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Effect of Preheating on the Surface Roughness of Nanofilled and Nanohybrid Resin Composites: An *In Vitro* Study

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Abstract

Background: Resin composites can have their viscosity reduced and their polymerization altered by preheating; nevertheless, the effect of preheating on surface roughness may be composition-dependent.

Objective: The purpose of this experiment is to determine how preheating affects the surface roughness of resin composites that contain nanofillers or nanohybrids. To evaluate the effect of preheating on the surface roughness of nanofilled and nanohybrid resin composites. **Materials and Methods:** Four groups (n=12) were established based on material and temperature: either preheated to 70°C or at room temperature (24°C). Forty-eight disc-shaped specimens (8 mm × 2 mm) were made from Filtek Z350 XT and Tetric N-Ceram. Using a contact profilometer, we assessed the surface roughness (Ra) after standard grinding and polishing using Sof-Lex disks. We used Tukey's post hoc test (α=0.05) and two-way ANOVA to examine the data. **Results:** The mean Ra was 0.2717 ± 0.0035 µm for the preheated Filtek Z350 XT and 0.2262 ± 0.0034 µm for the room-temperature Tetric N-Ceram. There was a strong relationship between composite type and roughness ($p<0.001$), with Filtek Z350 XT showing greater values than Tetric N-Ceram. There was a slight but statistically significant increase in Ra ($p=0.009$) due to preheating. Preheating had no statistically significant effect on the material. Neither the heated nor room-temperature groups differed significantly when compared using Tukey's method.

Conclusion: Preheating has less of an effect on surface roughness than material composition. Preheating resulted in a minor increase in roughness, whereas Tetric N-Ceram made the polished surface much smoother.

Keywords: Composite preheating; surface roughness; nanofilled composite; nanohybrid composite; profilometer.

Introduction

The ever-improving mechanical and physical qualities, conservative application, and esthetically pleasing resin-based composites have made them the material of choice for tooth-colored direct anterior and posterior restorations. However, material composition and operating variables continue to have a significant impact on their clinical efficacy. Traditional resin composites have a high viscosity, which can make shaping the material to fit inside a cavity more difficult and even cause interfacial flaws and voids to occur. A straightforward method to enhance the handling properties of restorative composites with a high resin content without adding

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more resin to the material is to preheat them before use.

Because it increases molecular mobility within the organic matrix, preheating a resin composite before insertion momentarily reduces its viscosity. A possible benefit of this viscosity reduction is enhanced material flow and adaptability to the cavity's interior surfaces. Compared to resin composites kept at ambient temperature, those that were heated to 60°C had much lower viscosity values, according to Lucey et al. (1). You can speed up the polymerization reaction by raising the temperature just before photoactivation. This makes the monomers and free radicals more mobile and increases the frequency of their collisions. Even with shorter light-exposure times, preheated composites achieved more conversion, as Daronch et al. showed a clear positive association between composite temperature and monomer conversion (2, 3). A number of factors, including the resin-matrix composition, filler loading, filler morphology, heating temperature, and the time passed between removal from the heating device and photoactivation, can affect the effect of preheating, depending on the material (4, 5).

Preheating resin composites may enhance their adaptability, handling, and some features associated with polymerization, but how it affects the surface characteristics after polymerization is still unknown. Because an uneven surface may allow for plaque retention, extrinsic staining, loss of gloss, and degradation of the restoration and opposing teeth, surface roughness is a major predictor of the clinical efficacy of composite restorations. The arithmetic mean roughness value (Ra) is a popular way to measure surface roughness. It quantifies the average deviations of a surface profile from its mean line. Therefore, for direct restorations to be aesthetically pleasing and biologically compatible, it is crucial to achieve and maintain a smooth composite surface.

Both the finishing and polishing processes and the intrinsic formulation of a resin composite contribute to its surface quality. To what extent a material reacts to surface treatment depends on factors such as the inorganic filler's size, shape, hardness, distribution, and proportion, and the quality of the filler-matrix interface (6, 7). Pits, scratches, filler protrusion, and particle dislodgment can result from the differential removal of the harder filler particles and the softer resin matrix during the finishing and polishing processes. Research by Elbishari et al. (8) linked filler properties to the durability of resin composites against abrasive stress and their ability to retain gloss. Similarly, modern nanofilled, nanohybrid, and microhybrid composites varied in surface roughness depending on the material. However, after standardized polishing with Sof-Lex disks, these variations were less noticeable.

