

# The effect of different polishing methods and composite resin thickness on temperature rise of composite restorative materials

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## Abstract

**Background and Aim:** Along with improvements in esthetics and longevity of restorations, finishing and polishing, can produce potentially injurious temperature rise within the pulp chamber. The purpose of the current study was to find whether different polishing methods and thickness of composites have any effect on temperature rise of composite restorative materials.

**Materials and Methods:** Sixty composite resin specimens 9 mm in diameter were prepared and assigned to three experimental groups with three sample thicknesses (2, 3 and 4mm). Each group was divided into four subgroups randomly. Polishing in subgroups 1 and 2 (continuous and intermittent dry polishing) and subgroups 3 and 4 (continuous and intermittent wet polishing) was carried out with a slow speed contra-angle hand piece at a medium speed for 120 seconds in a roll on motion. Immediately after polishing, temperature was measured on the top and bottom surface of each sample using a laser thermometer. One and two way ANOVA, Duncan, and paired t-test were used to analyze the data.

**Results:** The mean temperature rise after polishing in different methods was significant; continuous dry polishing produced the maximum temperature rise. In addition, increasing the thickness of composite resin up to 4mm did not significantly affect thermal transfer from the top surface to the base during polishing.

**Conclusion:** Copious use of water coolant during finishing and polishing procedures is considered a simple and effective method for pulpal protection. Increasing the thickness of composite resin does not have a significant role in compensating the heat generated during polishing procedure.

**Key Words:** Composite resin, dental polishing, thermal transfer

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## Introduction

Composite resins are the main esthetic restorative materials currently in use. Tooth-colored restoration esthetics depend largely on finishing of these restorations [1]. Finishing process is removal of portions of restoration to achieve the right form and anatomy, but polishing that follows, is considered to eliminate coarseness created by finishing

tools. Restoration surface roughness causes plaque accumulation, leading to gingival inflammation and creation of secondary caries, as well as staining of the composite surface [2]. Besides esthetics, the polished surface prolongs restoration life and increases oral tissue compatibility [3, 4]. Polishing composite resins may damage the pulp due to increased temperature. Studies indicate a pulp cham-

ber temperature rise by 4°C in 30 seconds of high-speed cavity preparation [5]. Initial studies on the effect of thermal agitation on pulp showed that an increase of 5 to 6 °C can cause an irreversible damage to a healthy pulp [6]. Other studies revealed that any temperature over 43 °C causes increased blood circulation in the pulp, and temperatures over 49 °C may irreversibly damage the pulp [7]. It has been proved that the amount of remaining crown plays an influential role in pulp temperature increase following any temperature rise on the composite restoration surface due to polymerization or polishing processes [8]. A significant temperature rise occurs due to friction during polishing process. High-speed sand paper discs or rubber caps are used dry, which can produce sufficient temperature rise to damage the pulp [9]. This study aims to investigate the effect of coolant and continuous and alternating pressure exerted by the fine and ultra-fine polishing discs on the surface temperature rise during finishing and polishing restorative materials. Furthermore, we aim to find if the thickness of restorative composites affects heat transfer created during polishing because the reduced thickness of remaining crown naturally means use of thicker restorative material.

### Materials and Methods

This was an experimental study, in which a total of 60, 9mm wide composite discs in 3 different thicknesses of 2, 3, and 4 mm (20 discs of each thickness) were prepared. The composite material was a hybrid composite (Valux plus A2 shade, 3M ESPE, St Paul, MN/UA). To prevent formation of non-polymerized layer and to create a smooth surface on the samples, a glass slab and slide (1 mm thick) were positioned underneath and above the mold. The mold was placed on a glass slab and using a dressing spatula, small pieces of composite were put inside the mold, and the composite was packed from one side to prevent bubble formation. When the mold was sufficiently filled with composite, a slide was placed on top and pressed down. The set was cured for 20 seconds on each side (top and bottom) using a light curing unit (LED light

curing unit, Apoza-Turbo/Taiwan). The tip of curing unit was in contact with glass slab and exactly on the composite part inside the mold. Diameter of the curing unit head was the same size as that of the samples (9 mm). All samples were cured by the same curing unit to maintain homogeneity. The intensity of light radiation of 400 mW/cm<sup>2</sup> was measured by a light-meter set (LED, light meter, Apoza, LCM 1000). The bottom surface of the composite disc was marked by a marker. Then, the discs were placed in distilled water at 37 °C for 24 hours to complete final polymerization of the composites and preserve the best physical properties. After 24 hours, the top and bottom surface temperatures were measured using an accurately calibrated digital laser thermometer with a range of 0 to 50 °C (Digital thermometer, Scan Temperature 485, Dostman Electronics). This unit measures the temperature of a point or surface of an object with a laser beam. Therefore, the laser focal point was precisely adjusted onto the composite disc center and the temperature reading was recorded.

