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Original Article

Dentistry Section

Effect of Cigarette Smoke on Surface Roughness of Different Denture Base Materials

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ABSTRACT

Background: Surface roughness is an important property of denture bases since denture bases are in contact with oral tissues and a rough surface may affect tissues health due to microorganism accumulation. Therefore, the effect of cigarette smoke on the surface roughness of two commercially available denture base materials was evaluated to emphasize which type has superior properties for clinical use.

Materials and Methods: A total numbers of 40 specimens were constructed from two commercially available denture base materials; heat-cured PMMA and visible light cured UDMA resins (20 for each). The specimens for each type were randomly divided into: Group I: Heat cured resin control group; Group II: Heat cured acrylic resin specimens exposed to cigarette smoking; Group III: Light cured resin control group; Group IV: Light cured resin specimens exposed to cigarette smoking. The control groups used for immersion in distilled water and the smoke test groups used for exposure to cigarette smoking. The smoke test groups specimens were exposed to smoking in a custom made smoking chamber by using 20 cigarettes for each specimen. The surface roughness was measured by using Pocket SurfPS1 profilometer and the measurements considered as the difference between the initial and final roughness measured before and after smoking.

Results: The t-test for paired observation of test specimens after exposure to smoking was indicated significant change in surface roughness for Group II ($p< 0.05$) but has no significance with Group IV. Otherwise, there were no significant differences with control groups (Group I and III).

Conclusion: The surface roughness of the dentures constructed from heat cured acrylic resin had been increased after exposure to cigarette smoke but had no impact on the dentures constructed from visible light cured resin.

Keywords: Cigarette smoke, Denture base, Eclipse resin, Profilometer, Surface roughness

INTRODUCTION

Since Walter Wright first introduced it in 1937, the heat cured polymethyl methacrylate (PMMA) polymers have referred to as conventional denture base materials and considered the most popular material for non-metallic denture constructions. Its extensive use was due to low water sorption, solubility and cost, as well as, ease of construction of denture bases by simple processing techniques with acceptable physical and mechanical properties. Despite these favourable properties, a growing number of patients are presenting with hypersensitivity reactions to PMMA which induced by the residual methyl methacrylate monomer [1-3]. Recently, a presumably hypoallergenic resin such as visible light activated Urethanedimethacrylate (UDMA) polymers have developed as a denture bases to surpass contact allergies, laboratory vapours and the traditional lengthy lost wax technique which used with the conventional PMMA materials. This system consists of special resin and curing unit that emits high intensity light in the shorter blue wavelength as activated by light in the wavelength range of 460–470 nm [4-6].

Clinically, with any case the denture base material has smooth and highly polished surface for patient's comfort and for more denture longevity, good aesthetic, oral hygiene and low plaque retention [7]. Therefore, the surface roughness is an important property of the denture bases since it is in contact with the buccal tissues and a rough surface may affect tissue health due to microorganism accumulation. These microorganisms are protected from shear forces and oral hygiene measures which may lead to an increase in the prevalence of denture stomatitis, rate of staining, halitosis and discomfort. Therefore, the surface roughness is of a great clinical relevance for dentures success [8,9].

In the oral cavity, the denture base materials were exposed to complex environment that compress harmful endogenous and exogenous compounds which resulting in a biodegradation phenomenon that altering the physical and mechanical properties of the material, one of these is a cigarette smoking. According to the World Health Organization, cigarette smoking is a public health problem reported in almost 1.3 billion people around the world [8,10].

The toxic substances of cigarettes may be in the tobacco plant or produced during its burning. In case of denture wearer's smoker patients, the denture base materials were exposed to thousands of cigarettes toxic substances such as carbon monoxide, formaldehyde, radioactive polonium, ammonia, nickel, arsenic, tar and heavy metals such as lead and cadmium [11]. Previously, many investigators reported that, cigarette smoke can change the colour, alter the microhardness and increase the surface roughness of dental composites, highly cross linked resin teeth and other different types of denture teeth [8,12,13].