Aggregated zirconia-silica nanoclusters and non-agglomerated zirconia and silica nanoparticles make up the nanofilled restorative composite known as Filtek Z350 XT.(9, 10) On the other hand, Tetric N-Ceram is a nanohybrid composite that includes prepolymerized filler particles, barium glass, ytterbium trifluoride, mixed oxide, and other components (11, 12). They may react differently to preheating and have different starting surface roughnesses due to variations in filler architecture and organic matrix composition. Despite employing the same preparation and polishing techniques, composites with different filler systems can nonetheless display distinct surface behaviors, as shown in previous investigations (13, 14).

The existing research on how preheating affects the surface roughness of composites is contradictory. Although the difference was not statistically significant, Elkaffass et al. found that warmed Filtek Z350 XT had a slightly higher mean surface roughness compared to its non-preheated counterpart (5). The surface roughness of warmed and non-preheated specimens of a silorane-based composite differed significantly, according to a different study (15, 16). Because of these contradictory results, it is safe to say that preheating

does not have the same effect on all resin composites. There are a lot of factors that make it hard to compare studies side by side, including variations in heating temperatures, specimen preparation, surface treatment, and measuring procedures.

This *in vitro* study sets out to compare the effects of preheating on surface roughness in two resin composites made with different filler technologies: Filtek Z350 XT, a nanofilled composite, and Tetric N-Ceram, a nanohybrid composite. The samples were polished and finished according to a standard protocol. Finding out whether different types of resin composite have different effects on surface roughness when preheated was another goal of the investigation. We started with three null hypotheses: (1) that preheating wouldn't change the surface roughness of the resin composites we tested; (2) that nanofilled and nanohybrid composites wouldn't differ significantly in surface roughness; and (3) that preheating wouldn't interact significantly with composite type.

Materials and Methods

Study Design

We looked at how surface roughness changed with different types of resin composites and preheating in this in vitro experiment. The study examined two independent variables: the type of resin-composite (nanofilled or nanohybrid) and the preheating condition (room temperature or warmed). As measured in micrometers (µm), the arithmetic mean surface roughness (Ra) served as the dependent variable. This led to the utilization of a 2 × 2 factorial experimental design with four groups.

Materials

We utilized two light-cured resin composites that were the same shade (A2): one was Tetric N-Ceram, a nanohybrid resin composite, and the other was Filtek Z350 XT, a nanofilled resin composite. To keep pigmentation-related variations in light transmission and polymerization to a minimum, we dyed both materials the same hue.

Table 1. Resin composites used in the study

Material	Classification	Principal organic-matrix components	Principal inorganic fillers	Manufacturer
Filtek Z350 XT	Nanofilled resin composite	Bis-GMA, UDMA, TEGDMA, Bis-EMA and PEGDMA	Non-agglomerated silica and zirconia nanoparticles and aggregated zirconia–silica nanoclusters	3M ESPE, St. Paul, MN, USA
Tetric N-Ceram	Nanohybrid resin composite	Bis-GMA, Bis-EMA and UDMA-based dimethacrylates	Barium glass, ytterbium trifluoride, mixed oxides and prepolymerized fillers	Ivoclar Vivadent, Schaan, Liechtenstein

Bis-GMA: bisphenol A-glycidyl methacrylate; UDMA: urethane dimethacrylate; TEGDMA: triethylene glycol dimethacrylate; Bis-EMA: ethoxylated bisphenol A dimethacrylate; PEGDMA: polyethylene glycol dimethacrylate.

Sample-Size Determination

Results from a prior study assessing surface roughness in warmed resin composite (5) informed the determination of the sample size. There were a total of 48 specimens, 12 from each experimental group. We felt this was a large enough sample to draw firm conclusions on the impacts of preheating, composite type, and their interaction.

Experimental Groups

We divided the 48 samples into four equal groups based on the type of resin composite and the preheating setting (n = 12):

- **Group ZR:** Filtek Z350 XT maintained at room temperature.
- **Group ZH:** Filtek Z350 XT preheated to 70°C.
- **Group TR:** Tetric N-Ceram maintained at room temperature.
- **Group TH:** Tetric N-Ceram preheated to 70°C.