The samples were polished by fine (blue) and ultra-fine (cream) Bisco discs (Bisco finishing disks, fine and ultra-fine/INC, USA), and a slow-speed hand-piece (low-speed contra-angle hand piece, NSK/Japan). For each sample, one Bisco disc was used, and surface speed was set at 15000 rpm. The polishing disc was moved across all points on the surface, but did not remain more than 10 sec on one point). All samples were polished for a two-minute complete cycle (120 seconds), closely simulating clinical conditions, using fine disc for 60 seconds followed by ultra-fine disc for a further 60 seconds. At the time of polishing, discs were held by rubber insulated forceps. All four polishing methods were used for each thickness (to control variability, one person carried out this task).

The first sub-group (dry continuous polish): Each sample was dry-polished at continuous pressure.

The second sub-group (dry intermittent polish): Each composite sample was polished intermittently (4, 15-second polishing cycles, with 10 second pause between each).

The third sub-group (wet continuous polish): Each

sample was polished under constant pressure in presence of water. An assistant poured ample water at constant speed with a syringe during polishing cycle (the cooling water was at room temperature of 23-24 °C).

The fourth sub-group (wet intermittent polish): As in the second sub-group, but with water. Soon after finishing the polishing cycle, the top and bottom surface temperatures of the composite discs were measured. These temperatures were also measured in the interval between fine and ultra-fine discs.

The SPSS-18 software was used for data analysis, and  $P < 0.05$  was considered significant. To compare mean temperature rise in different polishing methods, one-way analysis of variance test and Duncan motivational test were used. To assess the simultaneous effects of thickness of samples and polishing method, two-way variance analysis was used, and to compare mean temperature rise in two different polishing disc roughnesses, the independent t-test was used.

## Results

The highest temperature rise was associated with the dry-continuous polishing method ( $45.6 \pm 5.2$ ), and the least temperature rise was associated with wet-intermittent polishing method ( $22.5 \pm 1.4$ ). The variance analysis test with repeated observations (repeated measure ANOVA) showed that the change in surface temperature (top or bottom) of samples after polishing (compared to before polishing) in the dry-continuous and dry-intermittent methods was significant, but in the wet-continuous and wet-intermittent methods, the change in temperature

was insignificant. Based on the Duncan test, comparison of the 4 polishing methods showed that dry-continuous polish produced the highest temperature change on the surface of composite ( $19.8 \pm 5.4$ ), and the second highest change belonged to dry-intermittent polish ( $15.1 \pm 4.5$ ). The change in temperature in the other two methods was insignificant. Therefore, polishing method did affect the level of temperature increase ( $P < 0.001$ ). According to table 2, the highest top-bottom temperature difference was in the 4 mm composite disc with dry-continuous method ( $3.1 \pm 1.2$  °C), and the lowest top-bottom temperature difference was in the 2 mm thick composite disc with wet-continuous method ( $-0.4 \pm 0.7$  °C). The two-way variance analysis test revealed that the composite resin thickness did not affect heat transfer from the top to bottom of the disc during polishing ( $P = 0.62$ ). In other words, the temperature difference in different thicknesses was insignificant. As can be seen in chart 1, with increasing composite resin thickness, the top-bottom temperature difference increases in different polishing methods (especially in dry methods). In other words, with increasing thickness, the transferred temperature to the bottom decreases, but the difference is not statistically significant.