Although, not many studies in literature have standardized the manner of subjecting restorative materials to cigarette smoke. Such studies evaluated the effect of cigarette smoke without standardizing the type of equipment used, number of cigarettes, smoke flow and time of the material exposure to the agent [14,15]. Furthermore, literature lacks information regarding the effect of this common harmful oral habit on different types of denture base materials.

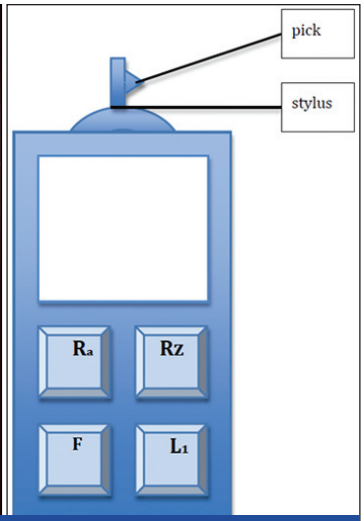
Against this backdrop of information scarcity, this invitro study was undertaken to analyse the impact of cigarette smoke on surface roughness of heat polymerized PMMA and visible light polymerized UDMA. The null hypothesis undertaken was that, cigarette smoking could increase the surface roughness of both types of denture base materials. The resulting foundation insuring that, the surface change of heat cured PMMA materials has occurred but no change with visible light cured UDMA.

MATERIALS AND METHODS

A total numbers of 40 specimens were constructed from chemically different two commercially available denture base materials with a minimum thickness of 2mm to resemble the thickness of the denture base clinically. The first group (Heat cured resin); 20 specimens of heat cured PMMA (Ecocryl, Hot protechno, Girona, Spain, BT 12-26964) were prepared (10x10x2 mm) by investing the wax pattern (10x10x2 mm) in gypsum stone (LabStone, Dentsply) with a conventional flasking procedure in metallic denture flask. After dewaxing, the PMMA material was mixed with its liquid, packed and processed in a thermostatically controlled water bath in accordance with manufacturer's instructions. The water was heated up to 80°C and maintained for 2 hours and then allowed to boil for further 30 minutes. After curing, the flasks were cooled at room temperature before opening.

Another group (Light cured resin); 20 specimens of visible light cured UDMA (Eclipse, Dentsply, New York, USA) were prepared (10x10x2 mm) in well-designed Perspex mold. By finger pressure the light cured resins material was pressed into the mold cavity after applying petroleum jelly and polymerization performed in light cured unit (Eclipse Processing Unit, Dentsply Trubyte) at 400 to 500 nm for 10 minby exposing the sample to visible light [16].

After complete polymerization of both resins types, the specimens were retrieved from the flask for heat cured resin and from the mold for light cured resin then finished by finishing discs and stones using a hand piece at low speed. Furthermore, one surface of each acrylic specimen was finished using 280, 360 and 400 grit abrasive papers (Middle East Factory- KSA) then polished on a wet rag wheel with slurry pumice. All the test specimens were stored in distilled water at 37°C for 48 hours for residual monomer release. After incubation period, the specimens were dried with air and the initial surface roughness (IRa) was measured for the polished surface of all specimens.



[Table/Fig-1]: Surface roughness test **[Table/Fig-2]:** Schematic representation of pocket profilometer with diamond stylus for measuring surface roughness