We employed a computer-generated randomization sequence to decide the order of surface-roughness assessment and specimen preparation.

Preheating Procedure

Specimen preparation required a minimum of one hour of keeping the resin composites at 24 ± 1°C for the room-temperature groups. We used a calibrated digital thermometer to keep an eye on the room temperature.

The AR Heat Composite Warmer (AR Heat, China) was set to 70 ± 1°C, and the resin-composite syringes were inserted into it for the preheated groups. After turning on the apparatus and letting it reach the temperature we wanted, we inserted the composite syringes. Constant light from the matching temperature indicator denoted that the set temperature had been reached.

We warmed the composite syringes in the apparatus for five minutes. Quickly after taking it out of the warmer, the mold was filled with a consistent amount of composite. For optimal heat retention, the specified curing time was 50 seconds, which was the time between removing the composite from the warming device and starting the light curing process.

We used a calibrated digital thermometer to make sure that after five minutes of preheating, each resin composite actually achieved the temperature that was required for the experimental specimens. Every specimen underwent the identical preheating and transfer times.

Since 68°C was the preheating temperature most commonly employed in earlier studies (1, 2, 5)we figured that, being the closest AR Heat device setting to that, we'll go with 70°C.

Specimen Preparation

Use of a standardized split Teflon mold resulted in the preparation of 48 disc-shaped specimens with dimensions of 8 mm diameter and 2 mm thickness. Placing the mold on top of a flat piece of glass that had a clear polyester strip covering it was the protocol.

Using a non-stick composite-placement tool, the resin composite was filled into the mold in increments of 2 mm. The composite was covered with a second polyester strip, and then a second glass slab was placed on top. Extruding the extra material and creating a smooth surface required 10 seconds of gentle pressure. We kept the polyester strip in place and removed the upper glass slab.

A curing pen-E from Eighteeth, a company in Changzhou, China, was used to photoactivate the specimens through the polyester strip. We ran the curing unit for 20 seconds in the standard P1 mode with an irradiation of 1200 mW/cm².

Straight across from, in the middle of, and touching the polyester strip was the 8-millimeter light-curing tip. It just took one exposure, as the specimens' diameters were identical to those of the light-curing tip. The light-curing tip was consistently aligned with each specimen using a positioning guide.

Using a calibrated dental radiometer, we measured the irradiance of the curing unit before each

specimen was prepared and after every ten specimens. Each session of preparation began with thorough cleaning and inspection of the curing tip.

Thoroughly removing the specimens from the mold and examining them under magnification followed the polymerization process. We excluded and replaced specimens that showed apparent faults such as cracks, voids, incomplete edges, surface contamination, or any other problems. Every specimen had its underside tagged so that we could quantify roughness, polishing, and finishing on the correct surface.

The specimens were kept separately in containers with labels, which contained distilled water, at a temperature of 37 ± 1°C for a period of 24 hours prior to surface treatment.

Surface Standardization

We used a MoPao 160E Metallographic Specimen Grinding and Polishing Machine (China) to standardize the test surface of each specimen after the initial storage time.

Under constant water irrigation, each specimen was wet-ground for 30 seconds with 600-grit silicon carbide abrasive paper at a constant rotating speed of 300 rpm. This process leveled the surface before polishing, removing the resin-rich layer that had formed during polymerization on the polyester strip (13).

The same qualified operator consistently applied uniform light pressure while keeping the specimens perpendicular to the abrasive surface. Each set of five specimens required a new sheet of abrasive paper to keep variations caused by wear to a minimum. After the specimens were surface-standardized, they were gently air-dried and washed with distilled water for 10 seconds.

Finishing and Polishing Procedure

Utilizing the four-stage Sof-Lex Extra-Thin Contouring and Polishing Disk System (3M ESPE, St. Paul, MN, USA), every specimen underwent the identical finishing and polishing procedure.

Coarse, medium, fine, and superfine grit disks were utilized in that order. The manufacturer-recommended rotational speed was used with a low-speed handpiece to apply each disk for 40 seconds. Every specimen followed the same protocol: the same trained operator applied light, intermittent pressure in the same direction of polishing.