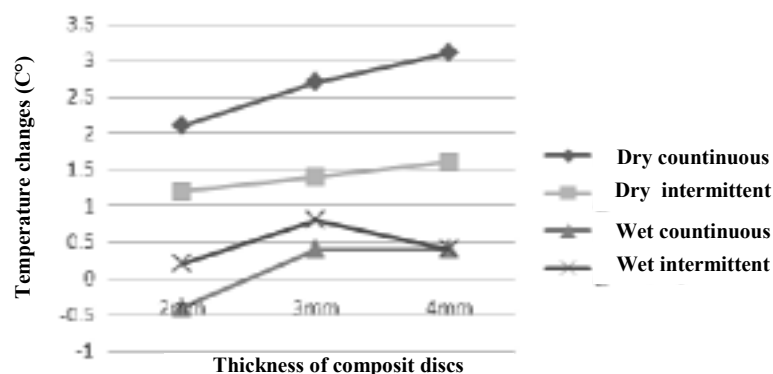
The paired t-test showed that the fine disc created a higher temperature rise than the ultra-fine disc. For example, in dry-continuous method, fine disc caused 18.1°C change in initial temperature, but the change due to ultra-fine disc was only 1.8°C following fine disc polish. However, these changes were not significant in wet methods (table 3).

**Table 1:** Composite disc top-bottom temperatures before and after different polishing methods

Polishing method	Top surface temperature before polishing		Top surface temperature after polishing		Bottom surface temperature before polishing		Bottom surface temperature after polishing	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Dry-continuous	25/8	1/1	45/6	5/2	25/7	1/3	42/9	4/6
Dry-intermittent	25/5	1/4	40/7	4/3	25/5	1/2	38/9	3/9
Wet-continuous	24/3	0/9	22/6	0/9	23/8	0/9	22/2	1/1
Wet intermittent	23/4	1/7	22/5	1/4	23/1	1/7	21/8	0/9
P	0/2		<0/001		0/3		<0/001	

**Table 2:** Composite disc mean top-bottom temperature difference after fine-disc polish

Polishing method	2		3		4		All thicknesses	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Dry-continuous	2/1	3/5	2/7	5/6	3/1	1/2	2/6	3/6
Dry-intermittent	1/2	1/2	1/4	1/3	1/6	1/8	2/1	1/4
Wet-continuous	-0/4	0/7	0/4	0/2	0/4	0/4	0/1	0/7
Wet-intermittent	0/2	0/3	0/8	0/4	0/4	0/3	0/5	0/4
Total methods	0/8	1/9	1/3	2/8	1/4	1/5	1/1	2/1

**Chart 1:** Comparison of top and bottom temperature of the composite after polishing**Table 3:** Mean temperature difference before and after different polishing methods with fine and ultra-fine discs

Polishing method	Surface temperature before polish		Surface temperature after fine polish		Surface temperature after ultrafine polish	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Dry-continuous	25/8	1/1	43/8	5/4	45/6	5/2
Dry-intermittent	25/5	1/4	38/7	2/9	40/7	4/3
Wet-continuous	24/3	0/9	22/9	0/9	22/6	0/9
Wet-intermittent	23/4	1/7	22/6	1/1	22/5	1/4
Total	24/8	1/6	31/9	9/9	32/9	11/1
P	0/2		<0/001		<0/001	

## Discussion

An issue closely associated with esthetics of tooth-colored restorations is surface finishing. This is potentially accompanied by pulp temperature rise. Temperature rise through an external source could increase pulp chamber temperature, leading to irreversible pulp damage [10]. In this study, the effects of different polishing methods and different composite thicknesses on restorative material temperature rise were investigated.

Zach and Cohen [6], reported any increase in temperature over 42 °C could cause irreversible damage to the pulp. Also, Raab et al. study [11] showed that temperatures under 31°C reduce, and temperatures over 43 °C increase blood circulation, and temperatures higher than 49 °C irreversibly destroy pulp blood circulation. In this study, temperature rise over 42 °C occurred in the dry polishing method. But in the wet polishing method, temperature rise was less than 42 °C. Therefore, an

increase in temperature due to polishing could be compensated by cooling. The highest recorded temperature in this experiment was associated with dry-continuous polish that elevated the surface temperature to 53.7 °C.

In a study by Watts [12, 13], it was stated that composites with 70% filler of radiopaque inorganic silica have lower heat transfer, close to that in enamel and dentin. But some have higher heat transfer and require liner material. Although the volume percentage of filler (silica, and Zirconium) in the composite used in this study was 66%, and according to Watts' study, it should have had low heat transfer, statistically, no obvious reduction in heat transfer was observed with increasing thickness of the composite resin. The discrepancy may have been due to different amounts of silica in the composites (compared to other fillers).

