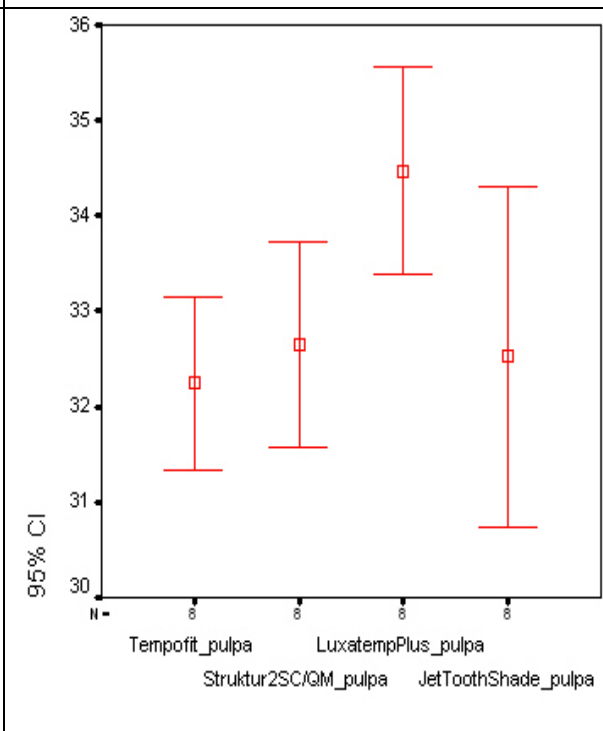
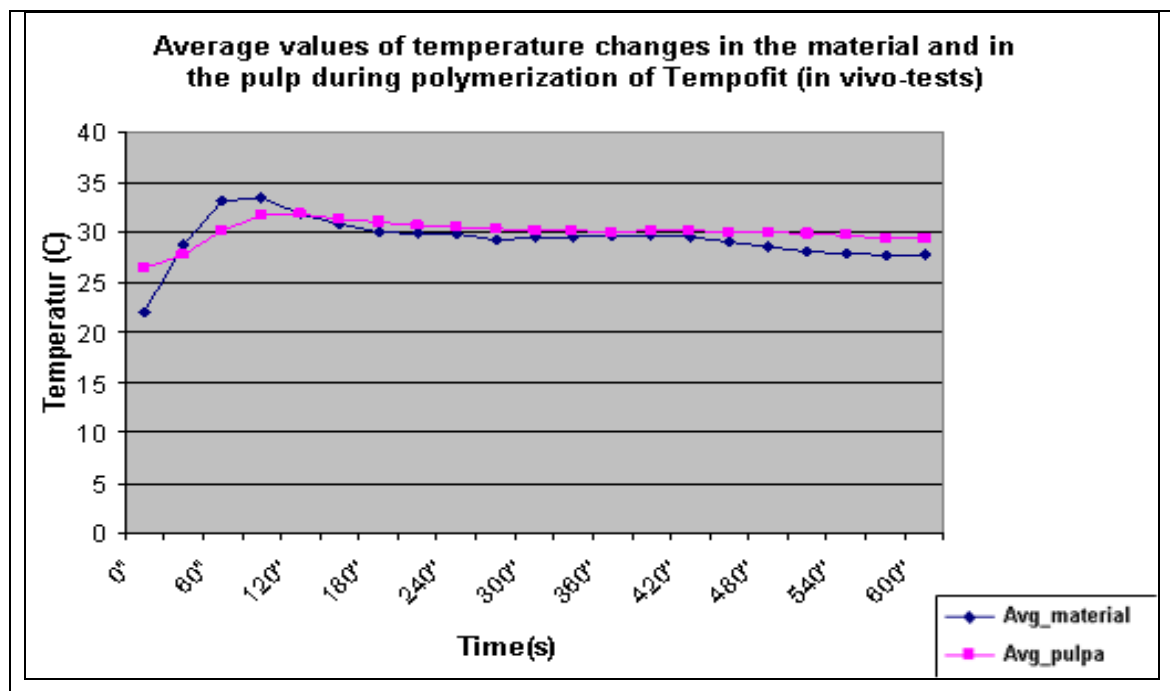