So that any remaining abrasive particles wouldn't impact the polishing procedure that followed, the specimens were gently air-dried between disks after a 10-second wash with distilled water. We utilized a fresh polishing disk after no more than five specimens, or sooner if we noticed any evident degradation.

Ultrasonic cleaning in distilled water for five minutes after polishing was performed to remove any remaining polishing residues from the specimens. After that, they were each kept for another day in clean distilled water at a temperature of 37 ± 1°C prior to measuring their surface roughness.

Specimen Coding and Blinding

To protect the confidentiality of the specimens' composite types and preheating conditions, we issued each one a unique numerical identification code. An investigator who was not involved in the surface-roughness measurements carried out the coding procedure. Thus, the profilometer examiner did not know which groups to look at when they were collecting data.

Profilometer Calibration and Verification

We used a Pocket Surf IV Portable Surface Roughness Gage (Mahr Federal Inc., Providence, RI, USA) to measure the roughness of the surfaces. We followed the manufacturer's instructions to calibrate the device using its certified reference specimen before we started taking experimental data.

There was a comparison between the certified Ra value and the value recorded from the reference specimen. When the measured value was within the allowed range from the calibration certificate, we said that the calibration was successful. Before every measurement, the calibration was double-checked.

Following the same technique, additional Filtek Z350 XT specimens were produced and polished. In order to compare their roughness values, researchers looked at old profilometric data for the identical polishing technique and material (13). Calibration with the certified reference specimen was still necessary; this comparison served only as a procedural check.

Surface-Roughness Measurement

Using the Pocket Surf IV contact profilometer, we recorded the micrometer-scale arithmetic mean surface roughness (Ra) of every specimen. Running the instrument with a nominal total traverse length of 5.0 mm and an evaluation length of 4.0 mm required five consecutive cut-offs, each with a cut-off length of 0.8 mm.

A horizontal platform that was both steady and free of vibration was used to place each specimen. We moved the profilometer stylus around the specimen's core region while keeping it perpendicular to the polishing marks' prevailing direction. It was not possible to take measurements that would have gone beyond the boundaries of the specimen.

Each specimen underwent three distinct profilometric measurements. Every time we took a reading, we turn the specimen around about 120 degrees. For each specimen, we took three readings and averaged them to get the representative Ra value.

A single calibrated examiner, who was not aware of which groups were participating in the experiments, conducted all of the measurements in a controlled setting. Instead of considering each profilometer trace as a separate unit, the statistical unit was the specimen itself.

Examiner Reliability

The examiner measured the surface roughness of five extra specimens (not part of the primary study) twice before taking the final measurements. A 48-hour gap followed the second round of measurements.

A measure of intra-examiner dependability was the intraclass correlation coefficient. Acceptable measurement reliability was defined as a coefficient of 0.90 or higher.

Statistical Analysis

To conduct the statistical analysis, we utilized IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA).

For every set of data, we derived certain descriptive statistics, such as the average, standard deviation, minimum, maximum, and 95% CI. In the absence of a proven mistake in specimen preparation or measurement, potential outlier results were considered using box plots.

Using the Shapiro-Wilk test and visual inspection of Q-Q plots, we checked if the data distribution was normal. Using Levene's test, we checked for variance homogeneity.

We utilized a two-way analysis of variance to assess the major effects of preheating condition, resin-composite type, and the interaction between the two on surface roughness.

We used Tukey's honestly significant difference test with correction for multiple comparisons to conduct pairwise comparisons when we found a statistically significant main or interaction effect. Where applicable, we gave effect sizes together with 95% confidence intervals. The level of significance was determined to be $\alpha = 0.05$.

Ethical Considerations

Human subjects, extracted teeth, biological tissues, or personally identifiable information were not a part of this in vitro study, which utilized commercially available dental materials. According to the

standards of the linked institution, the study did not require official ethical approval.

Results

Twelve specimens from each experimental group made up the forty-eight specimens used for statistical analysis. The analysis did not exclude any specimens.