According to the results obtained by Van Amerongen [14], in continuous polishing of the amalgam, or during higher rotational speeds, the pulp reaches temperatures in excess of 20 °C in 30 seconds, and this temperature rises further with increasing rotational speed of the polishing disc. This study also showed that polishing amalgam restorations without cooling always leads to increased pulp temperature. Pulp temperature is reduced with application of cooling and alternating pressure by 9 °C, and with constant pressure, by 4 °C. However, in this study, 120 seconds of dry-continuous polishing produced a 19.8 °C temperature rise on the composite surface. This was due to higher specific heat capacity of the composite compared to amalgam.

In his study, Stewart [15] reported restorative amalgam polishing creates the highest temperature rise, but composite and glass ionomer were not different from untreated tooth. Also, polishing with constant pressure produces higher pulp temperature rise than with alternating pressure. This may be due to less contact of the polishing disc with restoration surface with alternating pressure. However, in this study, the sum of cycle time was also considered 120 seconds with intermittent pressure.

Therefore, the 10 seconds of pause is effective in reducing surface temperature.

Briseno [16] reported that the maximum continuous polishing speed of 4000 rpm must be used without cooling. Nonetheless, the speed could confidently rise to 10000 rpm with cooling and constant pressure. Also, in Daniel's study, the least temperature rise was obtained with cooling and alternating pressure. In addition, rougher discs generated more heat (higher temperature rise) than smoother, finer ones. The 4000 rpm is the safest speed for finishing composites without cooling, and speeds higher than 6000 rpm produce pulp temperature rise in the range of 41.6 °C that may be damaging. According to the results of this study, speeds of 15000 rpm, with cooling may be used without excessive temperature rise.

Antonson et al. [18] stated that constant pressure produces higher temperatures in both polishing methods of PoGo and EP. In Antonson study, polishing time of 30 seconds with fine disc and 30 seconds with super fine disc were considered, with less change in temperature compared to this study. Therefore, longer polishing and prolonged application of polishing disc to the surface cause higher temperature rise. Furthermore, polishing method also affects temperature rise during polishing.

According to Uysal [19], angled hand-piece, at high speed and no coolant had the highest temperature changes during adhesive removal. Thus, ample coolant must be present to avoid excessive pulp temperature rise. Also, based on Madhavan's results [9], dry polishing at speeds higher than 5000 rpm is not recommended, and if imperative to use dry polishing, then, alternating pressure at lower speeds must be used. To protect pulp vitality, use of water and intermittent pressure in any restorative work is necessary. In this study, too, use of coolant was effective in controlling temperature rise.

In his study, Singh reported that there was a significant difference in temperature rise between dry and wet polishing. In addition, there was a significant correlation between temperature rise and thickness of the remaining dentin in dry-

intermittent polishing, and it was depended to the application time of discs. Also, the thickness of the remaining dentin plays an important role in control of temperature rise in restoration polishing.

According to Matalon [20], there was a reversed relationship between material thickness and the measured thermal conductivity, and tip of the light cure unit distance to the restorative materials. Different composite resins have different thermal conductivities. As opposed to this study, Matalon regarded thickness effective in thermal conductivity during curing. But these differences could be due to the type of composites used.

Despite the clear temperature rise during polishing, in this experimental study, temperature increase or decrease, slow or rapid, may not accord with damages to real pulp in clinical conditions. Based on this study, the simple and effective method for protection of pulp during finishing and polishing processes is use of ample water. Maintaining remaining dentin under composite restorations is more important than increasing composite thickness (as heat insulator).

## Conclusion

Use of coolant limits temperature rise in fine and ultra-fine polishing discs. Therefore, wet polishing produces the least temperature rise. Intermittent polishing method is preferred to continuous method, as with application of alternating pressure; less heat is generated compared to constant pressure. Fine discs produce higher temperature than ultra-fine discs. Thus, polishing disc roughness is an important factor in temperature rise. With increasing composite thickness to 4 mm, no obvious change in temperature rise due to polishing was observed. In other words, although composite restorations do act as heat insulators, their effect does not significantly reduce the heat produced during polishing process.

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