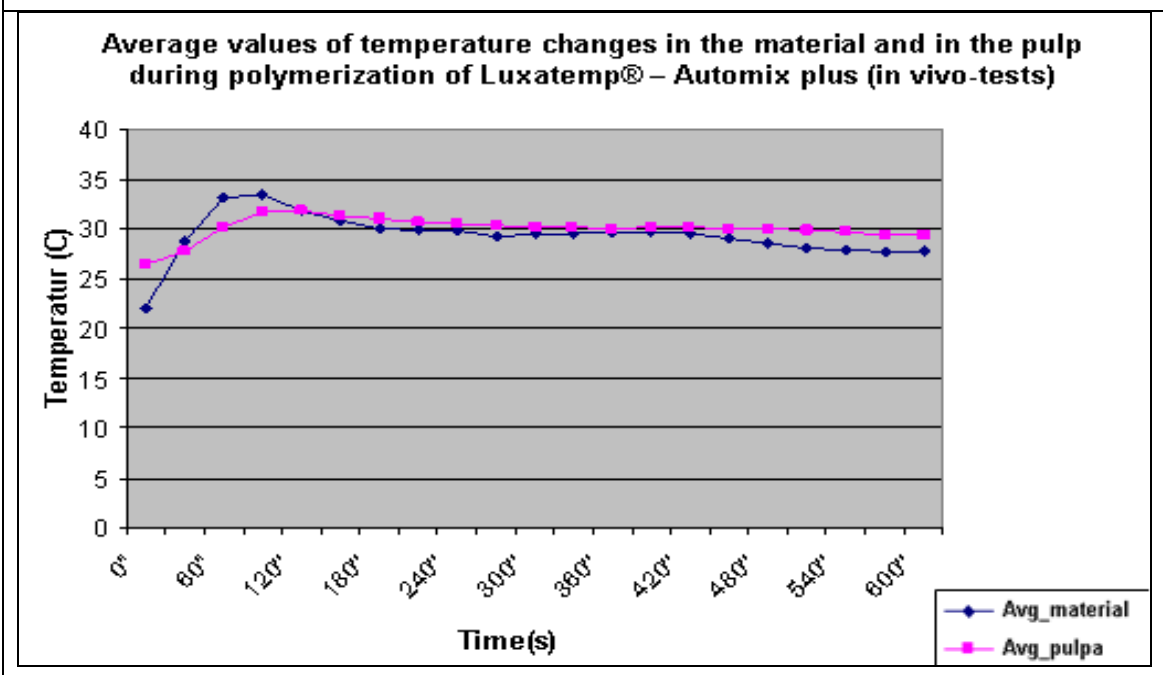
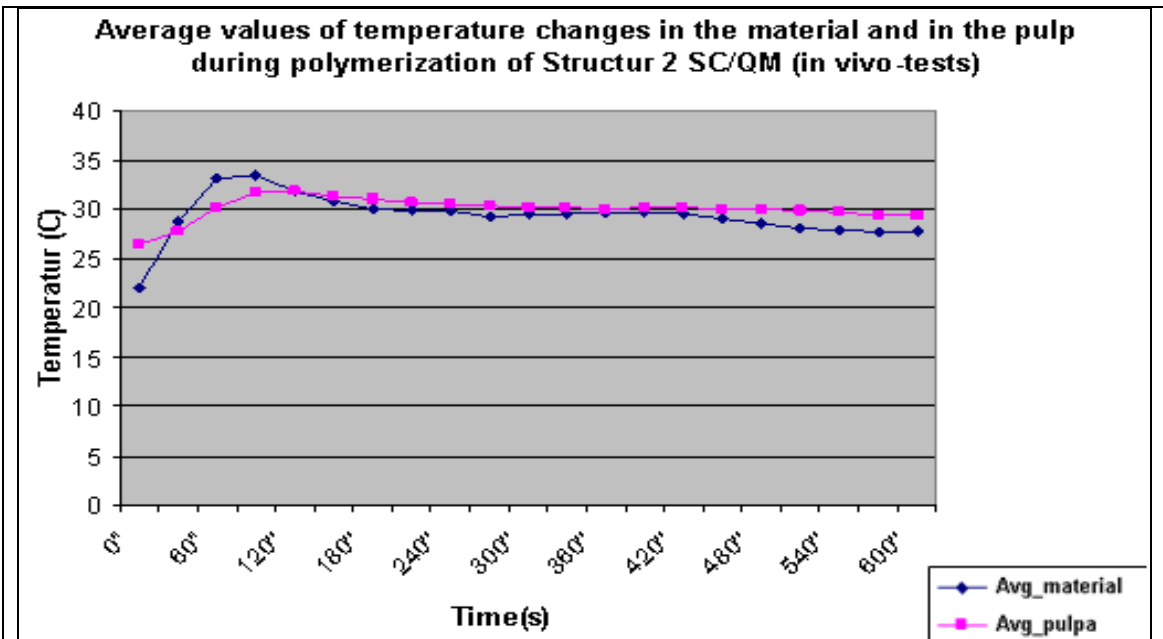
Fig.7: Confidence limits of the maximum temperatures in the pulp.