Assessment of Statistical Assumptions

The results of the Shapiro-Wilk test showed that the data on surface roughness followed a normal distribution across all of the experimental groups. For Filtek Z350 XT at room temperature (0.774), preheated (0.911), room temperature (0.954), and preheated (0.098) Tetric N-Ceram, the p-values were as follows.

The results of Levene's test showed that the four groups' variances were similar ($F = 0.139$, $p = 0.936$). Hence, two-way analysis of variance met all of its prerequisites.

Descriptive Surface-Roughness Results

Table 2 displays the results for surface roughness descriptiveness. Tetric N-Ceram kept at ambient temperature had the lowest mean Ra value (0.2262 ± 0.0034 µm), while warmed Filtek Z350 XT had the highest (0.2717 ± 0.0035 µm).

Both materials' mean surface roughness increased slightly after preheating. Preheating Filtek Z350 XT caused an increase in the mean Ra from 0.2683 µm at room temperature to 0.2717 µm. From 0.2262 to 0.2283 µm, the corresponding mean for Tetric N-Ceram rose.

Effects of Material Type and Preheating

Table 3 displays the outcomes of the two-way analysis of variance. There was a highly significant relationship between the type of resin composite and surface roughness ($F_{1,44} = 1801.406$, $p < 0.001$, partial $\eta^2 = 0.976$). In comparison to Tetric N-Ceram, Filtek Z350 XT has an overall estimated mean Ra value of 0.2700 µm. Without regard to the preheating situation, Filtek Z350 XT showed noticeably rougher surfaces than Tetric N-Ceram.

The main effect of preheating on surface roughness was similarly statistically significant ($F_{1,44} = 7.454$, $p = 0.009$, partial $\eta^2 = 0.145$). By combining the outcomes of the two materials, the predicted average Ra value rose from 0.2473 µm at ambient temperature to 0.2500 µm after preheating.

There was no discernible interaction between the type of resin-composite and the preheating condition ($F_{1,44} = 0.335$, $p = 0.565$, partial $\eta^2 = 0.008$). This showed that neither Filtek Z350 XT nor Tetric N-Ceram was significantly different from the other when it came to the impact of preheating on surface roughness.

Post Hoc Comparisons

Table 4: Both groups of Filtek Z350 XT showed surface-roughness values that were significantly greater than those of Tetric N-Ceram, according to Tukey's post hoc analysis ($p < 0.001$).

Even though heating the materials beforehand made their numerical mean surface roughness higher, after accounting for multiple comparisons, there was no statistically significant difference between the Filtek Z350 XT at room temperature and after heating (mean difference = 0.0033 µm, $p = 0.104$). Likewise, at both room temperature and warmed Tetric N-Ceram, there was no notable difference between the two (mean difference = 0.0022 µm, $p = 0.434$).

In both temperature conditions, Filtek Z350 XT showed a rougher surface than Tetric N-Ceram. Although both materials saw a minor increase in surface roughness due to preheating, the amount of this effect was similar.

Table 2. Descriptive statistics of surface roughness according to material and preheating condition

Group	Material	Temperature condition	Mean Ra ± SD (µm)	95% CI	Minimum–maximum
ZR	Filtek Z350 XT	Room temperature	0.2683 ± 0.0038[a]	0.2659–0.2707	0.261–0.274
ZH	Filtek Z350 XT	Preheated to 70°C	0.2717 ± 0.0035[a]	0.2695–0.2739	0.265–0.277
TR	Tetric N-Ceram	Room temperature	0.2262 ± 0.0034[b]	0.2240–0.2283	0.221–0.232
TH	Tetric N-Ceram	Preheated to 70°C	0.2283 ± 0.0032[b]	0.2263–0.2304	0.224–0.234

Ra: arithmetic mean surface roughness; SD: standard deviation; CI: confidence interval. Groups sharing the same superscript letter were not significantly different according to Tukey's post hoc test ($p > 0.05$). Groups with different superscript letters differed significantly ($p < 0.001$).

Table 3. Two-way analysis of variance for the effects of material and preheating on surface roughness

Source of variation	Sum of squares	df	Mean square	F-value	p-value	Partial η²
Composite material	0.021931	1	0.021931	1801.406	<0.001	0.976
Preheating condition	0.000091	1	0.000091	7.454	0.009	0.145
Material × preheating	0.000004	1	0.000004	0.335	0.565	0.008
Error	0.000536	44	0.000012	—	—	—

Statistical significance was established at $p < 0.05$.

