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Original Article

Risk of pulp damage may increase due to intrachamber temperature during the usage of prophylaxis cup without paste

Ihsan Furkan Ertugrul[1], Ekim Onur Orhan[2]

[1]Pamukkale University, Faculty of Dentistry, Department of Endodontics, Denizli, Turkey
[2]ESOG University, Faculty of Dentistry, Department of Endodontics, Eskisehir, Turkey

Abstract

Aim: The aim was to measure in vitro pulp temperature increase over physiologic temperature during usage of different prophylaxis regimes at two different application pressures.
Material and Methods: The aim was to measure in vitro pulp temperature increase over physiologic temperature during usage of different prophylaxis regimes at two different application pressures.
Results: The aim was to measure in vitro pulp temperature increase over physiologic temperature during usage of different prophylaxis regimes at two different application pressures.
Conclusion: Within the limitations of this in vitro study following conclusion can be drawn: Prophylaxis cups without paste generated the highest intrachamber temperature thus, the risk of pulp damage might be increased during its usage. Naturel-bristled prophy brushes generated the lowest intrachamber temperature. Vigorous application pressure increased the intrachamber temperature.

Keywords: Dental prophylaxis; pulp; prophy cups; tooth-polishing; pulp damage

INTRODUCTION

The goal of preventive dentistry is to protect dental hard tissues, and preserve the periodontal health. Caries is the most common problem encountered in hard tissues of tooth also, "gingivitis" is the most common problem of periodontal tissues. The local etiological factors as dental plaque and calculus formation cause tooth decays and periodontal problems, and therefore, it must be eliminated by maintaining oral hygiene (1). A smooth enamel is the essential criterion to prevent plaque formation which can be achieved by performing tooth-polishing after scaling, professionally (2). Practically, tooth-polishing is mostly performed by engine-driven tips as rubber/prophy cup and bristle/prophy brush in combination with various prophylactic pastes (3).

The Pro-Cup™ (KerrHawe SA, Bioggio, Switzerland) cleaning & polishing cups comprise a disposable polishing system, made by natural latex. The Pro-Cup™ has the lamellar inner and outer profile, it impels the paste and saliva towards the edge of the cup on a helical principle thus, the prophylaxis paste is continually carried in the direction of the teeth. It is also designed with varying degrees of flexibility as soft and hard. The Pro-Cup™ is recommended maximum as 5000rpm speed and to use with prophylaxis paste. According to the manufacturer, teeth overheating are avoided due to the material being with low coefficient friction.

Pasteless Prophy™ (KerrHawe SA, Bioggio, Switzerland) polisher cups are indicated for the cleaning of tooth enamel surfaces when extreme staining occurs. The cups are "not" made by a natural latex. According to the manufacturer, it is comprised of fluoride and the fluoride is released during its application. Pasteless Prophy™ cups are autoclavable for multiple use and it is recommended maximum as 5000rpm speed and to use without prophylaxis paste.

Pro-Brush™ (KerrHawe SA, Bioggio, Switzerland) is a tooth

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Corresponding Author: Ekim Onur Orhan, ESOG University, Faculty of Dentistry, Department of Endodontics, Eskisehir, Turkey
E-mail: ekimonurorhan@gmail.com

cleaning and polishing brush. Non-conventionally, the bristles are attached into a biocompatible polymer cup. Therefore, this polymer cup avoids scratches or damaging on adjacent teeth surfaces when they accidentally come in contact with the cup during the cleaning and polishing procedure. The polishing brush is also disposable, and the bristles of the Pro-Brush are manufactured as natural-type and nylon-type. The Pro-Brush™ is recommended maximum as 5000rpm speed and to use with prophylaxis paste. According to the manufacturer, the surface heating is low during the brushes in operation. However, for all above-mentioned systems, the frictional force or any data related their heat generation is not disclosed by their manufacturers. Neither no available data of the subject in the literature. The intrachamber temperature changes related to finishing and polishing procedures of the restorations is well-documented (4-6). Generally, dental rotating systems and its associated products generate heat due to frictional forces (4,6). The generated heat physically transferred into tooth structures and therefore, may negatively affect pulp vitality (7). Temperature-related pulpal damage has been reported and the pulpal damage "threshold level" of intrachamber is determined ≥ 5.6°C in literature (7). It has been reported that the risk pulp damage may occur above this threshold (7-9). The temperature of pulp chamber may also increase by frictional forces during polishing procedure of teeth. Frictional forces are affected by the characteristics of the contact surface and the structural components of dental polishing products (3). Moreover, operational pressure exerted by practitioners can also cause increases in heat generation (6). However, there is no available data related with the tooth-cleaning/polishing regimes and their intrachamber heat production, which perhaps is the most vital on tooth tissues.