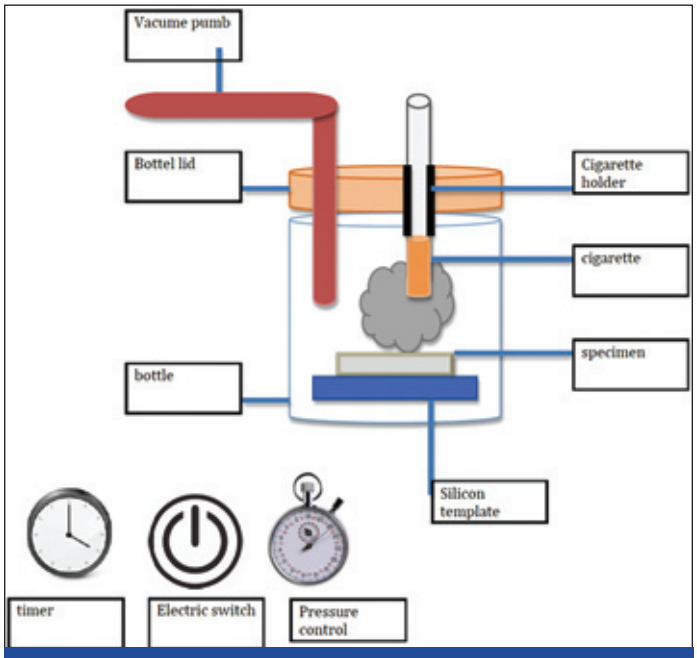
[Table/Fig-3]: Smoking machine assembly fastened in vacuum pump machine

The surface roughness (Ra) values were measured by using a pocket profilometer ((Mar Surf PS1, Mahr, Germaine, version prog v1.01-08). The pocket profilometer can measure small surface variations by moving a diamond stylus across the specimen surface [Table/Fig-1]. The tracing length of the instrument stylus was (5.6 mm) and a cut off (0.8 mm) at speed of (0.5 mm/s) [Table/Fig-2]. The stylus moved across the specimen surface and three scanning lines were recorded with a distance of 1 mm between each scanning line. The mean value for the three readings of the surface roughness was considered the measured surface roughness value (Ra) for each specimen.

After the initial surface roughness was measured, the specimens of both acrylic resins were randomly divided into four subgroups (n= 10) according to the treatment option. Group I: Heat cured resin control group. Group II: Heat cured acrylic resin specimens exposed to cigarette smoking. Group III: Light cured resin control group. Group IV: Light cured resin specimens exposed to cigarette smoking. For both resins type, the control groups (groups I and III) were used for immersion in distilled water at 37°C for another 48 hours and the smoke test groups (group II and IV) were used for exposure to cigarette smoking.

The smoke test group specimens were subjected to smoking in a custom made smoking chamber that simulated the process of smoking invivo. The study was conducted in Alfarabi collage at research unit for one week interval with ethical approval number 249/2015, the consent was obtained. The study was employed the smoking machine developed by the principles of Wasilewski S et al., in order to reproduce (in vitro) the smokers mouth cavity conditions but with some modification [13]. The modifications were done by using smaller size glass jar with silicon template fitting in its bottom to suite and fit only one specimen at a time and prevent the smoke from being dissipated into larger spaces without changing the specimen position, also the device can receive only one cigarette at a time for trying to simulate the clinical condition. In accordance of these principles, the chamber assembly was formed from a glass jar of 20 ml volume tightly closed with a lid. The lid of the jar had two opening passing two silicon tubes, one tube for snugly fit the cigarette and the other tube fastened to a vacuum pump that causes a negative pressure to aspirate the smoke released by cigarette.

The pre-prepared Silicon (Speedex Putty, Coltene/whaledent AG-Switzerland) template was constructed to support one specimen at the time in the center of the bottom of the glass jar. For the test procedure performance, the specimen was placed in the jar fitted in its site of template as the polished surface come in direct exposure to cigarette smoke then, the lid was locked and the cigarette was snugly fitted in its tube until 10mm distance from specimen surface. Then the machine



[Table/Fig-4]: Schematic representation of smoking machine

was assembled in vacuum pump machine with another tube after adjusting the negative pressure (20 mm Hg; 1 mm Hg = 133 Pa) for cigarettes (Marlboro, Phillip Morris, Germany) smoking [Table/Fig-3].