Table 4. Tukey's post hoc comparisons between experimental groups

Comparison	Mean difference (µm)	95% CI	p-value
ZR vs ZH	−0.0033	−0.007 to 0.000	0.104
TR vs TH	−0.0022	−0.006 to 0.002	0.434
ZR vs TR	0.0422	0.038 to 0.046	<0.001
ZR vs TH	0.0400	0.036 to 0.044	<0.001
ZH vs TR	0.0455	0.042 to 0.049	<0.001
ZH vs TH	0.0433	0.040 to 0.047	<0.001

ZR: room-temperature Filtek Z350 XT; ZH: preheated Filtek Z350 XT; TR: room-temperature Tetric N-Ceram; TH: preheated Tetric N-Ceram.

Discussion

Using a standardized finishing and polishing technique, this study compared the surface roughness of Filtek Z350 XT and Tetric N-Ceram after preheating and different types of resin-composite. Although there was no statistically significant interaction between composite type and preheating, the data showed that both of these parameters considerably affected surface roughness. This led to the acceptance of the third null hypothesis and the rejection of the first two.

The type of resin composite has the most impact on surface roughness. Under both temperature conditions, Filtek Z350 XT showed substantially higher Ra values than Tetric N-Ceram. For Filtek Z350 XT, the average surface roughness was 0.2700 µm, while for Tetric N-Ceram, it was 0.2273 µm. The significant partial eta-squared value for material type (partial $\eta^2 = 0.976$) suggested that variations in the two restorative materials, rather than preheating, were the primary cause of the variation in surface roughness.

Variations in the filler's composition, shape, distribution, and interaction with the resin matrix are the main causes of this discovery. Nanozirconia and nanosilica particles, as well as aggregated zirconia-silica nanoclusters, are present in Filtek Z350 XT. The measured roughness might go up if these nanoclusters become partly separated from the surrounding resin matrix while polishing and grinding. This would cause small depressions to form on the surface. When compared, Tetric N-Ceram's ingredients list barium-glass particles, mixed oxides, ytterbium trifluoride, and prepolymerized fillers. A more consistent finish might have resulted from the fillers' reaction to the polishing abrasives.

The current findings are in agreement with those of Patel et al., who, using standardized polishing processes, discovered that Tetric N-Ceram outperformed Filtek Z350 XT in terms of polishability and surface roughness (17, 18). The scientists concluded that the materials' unique filler systems and how they interacted with the polishing abrasives were responsible for the observed discrepancies. Other research has also found that surface roughness varies depending on the material; thus, it's clear that a composite's nanofilled or nanohybrid status doesn't tell the whole story when it comes to its surface behavior (8, 13, 19).

Obtaining room-temperature roughness levels in the current study was strikingly similar to what Zhang et al. found after polishing using the Sof-Lex disk method (13). The average Ra values for Filtek Z350 XT were 0.269 ± 0.059 µm, and for Tetric N-Ceram, they were 0.225 ± 0.065 µm. The respective values in this investigation were 0.2262 ± 0.0034 µm and 0.2683 ± 0.0038 µm. Consistency between the two studies lends credence to the repeatability of the methods employed in this investigation for specimen preparation, polishing, and profilometric measurements. In contrast to the current study, which demonstrated a substantial material-related difference, Zhang et al. discovered no such difference following Sof-Lex polishing. Differences in sample size, measurement dispersion, material batches, operator pressure, polishing duration, and profilometer settings could be at the root of this discrepancy.

Surface roughness increased little, yet significantly, after preheating. By combining the data from both materials, the mean Ra rose from 0.2473 µm at ambient temperature to 0.2500 µm after preheating. Statistically significant ($p = 0.009$; partial $\eta^2 = 0.145$) was the main effect of preheating, even though the absolute change was just 0.0027 µm. It is important to differentiate between the statistical significance and the extent and possible therapeutic implications of the observed change, according to this result.