The aim of the present study was to measure intra operational pulp temperature during usage of different prophylaxis regimes at two different application pressures. The null hypothesis tested was that the different tooth-polishing regimens would not influence to increase in intrachamber temperatures above of the threshold level, and that different application pressures would not influence increases in intrachamber temperatures.

MATERIAL and METHODS

Ethical approval was done with reference 60116787-020/8895. Ten human maxillary incisor teeth with similar dimensions, stored in 0.1% thymol, were used. Then tooth samples were separated horizontally using a low-speed disc saw disc from 1 mm below the cement-enamel junction. The smear layer on the separated surfaces was removed using the 17% EDTA solution (Lot# 190804, Promida Co. Eskişehir, Turkey) by 1 min continuous flushing. The pulp tissues were removed using an excavator, then the pulp chamber was cleaned with 5.25% with sodium hypochlorite (Lot#190800, Promida Co. Eskişehir Turkey), was disinfected with 2% chlorhexidine (2% ProChex Lot# 190802, Promida Co., Eskişehir Turkey) and was dried with air-compressor. The crown samples were placed in the previously described pulpal blood microcirculation model (PBMM) was used in present study (4).

Experimental groups

Four-type of polishing regimes were used in this study. The sample size for each group was calculated using PS v3.1.6 (Power and Sample Size Calculation, Vanderbilt University, Nashville, TN) software. Ten samples from each subgroup were tested ex-vivo pulp microcirculation model (Figure 1). The tested polishing materials are listed in (Table 1).

Table 1. Experimental groups

	Groups	Manufacturer	Prophy paste recommendation	Recommended speed (rpm)	Load	n
PC04	The Pro-Cup ™ Polishing cups Standard/Hard	KerrHawe SA, Bioggio, Switzerland	Yes	< 5,000	0.4 N	10
PC08			Yes	< 5,000	0.8 N	10
PP04	Pasteless Prophy ™ Polishing cups Standard		No	< 5,000	0.4 N	10
PP08			No	< 5,000	0.8 N	10
PBN04	Pro-Brush™ Polishing brushes - Natural bristles		Yes	< 5,000	0.4 N	10
PBN08			Yes	< 5,000	0.8 N	10
PBS04	Pro-Brush™ Polishing brushes – Nylon (Synthetic) bristles		Yes	< 5,000	0.4 N	10
PBS08			Yes	< 5,000	0.8 N	10

Experimental groups were as follows: Pro-Cup™ polishing cups with prophylaxis paste at low-loading force of 0.4N (PC04); Pro-Cup™ polishing cups with prophylaxis paste at high-loading force of 0.8N (PC08); Pasteless Prophy™ polishing cups at 0.4N (PP04); Pasteless Prophy™ polishing cups at 0.8N (PP08); Pro-Brush™ natural bristles with prophylaxis paste at 0.4N (PBN04); Pro-Brush ™ natural bristles with prophylaxis paste at 0.8N (PBN08); Pro-Brush ™ nylon (synthetic) bristles with prophylaxis paste at 0.4N (PBS04); and Pro-Brush ™ nylon bristles with prophylaxis paste at 0.8N (PBS08). Polishing materials and prophylaxis paste were used with according to the manufacturer's instructions. The same amount of polishing paste (Cleanic™ KerrHawe