For each specimen exposure, 20 cigarettes were used and each cigarette burned in a standard time of 10 minutes. The aspiration time/pressure was controlled and programmed with a switch pressure and timer of the vacuum machine [Table/Fig-4]. After that, the specimen was removed, washed with distilled water and dried with air then, the final surface roughness (FRa) was measured by using the profilometer as before exposure to smoking, as well as, for the control group's specimens that incubated in distilled water. Changes in the surface roughness were calculated by the difference between the initial (IRa) and final (FRa) measurements found before and after smoking test of the samples, respectively. The data was collected and statistically analysed according to the paired sample t-test.

STATISTICAL ANALYSIS

The mean value and standard deviation of initial and final surface roughness (Ra) for studied groups were calculated using descriptive data analysis. The data collected from the different groups were analysed by using the paired sample t-test at a predetermined significance level of $p< 0.05$. All statistical comparisons were made with reference to the control groups and not to each other.

RESULTS

The mean values and standard deviations of the initial (IRa) and final (FRa) surface roughness measurements of the tested groups were showed in [Table/Fig-5].

Type of resin	Sub-groups	IR_a value (µm)	FR_a value (µm)	ΔR_a Values (µm)	p-value
Heat cured PMMA resin	Group I	0.137 (0.024)	0.138 (0.025)	0.001 (0.047)	0.968**
	Group II	0.135 (0.026)	0.168 (0.021)	0.033 (0.041)	0.032*
Light cured UDMA resin	Group III	0.114 (0.034)	0.115 (0.035)	0.001 (0.033)	0.912**
	Group IV	0.115 (0.035)	0.135 (0.021)	0.020 (0.032)	0.08**

[Table/Fig-5]: The Mean values and standard deviations of the initial (IRa) and final (FRa) surface roughness measurements of the tested groups

*Denotes significant difference ($p< 0.05$)
**Denotes no significant difference ($p>0.05$)

The paired sample t-test was showed that, there were a significant differences in surface roughness between Group I and II, (0.968 and 0.032) respectively, ($p<0.05$). Otherwise, there were no significant differences in surface roughness between Group III and IV, (0.912 and 0.08) respectively, ($p>0.05$).

According to the statistical analysis, there were significant changes in surface roughness of the heat cured PMMA specimens that have exposed to smoking test but no impact significance with visible light cured UDMA specimens. Otherwise, there were no significant changes in surface roughness with group I and group III specimens that were inserted in distilled water (control groups).

The same statistical test for Group II and Group IV comparison revealed that, cigarette smoking increased the surface roughness of heat cured type resin more than light cured type resin but had no impact significance for them.

DISCUSSION

The effect of cigarette smoking on the surface roughness of two chemically different denture base resins was evaluated with this study and the hypothesis that, cigarette smoke will increase the surface roughness of both types of denture resins could be partially supported. It has known that, the surface roughness of the denture base materials is one of the physical properties that may be changed because of surface degradation and considered as one of the determinant factors in the clinical longevity of the dental prosthesis [13,17].

Many techniques of polishing can be performed to reduce surface roughness of heat and light cure denture base materials through mechanical or chemical methods. Mechanical polishing is the conventional method performed by using abrasives, that causes controlled wear of the surface material, to reduce surface roughness. Alternatively, chemical polishing is performed by placing the finished acrylic resin denture in a chemical polisher containing heated monomer at 75°C for 10 s [18-20].

The clinical threshold value of surface roughness (Ra) for plaque retention on intraoral materials was 0.2 µm as advocated by Bollen C et al., [21]. In accordance, below a value there was no further reduction in plaque accumulation was expected but above it, a proportional increase in plaque accumulation occurs [20]. Therefore, smooth polished surface of a denture base material is highly recommended.

The findings of this study were revealed that, the exposure of the PMMA specimens to cigarette smoke increased the surface roughness values, this may be attributed to the deposition of cigarette substances on the surface of the acrylic resin specimens. As when burning the cigarette, the resultant smoke contains multiple components, such as carbon monoxide, carbon dioxide, nicotine, ammonia, nickel, arsenic, tar and heavy metals such as lead and cadmium [10,22]. Another possible explanation may be due to the increase of temperature within the smoking chamber, i.e. the thermal effects of the smoking, as reported in previous study [23].

