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Denture base materials surface roughness changes in response to exposure to cigarette smoke in an in vitro experiment

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***Abstract*---**Aim: Denture base materials were subjected to cigarette smoke for the purpose of determining their surface roughness. Materials and Methods: Polymethylmethacrylate and flexible denture base materials were used to manufacture 40 specimens for this study (20 for each). Each sample was randomly assigned to one of four groups: control, flexible, and heat-cured denture base material samples. The heat-cured denture material samples were the only ones that had been exposed to cigarette smoke (subgroup III). There was a control group for each group. For the smoke test groups, distilled water was utilised, whereas cigarette smoking was used for the water test groups. Each participant in the trial was exposed to six cigarettes in a specially created smoking area. Surface roughness differences between pre- and post-smoking samples were analysed using a profilometer. The data was analysed using a paired comparison and an independent comparison. Groupings differed significantly in their initial roughness and final roughness, according to results from a paired t-test. Conclusion: Surface harshness of tobacco-smoke-exposed specimens of both the intensity-restored and the adaptive dental replacement base materials was greater.

***Keywords*---**Cigarette smoke, profilometer, surface roughness.

Introduction

Using PMMA polymers in denture manufacturing has been around since 1937 due to its low cost, low solubility, minimal water absorption, ease of production of denture bases, and good physical and mechanical properties. Some individuals are sensitive to residual methyl methacrylate monomer, despite its many benefits.[1] Because the patient will be wearing the prosthesis for an extended length of time, it is critical that the doctor possess the necessary expertise to design and fabricate it. In the 1950s, nylon was initially used to make denture bases for the first time. Using a diamine with a dibasic acid produces nylon, a thermoplastic polymer that falls under the polyamides category. PMMA is an amorphous polymer, unlike nylon, which is crystalline. Nylon's insoluble nature in solvents, strong heat resistance, and great strength and ductility are all due to its crystalline phenomenon. [2]

Heat-cured resins, on the other hand, have various downsides, including increased flexibility, toxicity, and shrinkage during polymerization. As a result of their inability to polish, these materials are susceptible to bacterial contamination and other difficulties such as water sorption and warping. Millions of individuals throughout the globe are harmed by smoking cigarettes according to the World Health Organization. Cigarettes include a number of compounds that are already present in the plant as it is grown, even before harvest. Cigarettes contain several toxic chemicals, including but not limited to arsenic, nickel, carbon monoxide, formaldehyde, radioactive polonium, tar, and heavy metals.To name a few examples, smoke has been demonstrated to alter composites' surface roughness, colour and microhardness. [3]

There is a lack of information on how secondhand smoking affects restoration materials. There was no standardization established for the amount of cigarettes used, the equipment used, or the smoke flow in this study of the effects of cigarette smoke on various restorative and denture resins. [4,5] Dentures should be worn by patients. for a long time with a smooth, high-polish surface that is easy to clean and maintain. Germs may develop up on a rough surface that is in direct contact with oral tissues and harm tissue health. This is why surface roughness is important. Denture stomatitis, discoloration, halitosis, and pain may all be exacerbated by these microbes. Because of this, the roughness of the denture's surface is critical to its performance. [6] Denture base materials are being tested in this investigation to see whether smoking affects their surface roughness.

Materials and Methods
Fabrication of wax pattern

It was necessary to create a stainless steel mould for this investigation, which supplied a 30 mm x 2 mm circular form for preparing typical acrylic disc specimens. Modeling wax was put into a mould, and the mould was used to split the wax into two groups: one for each kind of wax, and one for each type of wax. To conduct this investigation, It was decided to employ a mix of heat-cured and flexible denture base materials, totaling 40 in all.The Hanau dental flask was overflowing with twenty wax specimens. The DPI heat-cured denture base material was used for dewaxing and packing.