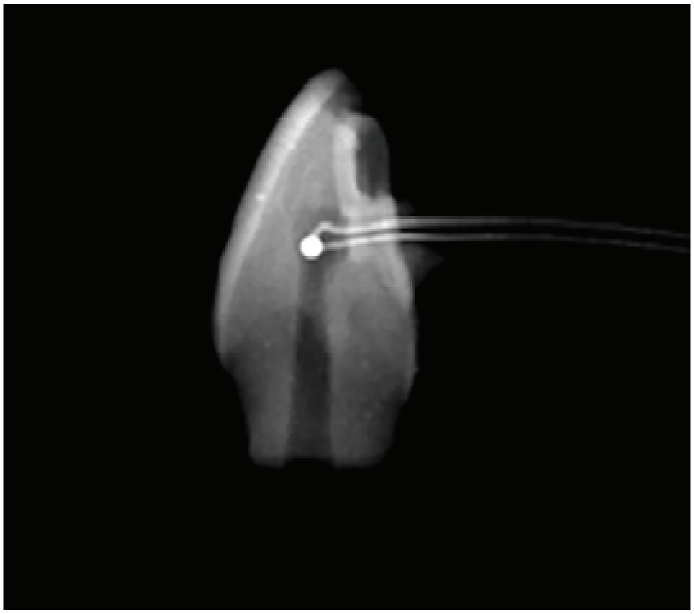

Figure 1. The periapical radiography shows the position of the thermocouple point

SA, Bioggio, Switzerland) was used in groups with prophylaxis paste.

The teeth surfaces were covered by the same amount of artificial saliva (GC Dry Mouth Gel, GC Co. Tokyo, Japan) to mimic the clinical situation accurately mainly due to lubrication and humidity.

The previously described low-loading and high-loading pressure values were selected (4). The in vivo parameters were at 37°C temperature, 10-second operation time, and 2,400 revolution-per minute speed (Figure 2) by using 1:1 contra angle hand piece (FX25, NSK-Nakanishi Inc., Tochigi, Japan). The average intrachamber temperatures (Δt) were calculated using a software (AzeoTech Inc., Ashland, OR, USA).

The time-temperature plot of samples revealed 5 distinct phases in each group (Figure 3). Phase 1: Latent phase and phase 2: active phase were defined intra operative of contiguous zone. Phase 3: Residual phase, phase 4: Flat phase, and phase 5: Cooling phase were non-contiguous zone.

Statistical analysis

Data were normally distributed. The Friedman test was used to test the differences among the data of different brand devices on the same tooth. In the analysis of group differences, "Bonferroni Corrected Wilcoxon Paired Two Sample Test" was used. These statistical analyses were performed on a software (SPSS version 24.0, IBM Corporation, Armonk, NY, USA). The level of statistical significance was set at 0.05.