For further interpretations, the increased roughness of PMMA specimens may be attributed to the adherence of the cigarette substances that cannot be totally removed when washed under distilled water. Therefore, it is recommended to use denture-cleaning agents for effective removal of these deposits, especially in elderly people with reduced manual dexterity. This is in agreement with Ayaz E et al., who found an increase in surface roughness of all the tested denture teeth materials after exposure to cigarette smoke and overall decrease in surface roughness value after subsequent immersion in denture cleaning agent [10].

As regarding the effects of cigarette in this study, smoke on visible light cured UDMA specimens demonstrated a less increase in surface roughness that was statistically non-significant. This may be due to the smoother surface of these specimens that did not allow adherence of cigarette smoke substance to it and the subsequent easy wash ability by distilled water.

Furthermore, in comparison between the initial Ra of UDMA specimens (0.115) with PMMA specimens (0.135) the results found that, the UDMA specimens have a smoother surface than the PMMA specimens. This may explain the fewer adherences of smoke substances to the UDMA specimens than the PMMA specimens as well as the difference in the chemical composition between both resins types as the presence of silica filler within the light polymerized UDMA render its surface and makes it more resistant to the thermal effect of smoke. This finding was in agreement to the previous studies which reported that, cigarette smoke does not cause change in roughness of dental composites that contain UDMA and silica fillers in its composition, but brushing after smoking may give rise to the surface alteration [13,24,25].

According to Mathias P et al., the tar of cigarette contains aromatic hydrocarbons that have a surface dissolving action on the polymeric materials, the polymeric material are insoluble in oral fluids, but they are soluble to some extent in aromatic hydrocarbons [14]. From another point of view, there is a possibility of the cigarette smoke getting mixed saliva which may have produced an acidic pH solution, damaging the surface integrity of the materials [8].

Some studies had been reported that, cigarette smoke does not cause change in surface roughness, but brushing after smoking may have led to this alteration. So, it is extremely important to perform the surface finishing/polishing adequately to avoid residual surface roughness [12,23-26]. In the study of Alandia-Roman et al., there was an increase in roughness of all the evaluated materials and it was observed that

the type of finishing had an influence on the change in roughness of composites, with significant difference between the finishing procedures [12]. These results were in disagreement with the result of the present study, wherein smoking altered the surface roughness of both tested resin types.

Regarding the smoking device used in the present study, its design principles were similar to that used in previous studies but with some modifications [10,13]. The surface roughness changes were evaluated for each acrylic resin specimen, after exposure to 20 cigarettes and each cigarette burned in a standard time of 10 minutes as in the previous study regimens [12].

Both Profilometry and SEM analysis can be used to assess qualitatively the surface characteristics of different denture material. Profilometry is most useful in the evaluation of the Ra properties of dental materials because it produces numerical data but with SEM provide visual comparisons [10].

The changes in the surface roughness of the acrylic resin specimens was measured by using profilometer as in previous investigations [12,27]. The main advantages of this method, is that, it is easy to conduct, accurate and the mean surface roughness of the acrylic specimens can be easily calculated in accordance to the manufacture's recommendation.

LIMITATIONS OF THE STUDY

This study being invitro might not have formulated an oral condition as would an cigarette smoke in oral cavity, in an invivo study (such as the presence of saliva that have washing and buffering effect into the smoke substances that might reduce the thermal effect of smoke on the denture base materials). Therefore, in the future, additional clinical studies are necessary to clarify the long-term effect of cigarette smoke on the surface properties of denture base materials.

CONCLUSION

The denture bases constructed from heat-cured acrylic resin material have a marked increase of surface roughness after exposure to cigarette smoke, but the denture bases constructed from visible light cured resin material have superior surface characteristics. The use of more accurate finishing and polishing surface procedures can reduce the adherence of harmful substances on denture base, in conjugation with subsequent good oral hygiene. Findings of this invitro study may guide the dental practitioners in proper selection of denture base materials and correct surface finishing procedures for smoker patients to ensure long duration of services.

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