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INFLUENCE OF PREHEATING ON MECHANICAL AND SURFACE PROPERTIES OF NANOCERAMIC RESIN COMPOSITES

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ABSTRACT

Objective: To assess the influence of preheating on microhardness and surface roughness of nanoceramic resin composite.

Methods: Forty disc-shaped specimens of nanoceramic resin composite Ceram X Duo (Dents ply De Trey, Konstanz, Germany) were made using a mold and then randomly assigned into two groups (with and without preheating where n=20). Each group was subdivided according to the test into two subgroups (n=10). Vickers hardness measurements for the top and bottom surfaces of the specimens were evaluated by tester machine and surface Roughness (Ra) was assessed using the Atomic Force Microscope.

Results: Results of both tests showed no significant difference among specimens either preheated or not. Nevertheless, microhardness results revealed significant difference if top surfaces compared to the bottom ones either the specimens were preheated or not. Surface roughness results exhibited no significant difference among the preheated and non-preheated specimens.

Conclusion: Preheating had a certain effect on the mechanical and surface properties of nanoceramic resin composite.

KEYWORDS: Preheating; nanoceramic composite; microhardness; surface roughness

Clinical significance: Preheating can be clinically beneficial for promoting the manipulation, marginal sealing, and surface features of nanoceramic resin composite.

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INTRODUCTION

Resin composite preheating has attained approval by the clinicians to improve manipulation, application and sculpture processes[1]. Also, preheating has a crucial impact on the polymerization process[2] where, high polymerization temperature improves the monomers movability and ameliorates the total conversion. This can be the reason of the development of resin composite properties especially mechanical and surface ones[3].

The mechanical properties of resin composites depend on their composition and microstructure[4]. Appropriate clinical execution and improved mechanical characteristics of resin composites have made them further favorable for restoration of posterior teeth[5]. Regardless of enhanced mechanical characteristics, bulk fracture is believed to be a major failure of resin composite restorations[6].

Clinicians may use the preheating process of resin composite for improving its handling characteristics and mechanical properties[7]. Hence, the mechanical characteristics of resin composite after preheating must be assessed so as to understand the influence of warming on the capability of resin composite to withstand the masticatory forces without fracture.

Preheating results in former investigations were unclear, and sometimes contradictory[8, 9]. Munoz *et al*.[8] showed that resin composites warming may enhance their hardness. However, Osternack *et al*.[9] mentioned that resin composite hardness was not affected by the preheating process.

The accessible information on the influence of the preheating process of resin composite on its microhardness and surface roughness are deficient, and yet indecisive. Subsequently, the goal of this research was to assess the impact preheating of resin composite on microhardness and surface roughness of a nanoceramic resin composite.

MATERIALS AND METHODS

Nanoceramic resin composite Ceram X Duo with shade of A2 (Dents ply De Trey, Konstanz, Germany) (Table 1) was used to fabricate Forty disc-shaped specimens by a Teflon mold with dimensions of 10 mm diameter and 2 mm thickness. These disc-shaped specimens were randomly assigned into two groups (preheated and without preheating where n=20). Each group was subdivided according to the test (microhardness and surface roughness) into two subgroups (n=10).

An appliance known as Therma-flo ™ composite warming kit (Vista, Wisconsin, USA) was used regarding to the manufacturer's guidance for resin composite preheating before application. It was turned on up till it come to 68°C. The resin composite cartridge was put within the heating device for a duration of 5 min to gain the heat of the appliance. After that, the cartridge was brought out and resin composite was put directly within the mold which was applied on a Mylar strip above a glass slab.

Later on, resin composite was capped with one more Mylar strip, compressed by a glass slide for

TABLE (1) Materials used in the study

Restorative System	Manufacturer	Matrix	Filler	Filler Degree
Ceram X Duo	(Dents ply De Trey, Konstanz, Germany)	Methacrylate modified polysiloxane, dimethacrylate resin, fluorescence pigment, UV stabilizer, stabilizer, camphorquinone, ethyl-4(dimethylamino)benzoate	Ba-Al-borosilicate glass, filler (1–1.5 m), silicon dioxidenanofiller (10 nm)	76 Wt%.

forcing out the overflow material and subjected to light-cure unit for 10 s. (Monitex BlueLEX™ GT-1200, New Taipei City, Taiwan). The mold, glass slabs and the mylar strips were heated to 37°C prior the resin composite application. The specimens were finished and polished using Enhance and PoGo kits (Dentsply Caulk, Milford, DE, USA) and then stored in distilled water in an incubator at 37˚C for 24 h.