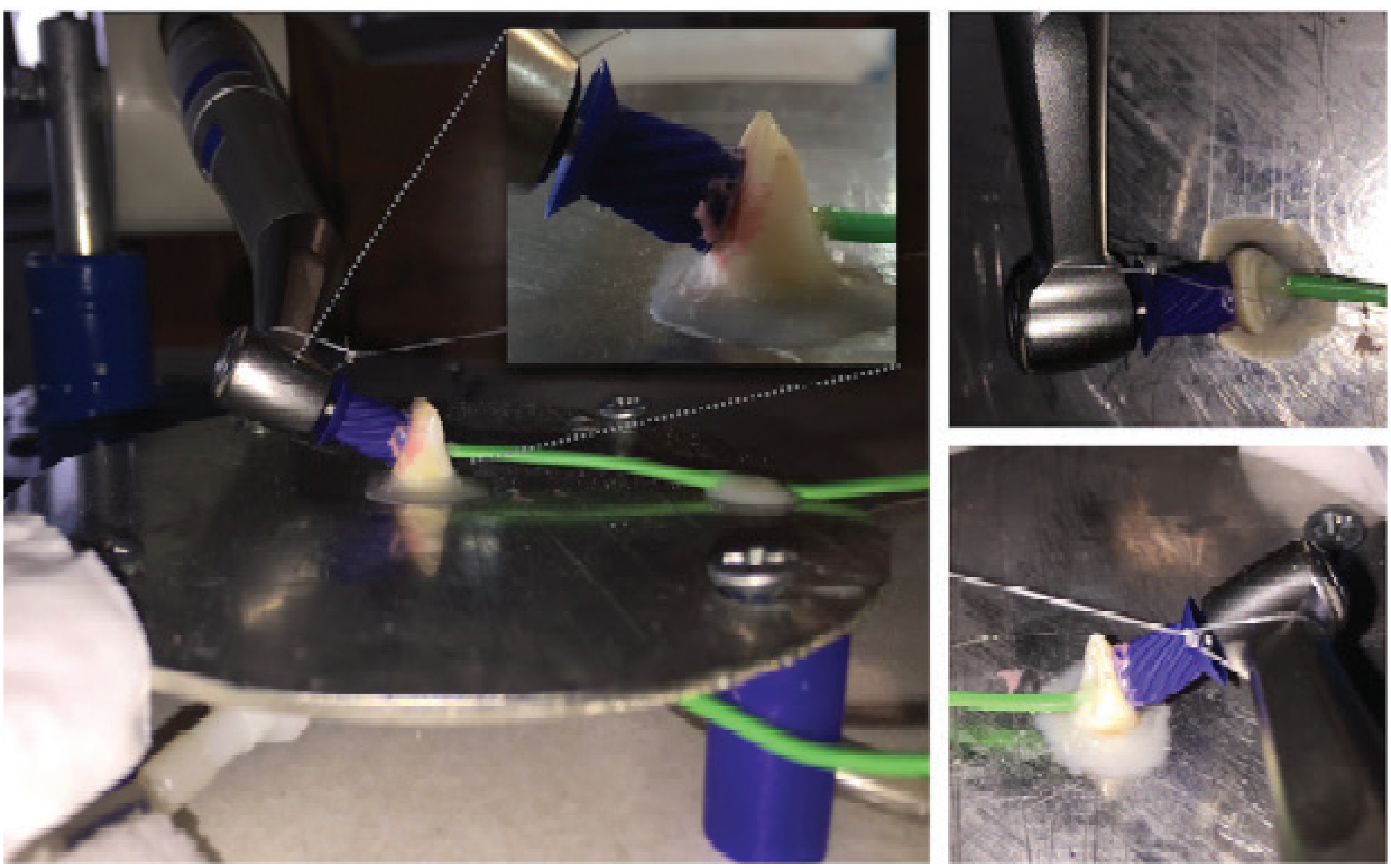

Figure 2. Representative photo of the PBMM set-up and the placement of the test material