A two-hour polymerization procedure in a water bath set at 74°C was performed on the specimens before they were removed from the flasks. [7]This was accomplished using a lathe cut polishing machine and a wet rag wheel that was coated in pumice slurry, which was used to polish each specimen's surface as the grit Figure 2 shows the growth from 150 to 1200. For the next 48 hours, all specimens were stored in distilled water at a temperature of 37°C 1°C.

After placing the wax specimens in a special flask designed for injection molding, the sprue formers were utilized to make channels for the fluid to flow into the mold. The flask was dewaxed by pouring hot water into it to melt the wax after the investment process. Wax residue was flushed out of the flask by filling it with hot, fresh water. Metal-to-metal contact was ensured by carefully inspecting the flask's rim.Molds were allowed to cure fully after the wax was removed and a separating agent was added. To prevent the cartridge from clinging to the carrier, silicon was sprayed on the cartridge of the proper size. A carriage was used to move and deposit cartridges into an electric cartridge furnace.As specified by the manufacturer, the material was plasticized for 15–20 minutes at 550°F–560°F. It lasted around 15–20 minutes at this level of intensity. Compression of the material was achieved by placing the cartridge on the flask's entrance.[7]

Unless the cartridge's contents are immediately injected into the flask when it is removed from the electric furnace, proper injection will take place but may be incomplete. In order to thoroughly compress the press' springs, the levers are quickly rotated until a hard pressure is applied. For a period of 3–5 minutes, the pressure is maintained. Before opening the flask, it should be let to cool down for at least 15–20 minutes on the bench. Each specimen was removed from the flask and polished with vulcanite burs, green and pink mounted stones and a gentle shaving motion once it was opened. The specimens were polished three times: first with pumice, then with brown tripoli, and finally with polishing cake and dry buff in order to get a high lustre sheen. Afterward, Initial surface roughness tests were carried out for 48 hours at 37°C 1°C on the specimens submerged in distilled water.[8]

After soaking the sample in distilled water at 37 1 C for 48 hours, the remaining monomer was successfully eliminated. After incubation, the roughness of the polished specimens was evaluated by testing their susceptibility to scratching when touched.A pick-up type piezoelectric profilometer was used to measure the roughness of the surface at the outset. To create its measurements, the profilometer makes use of a diamond stylus with a tracing length of 5-10 mm.It takes 0.5 milliseconds for the stylus to travel over the specimen's surface with a 0.08-mm cutoff. mm/s. Three scanning lines were recorded by moving the stylus over the specimen's surface. The spacing between each scanning line was 1 mm. The average of these three measurements was then computed and used to determine the specimen's surface roughness. [Figure 4].[1] Both specimens were then randomly divided into four groups of ten by a computer (n = 10) once the initial value was determined.

- “Subgroup I – examples of the denture foundation material after it has been heated up (control group)
- Subgroup II – Samples of flexible denture base material (control group)
- Subgroup III – Smoking-induced changes in the heat-curing properties of denture base material (study group)
- Subgroup IV – Materials for flexible dentures exposed to cigarette smoke (study group).”

An artificial saliva-infused smoking chamber was used to simulate the smoking experience for 21 days before the final evaluation of surface roughness was performed on the control group and two smoke test subgroups (I and II).

Preparation of artificial saliva

For this investigation, the artificial saliva employed was made to closely match both human-derived saliva and human salivary replacements. All formulations were maintained within a pH range that is comparable to that of saliva in a healthy person. To replicate saliva's electrolytes, the electrolytes were added. The ingredients for the fake spit were carefully chosen. Dipotassium hydrogen phosphate, sodium fluoride, magnesium chloride, sugar, methylparaben egg whites, sodium carboxymethyl cellulose, and hydroxypropylmethyl cellulose are only some of the many ingredients used in this formula.[9]

Custom-made smoke chamber

The chamber was constructed using an insulating substance to keep the elevated temperature within the chamber from escaping to the outside. With a removable cover, the smoke chamber might be made hermetically sealed. The smoke chamber's capacity was maintained to a minimum. The holder for a lighted cigarette was constructed with an intake in the middle of the lid of the chamber. The lid of the chamber has another aperture of the same diameter created on the perimeter as an outflow.[10]