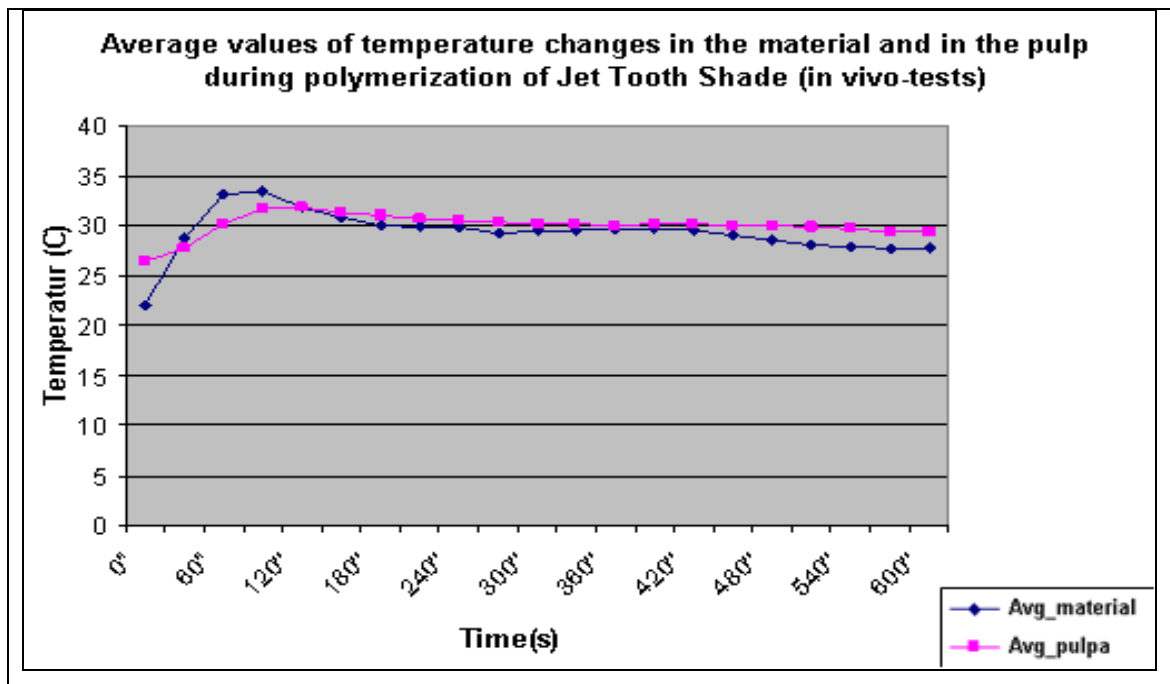


Figures 8, 9, 10 and 11 represent charts of the average values of temperatures recorded in the material and in the pulp.

Fig. 8, 9, 10, 11: Average values of temperature changes in the material and in the pulp.







For each material the differences between the averages of the maximum temperatures in the material and in the pulp stretch in the following confidence limits:

- For the material “Tempofit®” /Detax/ 95% confidence interval is 2,60°C (1,28°C-3,92°C).
- For the material “Structur 2 SC/QM” /Voco/ 95% confidence interval is 3,58°C (1,66°C -5,49°C).
- For the material “Luxatemp® - Automix plus” /DMG/95% confidence interval is 1,48°C (0,32°C -2,63°C).
- For the material “Jet Tooth Shade” /Lang Dental/ 95% confidence interval is 3,38°C (1,39°C -5,36°C).

To refine the analysis, confidence intervals are derived of the differences between the achieved maximum values of temperature in the pulp and its initial temperature (before the application of material in the cavity). Results show the following:

- During polymerization of the material “Tempofit®” /Detax/ it can be expected with 95% confidence the pulp temperature to rise with 5,83°C (4,09°C-7,56°C).
- During polymerization of the material “Structur 2 SC/QM” /Voco/ it can be expected with 95% confidence the pulp temperature to rise with 4,03°C (3,32°C -7,73°C).

- During polymerization of the material “Luxatemp® - Automix plus” /DMG/ it can be expected with 95% confidence the pulp temperature to rise with 6,73°C (6,19°C -7,26°C).
- During polymerization of the material “Jet Tooth Shade” /Lang Dental/ it can be expected with 95% confidence the pulp temperature to rise with 5,85°C (4,1°C -7,59°C).

Discussion

The comparative analysis of the obtained results for the confidence intervals of maximum temperatures in the material and in the pulp of each tested material and the existing literature data for critical temperature limits showed the following: None of the examined materials in vivo showed exothermic reaction of polymerization which causes temperature changes in the pulp exceeding the values indicated from a number of authors: from 41,5°C according to Schubert [32], from 39°C according to Pohto and Scheinin [29] and 42,5°C respectively from Zach and Cohen [40]. Account should be taken however, that in “in vivo” experiments the administered anesthesia has a vasoconstrictor effect, which allows temperature increase in the pulp to start from a lower baseline and during the tests it does not exceed physiological temperature tolerance range for maintaining the vitality of the pulp. For interpretation of the results account should be taken into the availability of open cavity surface that exchanges the heat quickly to the environment; drying of the cavity and cooling effect of the pulp. Therefore, values obtained from temperature measurements in the material and the pulp must be considered relatively, and relative to the experimental conditions and the impact of listed above factors.