Elkaffass et al. found that hot Filtek Z350 XT had a numerically greater surface-roughness value than room-temperature Filtek Z350 XT, but that the difference was not statistically significant (5). This

result goes in the same direction. Similarly, after preheating a low-shrinkage resin composite, Alizadeh Oskoee et al. found that surface roughness increased significantly (15). Eltoukhy et al. found no statistically significant difference between nanoceramic composite specimens that were heated and those that were not (20). Based on these contradictory results, it seems that material composition, heating strategy, surface preparation, and measuring technique all have a role in how preheating affects roughness.

Composites can have their viscosity reduced, and their monomer and reactive radical mobility increased by preheating. This has the potential to boost the rate of polymerization and the amount of conversion (1, 2). However, a more polished surface is not always the result of better polymerization. The filler particle and resin matrix behavior during polishing and finishing is the main factor that determines surface roughness. Changes to the filler-matrix interface tensions and the growth of the polymer network may result from rapid polymerization at high temperatures (21, 22). The resin matrix and inorganic fillers may experience different rates of thermal expansion, which could lead to minute variations at the interface. In spite of a presumably higher degree of conversion, surface imperfections may result from subsequent wear that exposes or dislodges filler particles. Confirmation of these mechanisms would necessitate microscopic and chemical analysis, but they remain plausible explanations.

It is also important to think about how the individual post hoc comparisons compare to the overall ANOVA result. Due to its evaluation of the overall temperature-related change across both materials, two-way ANOVA revealed that preheating had a significant main effect. Nevertheless, following the implementation of multiple comparisons, there was no individual significance in the rise from 0.2683 to 0.2717 µm in Filtek Z350 XT and from 0.2262 to 0.2283 µm in Tetric N-Ceram. So, instead of a large change particular to the material, the results show that preheating has a small, consistent overall effect.

The results showed that the material type and preheating condition did not interact significantly. This meant that both composites had a preheating effect, albeit in different directions and to different degrees. Following preheating, Filtek Z350 XT exhibited a rise of around 0.0033 µm and Tetric N-Ceram of around 0.0022 µm. So, the two materials' surfaces responded similarly to preheating, despite their vastly different total roughness.

In order to distinguish between the effects of preheating and material type, all specimens were ground and polished to the same specifications. To achieve a uniform surface, 600-grit silicon carbide paper was used to remove the top layer of resin that had developed on the polyester strip (23-25). Using the four-step Sof-Lex technique, we were able to mimic the clinical finishing and polishing processes by gradually smoothing out surface imperfections. Additionally, by uniformly applying the polishing regimen to all groups, we were able to exclude any potential confounding factors related to variations in abrasive composition or polishing method.

When analyzing the results, it is important to keep in mind a few caveats. The only variables included in the evaluation were the two resin composites, the preheating temperature, and the finishing and polishing technique. Clinically observed anatomical shapes, accessibility limits, and varied polishing pressure could not be replicated by the specimens, which were flat disks manufactured in a laboratory. We did not submit the specimens to thermocycling, abrasion by toothbrushing, pH fluctuations, or long-term water aging. We could only use the two-dimensional Ra parameter from the contact profilometer for surface evaluation; further parameters and 3D surface analysis would yield much more accurate results. We also did not use scanning electron microscopy to check for surface pits, filler loss, or matrix disruption as potential causes of the observed variations.

Before drawing any conclusions, it is important to keep in mind the following caveats. We only looked at two resin composites, one shade, one preheating temperature, and one finishing and polishing procedure. The specimens were flat disks made in a lab, so they didn't represent the real thing in terms of anatomy, accessibility, or the different levels of polishing pressure that patients actually experience. Not a single one of the specimens underwent any kind of thermal cycling, toothbrushing abrasion, pH fluctuations, or prolonged water aging. Surface evaluation relied on a contact profilometer's two-dimensional Ra parameter; further parameters and three-dimensional surface analysis would yield more comprehensive results. The scanning electron microscopy did not verify that the observed variations were due to matrix rupture, surface pits, or filler loss.

Conclusion

Type of resin-composite and preheating had a substantial impact on surface roughness within the constraints of this in vitro study. Under both temperature conditions, Filtek Z350 XT showed higher Ra values than Tetric N-Ceram. The lack of a statistically significant interaction suggested that the two materials reacted identically to preheating, but preheating to 70°C did raise surface roughness slightly. Preheating had a far smaller impact than the material's formulation.

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