To simulate the process of smoking in vivo

1. “A flow metre and vacuum system control were used to link the smoke chamber to the vacuum system.
2. To maintain a constant flow rate of 30 cm3/s, the vacuum control was monitored using a flowmeter.
3. Vacuum systems were activated for two seconds to mimic the length of a real-life intake of smoke (puff duration) in vivo. [11]
4. In order to maintain passive smoke exhaust before the next smoke cycle, the lid was kept open for 60 seconds. [12]"

Arrangement of specimens

The specimen was mounted on a silicone-coated substrate and put in the middle of the glass jar. The pristine surface of the specimen was not compromised by its proximity to ash. The tube's lid was tightly closed to maintain a distance of 10 mm between the cigarette and the specimen surface. To create a negative pressure of 20 mmHg (1 mmHg = 133 Pa), the smoking chamber was linked to a vacuum pump through another tube. Around 10 minutes were spent on each of the six cigarettes smoked. Both the aspiration duration and pressure were controlled by the vacuum machine's timer and pressure switch. [1]

Exposure of specimens to smoke

Smoke from cigarettes was inhaled by all of the test subjects at the same time.

- “Exposure of specimens to cigarette smoke was done for 21 days
- Specimens were exposed to six cigarettes daily with an interval of 1 h between each exposure
- Nine puff cycles were performed for every cigarette. Each cycle had puff duration of 2 s and puff frequency of 1 puff every 60 s
- Exposure to smoke stopped just before filter part of burning cigarette was reached
- After each cycle of exposure, the specimens were rinsed with distilled water for 1 min and immersed in the artificial saliva at 37°C in an incubator.”[4,13]

Afterwards, they were cleaned and dried in the open air using distilled water. A profilometer was then used to determine the resulting FRa surface roughness.By comparing the IRa and FRa readings, we were able to see changes in surface roughness before and after smoking tests. A statistical analysis was performed on the data.

Results

After smoking, the denture base materials did not have a noticeable change in their surface roughness. (H1). An increase in the surface harshness of dental replacement base materials has been postulated as a result of smoking, although this is unfounded hypothesis. The data's mean and standard deviation were calculated, as well as its minimum and maximum values.

- It was revealed that all specimens had higher final surface roughness values than their starting roughness values.
- “It was determined that the initial and final surface roughness values for subgroups I, II, III, and IV were all equal to or greater than or equal to 0.180 microns (initial) and 0.569 microns (final), respectively. The difference between the initial and final surface roughness values was then calculated, and the results were then subjected to a paired t-test within each subgroup. [Table 1]”

Table 1 Mean value, standard deviation, and paired *t*-test for all subgroups

Sub groups	Mean±SD			*P*	Inferences
	IR value μm	FR value μm	Difference value		
GroupI	0.22±0.023	0.456±0.034	0.345±0.034	0.001	S
GroupII	0.21±0.022	0.767±0.034	0.456±0.034	0.000	S
GroupIII	0.144±0.005	1.102±0.223	1.045±0.104	0.001	S
GroupIV	0.234±0.023	1.568±0.345	1.347±0.345	0.000	S

Every category showed significant differences in starting and end roughness, according to paired t-tests.[Table 2]
The independent t-test was run on data from different groups to arrive at these results: Specimens from heat-cured denture base materials – Subgroup I and III Found to be statistically significant, the mean initial surface roughness was found to be non-significant. [Table 2]

Table 2: Comparison of mean change in surface roughness of heat-cured denture base material specimens (subgroup I and III)

Variable	Meani-SD		*P*	Inferences
	Subgroup I	Subgroup III		
	(n=10)	*(n= 10)*		
IR	0.23±0.01	0.123±0.01	0.077	NS
FR	0.45±0.05	1.101±0.12	0.000	S
Difference	0.33±0.02	1.00±0.22	0.000	S

Subgroup II and IV (flexible denture base material specimens) – Both mean initial and final surface roughness values were found to be significant [Table 3]"