The presence of heat exchange in the phase border between the material and the pulp determines the change of temperatures in the pulp. For the proper interpretation of results it is important to establish for each material the absolute value of the difference between the maximum temperature reached in the material during polymerization process and the maximum temperature in the pulp. The obtained 95% confidence intervals of these differences indirectly orientate for the changes in the pulp during the polymerization of any one material, and the relationship is inverse - the bigger the difference is, the lower is the maximum temperature in the pulp achieved during polymerization process. It is noteworthy that the materials "Tempofit ®" / Detax / and "Luxatemp ® - Automix plus" have relatively low average values and upper limits of confidence intervals. More favorable for the pulp are the results for materials "Jet Tooth Shade" / Lang Dental / with a 95% confidence interval

3,38°C (1,39°C - 5, 36°C) and "Structur 2 SC / QM " / Voco / with a 95% confidence interval 3,58°C (1,66°C - 5,49°C).

Castelnuovo et al. determines that an increase of about 5,6°C is sufficient for the occurrence of pulp insult. Comparing these data with the confidence intervals of the differences between maximum values of temperature in the pulp and its initial temperature showed that in all tested materials the upper limits of confidence intervals exceed these reference values. It is important to establish, however, when do these temperature peaks occur - before or after the time of intraoral stay specified from the manufacturers.

According to the manufacturer's data [34] maximum temperature value of the exothermic reaction of polymerization of the material "Tempofit®" / Detax / is expected to be less than 40°C. The recommended time of intraoral stay of the material is 2min. For the materials "Luxatemp® - Automix plus" / DMG / the maximum temperature of polymerization, according to the manufacturer [35] is approximately 38°C and time of a recommended stay in the mouth is 2.30 min to 3.00 min.

The survey results show that for materials "Tempofit®" /Detax/ and "Luxatemp® - Automix plus" /DMG/ the maximum temperatures occur in the pulp at the end of the recommended intraoral stay of the material. The values of temperature increase in pulp exceed 5,6°C.

The recommended intraoral stay [37] for the material "Structur 2 SC/QM " /Voco/ is up to 1 min and we recorded that the maximum temperature in the pulp occurs 30 sec after the specified by the manufacturer intraoral stay and the temperature rise in the pulp is an average of 4,03°C.

According to the manufacturer's instructions [36] the intraoral stay of "Jet Tooth Shade" /Lang Dental/ should be initially 3min, then the material should be taken out from the mouth, excesses removed and then repeatedly put back again on the prosthetic field and took out of the mouth in order to avoid warming of dental stumps. The maximum temperature in the pulp recorded by us occurs 3min after the specified by the manufacturer time of intraoral stay, and the temperature rise is an average 5,85°C.

Conclusion

In order to summarize the results from this study we took into account the following: We referred to defined from Pohto and Scheinin limit value for pulp hyperaemia (39°C) and the limit value for pulp necrosis (above 42,5°C) by Zach and Cohen, take into account the starting temperature of the normal pulp (37°C), provided analysis of increase of the average temperature in the pulp and the intraoral stay of the materials. So we reached the following

conclusions:

1. There is certain risk of pulp hyperaemia during work with "Structur 2 SC/QM" /Voco/ and risk of pulp necrosis in materials "Tempofit[®]" /Detax/ and "Luxatemp[®] - Automix plus" /DMG/, if the recommendations of the manufacturers of intraoral stay of materials are not respected exactly.
2. In material "Jet Tooth Shade" / Lang Dental / the dangerous for the pulp values of maximum temperature occurred significantly later than the prescribed oral stay and can cause damage only in case of violation of operational protocol and failure to perform the recommended cooling procedures.

Application of scientific result:

1. The significance and relevance of discussed problematic is determined by the increasingly widespread use of provisional constructions in daily treatment activities and its establishment as an indispensable treatment stage of fixed prosthodontics.
2. Obtained results which display the existing heat exchange between material and the pulp are important for practice because they emphasize on the danger of thermal damage of the pulp when using direct methods of provisional prosthetic restoration. Understanding that the MMA are of a high temperatures should not be automatically and blindly followed because it is important the intraoral stay and working protocol. Emphasis is placed on the precise following of working protocol and on the need to respect the intraoral stay recommended by the manufacturers. Underestimation of this problematic in dealing with some contemporary materials for provisional prosthetic restorations would lead to serious contradiction with one of the most important features of the provisional constructions - their prophylactic effect on the pulp and tooth structures.

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