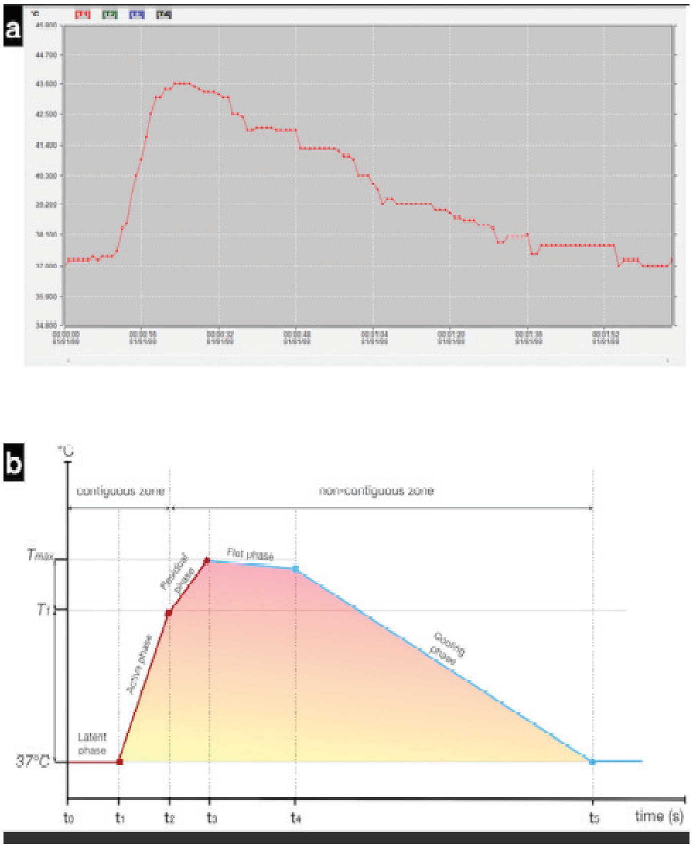

Figure 3. A representative time-temperature plot pastless prophy group at low-load mode (top). The time-temperature plot depicting 5 phases of a single test (bottom): Latent phase: The operation (contiguous zone) is launched, but the energy transfer is not sufficient to rise in the intrachamber temperature (t0-t1). Active phase: The operation (contiguous zone) is continuing until the application is finished (t1-t2). Residual phase: After the application is completed, the intrachamber heat increase (T1-Tmax) still maintained by the transferred energy (non-contiguous zone) (t2-t3). Flat phase: The phase is between the max. temperature value(Tmax) and the transition to the cooling phase (non-contiguous zone) (t3-t4). Cooling phase: The increased intrachamber temperature returns back to physiological temperature (non-contiguous zone) (t4-t5)

Table 2. The mean and standard deviation of Δt (°C) of groups at 10-second and the number of specimens exceeding 5.6°C (threshold level)

Groups	Mean ± SD	Number of specimens exceeding to the threshold level (5.6°C)
PC04	1.36 ± 0.44^a	0
PC08	3.03 ± 0.53^b	0
PP04	6.24 ± 0.72^c	8
PP08	7.11 ± 0.67^c	10
PBN04	0.25 ± 0.07^a	0
PBN08	0.97 ± 0.15^a	0
PBS04	1.13 ± 0.33^a	0
PBS08	2.81 ± 0.38^b	0

Means sharing the same letter are not significantly different (P>0.05)

RESULTS

The highest average was measured in PP08 (7.11°C), while, the lowest average was measured in PBN04 (0.25°C). Bonferroni corrected Wilcoxon paired two sample test analysis revealed a significant difference among the groups (P<0.0001). Mean with SD of the Δt values and the significant differences (°C) are summarized in (Table 2).

Regardless of material groups, higher loading generated higher Tmax values. However, these differences were only significant in PC04 and PBS04 (P<0.0001).

DISCUSSION

Smooth enamel surface is essential factor for maintaining the health of dental and periodontal tissues (10). Prophylaxis regime-related average temperature changes was presented in this study. Prophy cup without paste was mostly exceeded the threshold level (5.6°C) and therefore, the first null hypothesis was rejected. The second null hypothesis was also rejected, given that the vigorous application pressure increased the intrachamber temperature.

Previous thermal monitoring studies for dental materials have used different in vitro designs to simulate in vivo conditions (5,11,12). A previously described PBMM model was used in present study due to include a heat stabilizer for preventive cooling under the physiologic temperature and the water circulation flow rate was set at 0.026mL/min (4,13).

According to manufacturers' recommendation, Pasteless Prophy™, Pro-Cup™ and Pro Brush™ are recommended to use ≤5,000 rpm speed. However, there is no available data neither exact speed nor the amount of applied pressure for prevention the heat-related problems. To prevent heat-related problems, previous reports have recommended intermittent and slight application pressures at low speed. Therefore, we set the speed parameters at 2,400rpm and application pressure parameters at 0.4N and 0.8N.

The data were normally distributed. However, the standard deviations were originated from anatomical differences among the teeth samples (14). The thickness and composition of enamel is variable (15). The polishing brushes with natural bristles yielded the lowest average temperature values after 10s. It can be explained by the minimum contact on the surface caused minimum frictional force-related heat energy transfer.

The cups used with prophylaxis paste generated low temperature the threshold level whereas, the pasteless cup were mostly exceeded at the threshold level (5.6°C) in this study. The highest data were obtained in the pasteless cup in both loading modes. The mean values of the pasteless cup were over the threshold level, that may rise the heat-related irreversible pulpitis risk. It is probably explained that the margins of the pasteless cup was direct contact to the enamel surface causing more frictional force generation when the prophy paste was absent. Furthermore, the specific non-latex structure of the material might be transferred into the pulp chamber in a shorter time than in the other groups. Although the pasteless application is recommended by its manufacturer, the use of prophylaxis paste makes the surface slippery and reduces the contact between the surfaces. Authors recommended that if the practitioner or hygienist desires to use pasteless cups in their dental hygiene applications, they should use any cooling strategy to reduce the risk of pulp damage.