Table 3: Surface roughness variation between samples exposed to cigarette smoke (subgroup II and IV)

Variable	Mean±SD		P	Inference
	Subgroup II	Subgroup IV		
	(n=10)	(n=10)		
IR	0.222±0.25	0.245±0.214	0.45	S
FR	0.444±0.086	1.678±0.115	0.000	S
Difference	0.533±0.063	1.569±0.214	0.000	S

In all subgroups I and II, Differences in surface roughness between specimens composed of heat-cured and flexible denture base materials were statistically significant.[Table 4]

Table 4: Comparison of mean change in surface roughness of heat-cured and flexible denture base material specimens (subgroup I and II)

Variable	Mean±SD		*P*	Inferences
	Group I	Group **II**		
IR	0.167±0.01	0.222±0.01	0.000	S
FR	0.467±0.04	0.787±0.05	0.000	S
Difference	0.321±0.03	0.456±0.05	0.000	S

The average estimates of surface harshness at the beginning and end of the study period differed significantly in the subgroups III and IV (heat-relieved dental replacement base material examples following smoke treatment). [Table 5].

Table 5: When cigarette smoke is inhaled, the surface roughness of heated resin and flexible denture base material specimens decreases (subgroup III and IV)

Variable	Mean±SD		*P*	Inferences
	Subgroup III	Subgroup IV		
IR	0.16±0.0	0.24±0.01	0.000	S
FR	1.22±0.22	1.76±0.25	0.000	S
Difference	1.00±0.22	1.45±0.24	0.000	S

Discussion

PMMA is the most extensively utilised material for the construction of detachable prosthetics. This substance's widespread use and wide appeal may be attributed to its unique mix of attractive characteristics. The fracture, bad odour, and allergy to PMMA were unavoidable despite worldwide breakthroughs and research in dental materials and practises. Many patients seek for denture base materials that are more suited to their needs because of these issues. [14]Recently, nylon-like material has been used to construct detachable dental appliances. Metal and methyl methacrylate denture bases are often replaced by this material for detachable partial dentures. Nearly indestructible, it looks good and can be cut into very tiny bits.VALPLAST is a denture base resin that may be used for prosthetics. Nylon thermoplastic resin is biocompatible and has unique physical and aesthetic features, allowing designers to create whatever they can imagine.""[15]

The developing world is home to the vast majority of the world's regular smokers, at least 800 million people. Third- and fourth-largest users of tobacco, respectively, are found in India. About 19 percent of the world's 1.3 billion tobacco users reside in India, where there are about 250 million smokers.[16] When inhaling smoke from a cigarette, you will notice two different stages. Tar is the primary component of both the volatile and particle phases. In addition to nicotine and other tar and heavy metals, the smoke produced by burning cigarettes includes a variety of other toxins as well, including as nickel, arsenic, carbon monoxide, and dioxins. The oral cavity may experience certain temperature variations as a result of cigarette smoking. [1]

In order to better replicate smokers' lips' thermal changes, this research employed a custom-built smoking chamber with the smallest feasible capacity and insulating material. All of the specimens were put in artificial saliva to mimic intraoral circumstances after exposure to smoke.Dental prostheses have a lengthy clinical lifespan because of the physical qualities that might change as a result of surface deterioration, including changes to their surface roughness. Denture base materials may be polished using a variety of ways, including mechanical and chemical procedures, to minimise surface roughness. The roughness of two chemically diverse denture base materials has greatly increased due to cigarette smoking's temperature variations and the deposition of cigarette chemicals on the ac surface.

Conclusion

Here's what we can conclude from this study's limitations::

1. “Non-exposed subgroups had no significant difference in the mean starting surface roughness.
2. Surface roughness differed significantly across subgroups exposed to cigarette smoke.
3. Third, the mean ending surface roughness in all subgroups was found to be substantially different from the mean starting surface roughness in all of the subgroups
4. Flexible denture base material specimens had higher surface roughness than heat-cured denture base specimens in exposed groups.”