Microhardness Test

Vickers hardness measurements of the top and bottom surfaces of the specimens were done using microhardness testing machine (Tukon 1102, Buehler, Uzwil, Switzerland) through the application of a load (100 g) for 10 s. Three indentations with interspace of 1 mm were picked for every surface and the mean value was evaluated.

Surface Roughness Test

Surface roughness assessment (Ra) was gained using the Atomic Force Microscope (Autoprobe CP, Thermo-microscopes, Veeco Digital Instruments, Santa Barbra, Calif., USA) in 'contact' mode. Five various regions were chosen to have different images which can be scanned by software (Nanoscope v616r1, Veeco Metrology Group and WSxM 4.0 Develop 11.1, Nanotec Electronica, TreaCantas, Spain) and Ra assessments were demonstrated as the means ± SD.

Statistical analysis

The Shapiro-Wilk test at a=0.05 was used to assure the normal distribution of the results. The collected data was analyzed using independent sample t-test at a=0.05 (IBM SPSS Statistics 21.0 software, IBM Chicago, IL, USA).

RESULTS

Microhardness and surface roughness mean values are mentioned in Tables 2, 3. Shapiro-Wilk test revealed that the results for both tests followed a normal distribution pattern ($p>0.05$). T-tests showed no significant difference among specimens either preheated or not for both tests ($p>0.05$). While, results of microhardness test revealed significant differences between the top surfaces and bottom ones for both groups either preheated or not ($p<0.05$). The preheated specimens showed elevated surface roughness mean values (Fig.1) than non-heated ones (Fig.2) but, no significant difference between them was detected ($p>0.05$).

TABLE (2). Vickers hardness (VHN) mean values (Standard deviations) achieved in non-preheated and preheated modes.

Resin composite		Temperatures	
		Non-heated 24°C	Preheated 68°C
Ceram X Duo	Top	70.19 ± 2.74	70.06 ± 1.77
	Bottom	49.65 ± 5.80	51.27 ± 3.16

The values are shown as mean ± standard deviation.

TABLE (3). Fracture toughness (MPa) mean values (Standard deviations) achieved in non-preheated and preheated modes.

Resin composite	Temperatures	
	Non-heated 24°C	Preheated 68°C
Ceram X Duo	14.39 ± 1.37	15.67 ± 2.13

The values are shown as mean ± standard deviation, MPa: Mega Pascal

TABLE (4) Surface roughness average Ra (nm) mean values (Standard deviations) achieved in non-preheated and preheated modes by AFM.

Resin composite	Temperatures	
	Non-heated 24˚C	Preheated 68˚C
Ceram X Duo	7.05 ± 1.4	9.14 ± 2.06