The threshold level was demonstrated as ≥ 5.6°C in this study. The reproduced threshold data was reported in the previous study (7). Furthermore, above the 41.5°C has been reported as the critical limit for pulpal fibroblasts survival (8) and the pulpal blood flow rate rises if the intrachamber heat rises at > 43°C, finally the pulp microcirculation surcease irreversibly if the intrachamber heat rises at > 49°C (9).

The present study showed that pasteless cups had exceed the threshold level at 2,400 rpm after 10s application. Thus, they must be used under intermittent and slight pressures for cooling at low-speeds to reduce the risk of pulp damage.

Rotational speeds variations and intermittent loadings, or cooling strategies, can be evaluate the intrapulpal temperature in further studies.

CONCLUSION

Several conclusions can be drawn within the limitations:

1- Naturel-bristled prophy brushes generated the lowest intrachamber temperature.

2-Prophy cup without paste generated the highest intrachamber temperature thus, the risk of pulp damage might be increased during its usage.

3-Vigorous application pressure increased the intrachamber temperature.

Competing interests: The authors found that the conflict of interest did not fully coincide.

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Ihsan Furkan Ertugrul ORCID: 0000-0001-7583-6679

Ekim Onur Orhan ORCID: 0000-0002-8755-2558

REFERENCES

1. Westfelt E. Rationale of mechanical plaque control. J Clin Periodontol 1996;23:263-67.
2. Handleman SL, Hess C. Effect of dental prophylaxis on tooth-surface flora. J Dent Res 1970;49:340-5.
3. Madan C, Bains R, Bains VK. Tooth polishing: Relevance in present day periodontal practice J Indian Soc Periodontol 2009;13:58-9.
4. Ertugrul IF, Orhan EO, Yazkan B. Effect of different dry-polishing regimens on the intrapulpal temperature assessed with pulpal blood microcirculation model. J Esthet Restor Dent 2019;31:268-74.
5. Kodonas K, Gogos C, Tziafa C. Effect of simulated pulpal microcirculation on intrachamber temperature changes following application of various curing units on tooth surface. J Dent 2009;37:485-90.
6. Ozturk B, Usumez A, Ozturk AN, et al. In vitro assessment of temperature change in the pulp chamber during cavity preparation. J Prosthet Dent 2004;91:436-40.
7. Zach L, Cohen G. Pulp response to externally applied heat. Oral Surg Oral Med Oral Pathol 1965;19:515-30.
8. Schubert L. Temperature measurements in teeth using the light beam galvanometer during grinding and drilling. [in German] Zahnärztl Welt 1957;58:768-72.
9. Raab WH, Müller H. Temperature-dependent changes in the microcirculation of the dental pulp. Dtsch Zahnarztl Z 1989;44:496-7.
10. Quirynen M, Marechal M, Busscher HJ, et al. The influence of surface free energy and surface roughness on early plaque formation. An in vivo study in man. J Clin Periodontol 1990;17:138-44.
11. Ramoglu SI, Karamehmetoglu H, Sari T, et al. Temperature rise caused in the pulp chamber under simulated intrapulpal microcirculation with different light-curing modes. Angle Orthod 2015;85:381-5.
12. Sarı T, Celik G, Usumez A. Temperature rise in pulp and gel during laser-activated bleaching: in vitro. Lasers Med Sci 2015;30:577-82.
13. Baik JW, Rueggeberg FA, Liewehr FR. Effect of light enhanced bleaching on in vitro surface and intrapulpal temperature rise. J Esthet Res Dent 2001;13:370-8.
14. Kim D, Park SH. Effects of age, sex, and blood pressure on the blood flow velocity in dental pulp measured by Doppler ultrasound technique. Microcirculation 2016;23:523-39.
15. Arola D, Ivancik J, Majd H, et al. Microstructure and mechanical behavior of radicular and coronal dentin. Endodontic Topics 2012;20:30-51.