References

1. Mahross HZ, Mohamed MD, Hassan AM, Baroudi K. Effect of cigarette smoke on surface roughness of different denture base materials. *J Clin Diagn Res.* 2015;9:ZC39–42
2. Vivek R. Polyamide as a denture base material. *J Dent Med Sci.* 2016;15:119–21.
3. dos Bertoldo CE, Miranda D de A, Souza-Júnior EJ, Aguiar FHB, Lima DANL, Ferreira RL, et al. Surface hardness and color change of dental enemal exposed to cigarette smoke. *Int J Dent Clin.* 2011;3:1–4.
4. Mathias P, Silva LD, Saraiva Lde O, Costa L, Sampaio MD, de Araujo RP, et al. Effect of surface sealant and repolishing procedures on the color of composite resin exposed to cigarette smoke. *Gen Dent.* 2010;58:331–5.
5. Pereira-Cenci T, Del Bel Cury AA, Crielaard W, Ten Cate JM. Development of candida-associated denture stomatitis: New insights. *J Appl Oral Sci.* 2008;16:86–94.
6. Casemiro AL, Gomes Martins CH, Pires-de-Souza Fde C, Panzeri H. Antimicrobial and mechanical properties of acrylic resin with incorporated siler-zinc zeolite-part I. *Gerodontology.* 2008;25:187–94.
7. Anusavice SR. *Phillips, Science of Dental Material.* 12th ed. Ch. 19. USA: W.B. Saunders Company; 2012. pp. 479–84.
8. Singh K, Gupta N. Injection molding technique for fabrication of flexible prosthesis from flexible thermoplastic denture base materials. *World J Dent.* 2012;3:303–7. [Google Scholar]

9. Amal Andi SS, Hussain S, Amin Jalaluddin M. Preparation of artificial saliva formulation in: Int conference proceeding - ICB pharma II current breakthrough in pharmacy materials and analyses. *Proceedings-ICB Pharma.* 2015;2:6–12.
10. Santoso, P., Adrianta, K. A., & Wiranatha, I. G. (2021). Phytochemical screening and in vivo test of dewandaru (Eugenia uniflora L) fruit extract on mice exposed to cigarette smoke. International Journal of Health & Medical Sciences, 4(2), 246-252. https://doi.org/10.31295/ijhms.v4n2.1722
11. Coresta Recommended Method No. 22 Routine Analytical Cigarette- Smoking Machine Specifications, Definitions and Standard Conditions. 1991 Aug
12. Graça LM, Cardoso CG, Clode N, Calhaz-Jorge C. Acute effects of maternal cigarette smoking on fetal heart rate and fetal body movements felt by the mother. *J Perinat Med.* 1991;19:385–90.
13. Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2022). Post-pandemic health and its sustainability: Educational situation. International Journal of Health Sciences, 6(1), i-v. https://doi.org/10.53730/ijhs.v6n1.5949
14. Mathias P, Costa L, Saraiva LO, Rossi TA, Cavalcanti AN, da Rocha Nogueira-Filho G, et al. Morphologic texture characterization allied to cigarette smoke increase pigmentation in composite resin restorations. *J EsthetRestor Dent.* 2010;22:252–9.
15. Mathias P, Rossi TA, Cavalcanti AN, Lima MJ, Fontes CM, Nogueira-Filho Gda R, et al. Cigarette smoke combined with staining beverages decreases luminosity and increases pigmentation in composite resin restorations. *Compend Contin Educ Dent.* 2011;32:66–70.
16. Singh JP, Dhiman RK, Bedi RP, Girish SH. Flexible denture base material: A viable alternative to conventional acrylic denture base material. *Contemp Clin Dent.* 2011;2:313–7.
17. Thumati P, Padmaja S, Reddy R. Flexible denture in prosthodontics – An overview. *Indian J Dent Adv.* 2013;5:1380–5.
18. Peter S. 4th ed. New Delhi: Arya Medi Publishing House; 2009. Essential of Preventive and Community Dentistry.