The values are shown as mean ± standard deviation

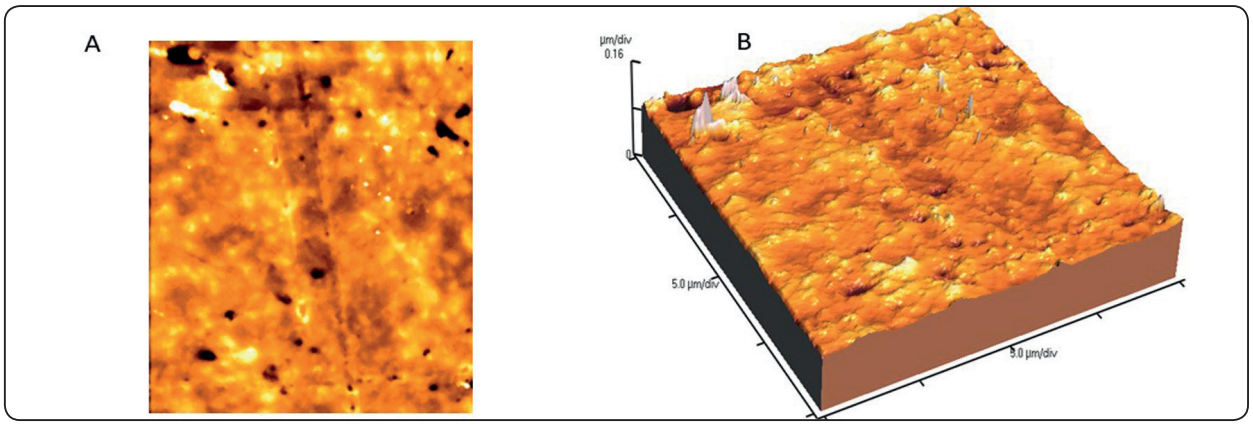

Fig. (1) AFM image of non-heated Ceram X Duo resin composite (A) 2D image; (B) 3D image

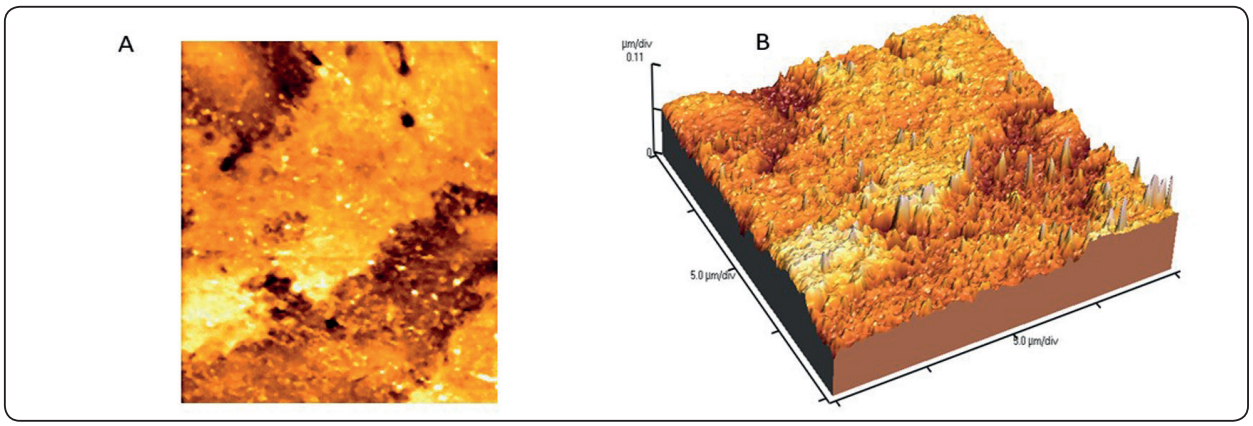

Fig. (2) AFM image of preheated Ceram X Duo resin composite (A) 2D image; (B) 3D image

DISCUSSION

Preheating is responsible for decreasing the viscosity of packable resin composites and giving them additional flowable state to be injected directly into the prepared cavity instead of packing by hand instruments[10] and obtained better mechanical and surface properties[11]. Earlier researches showed that increasing the temperature of resin composite leads to lower viscosity and better hardness[12, 13]. While, the current research revealed that the hardness of nanoceramic resin composite was not influenced by the warming method.

Hardness assessment is a technique for estimation the degree of conversion in resin composite. The top surfaces of the specimens revealed higher microhardness in comparison to the bottom ones, this was due to light was declined because it moved via resin composite during the curing procedure.

Considerable difference was detected in viscosity of various resin composites due to preheating, this can be explained by the great diversity in composition, chemistry and filler load. Increased molecular weight and high ability for hydrogen bonding, resin composite viscosity will be raised[14]. In addition, the chains of polymers converted into further twisted form by raising filler load owing to excess chain extension and forming excess ramifications, leading to elevated viscosity[14]. Furthermore, these barriers can be overcame by warming process through yielding adequate energy so as to allow molecules movement in a minimal drifting manner[14].

Surface roughness results of this research revealed no significant differences among specimens if preheated or not. While, preheated group manifested somewhat higher values. The nanoceramic resin composite involves nanofillers joined with nanoclusters. Nanofillers are separated and non-conglomerated fillers[15]. The nanoclusters raise the filler capacity and physical characteristics of the resin composite. So, the regular allocation of pre-cured particles within the matrix is the cause of not being influenced by the warming process[15].

CONCLUSION

Preheating had a certain effect on the mechanical and surface properties of nanoceramic resin composite.

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