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Effect of Peppermint Oil and Distilled Water Immersion on the Surface Hardness of Acrylic Resin at Different Immersion Times

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Abstract

Aim of the study: This study aimed to evaluate the effect of peppermint oil immersion on the surface hardness of polymethyl methacrylate (PMMA) acrylic resin after different immersion periods (1 day, 1 week, and 3 weeks). **Materials and methods:** Twenty rectangular samples were set up and split up into two groups, each group had 10 samples, first group was immersed in distilled water and second group was immersed in peppermint oil solution. They included three different periods: one day, one week, and three weeks. A daily immersion routine was adhered during these immersion times. This included immersing for eight hours in the immersion solution and then for sixteen hours in artificial saliva, all specimens were tested by hardness tester. The statistical analysis was used for the data and the comparison among all groups was obtained using analysis of variance test (two-way ANOVA-test) among all groups regarding the different immersion solutions in three different immersions periods. Further analysis was used post hoc comparisons Tukey-test to determine where the differences exist among groups at different times. In addition, Student's t-test was used for comparisons between the two-immersion media at each time interval. **Results:** The descriptive statistic revealed that there is an increase in surface hardness after immersion in distilled water and peppermint oil for three weeks, as the results of immersion in distilled water after three weeks (74.70) and the results of immersion in peppermint oil after three weeks was (75.10), but the two-way ANOVA indicated there was no significant interaction regarding immersion time of acrylic resin and both solutions, but there was a significant variation was detected regarding to immersion groups across time points. As well as, the Student's t-test revealed a significant difference was found between distilled water and peppermint oil after 1 day of immersion but there were no statistically significant differences were observed between the two-immersion media after 1 week or after 3 weeks of immersion. **Conclusion:** Immersion in peppermint oil and distilled water increased the surface hardness of acrylic resin. Hardness increased significantly from 1 day to later immersion times, while a difference between the two media were observed only after 1 day.

Keywords: acrylic resin, surface hardness, peppermint oil, distilled water, artificial saliva.

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Introduction

The denture bases have been fabricated using a range of materials over the years. Compared to other materials available for denture production, (PMMA) is the most mainly utilized denture base resin because it is less expensive, easier to manipulate, easier to create, and easier to repair (Jaafar, 2018). Walter H. Writer3 invented heat-polymerized acrylics in 1937. Since then, heat-cured acrylic has taken over the market for traditional full and/or partial dentures. The physical characteristics of the denture base material have been improved numerous times in an effort to increase its robustness and beauty (Mundada et al., 2022).

Because of its many benefits, including good aesthetics, ease of laboratory and clinical manipulation, appropriate fitness and stability in the oral environment, and affordable equipment, the denture bases is often fabricated by this type of resin (Nejatian et al., 2015). The chemical designation is poly (methyl meth acrylate), commonly referred to as acrylic resin or methacrylic resin. About 95% of the dentures are made with one of the thermally treated techniques and have this chemical formula: $C_5H_8O_2$. Its ease of processing is the reason for its enormous trials (Liu et al., 2022).

Peppermint oil is a member of the Lamiaceae family, which has many species with a wide range of traits and ploidy levels. Members of this family have significant commercial and medicinal value (Sgamma et al., 2017). The paper plant of the perennial herbs Mentha piperita L. and M. arvensis var. are used to make peppermint oil. Several notable species of essential oils, like spearmint, basil, lavender, rosemary, sage, marjoram, and thyme, are part of this family. These medicinal herbs have been traditionally used for various therapeutic purposes, including as analgesics, anesthetics, and antiseptics, in many indigenous medical systems (Alankar, 2009).

The degree of hardness of denture base resin indicates how simple a material is to polish and how resistant it is to scratches during cleaning operations (Fuad, 2021). A material's hardness is defined by its resistance to enduring deformation over time due to wear, abrasion, scratching, and indentation. The three primary methods of measuring hardness are rebound, indentation, and scratch Individual measurement scales exist within each of these measurement classes. Indentation hardness scales like Brinell, Shore, Vickers, and Rockwell are widely used (Fuad, 2021). Consequently, the study is focused on discovering if the use of peppermint solution for varying lengths of time alters the hardness of the resin.

Materials and method

In this study 20 samples were ready and split into two groups:

A. first group:10 samples (control group) immersion distilled water.

B. second group: 10 samples (experimental group) immersed in solution containing peppermint oil that was prepared using a 50% concentration of peppermint oil combined with 0.05% Tween 80 (v/v), which was mixed with 49.95%distilled water for diluting the mint oil.

Each group was being further split up into 3 groups depending on immersion period: one day, one week, and three weeks (Zarean et al., 2023).

Sample preparation

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For the hardness test, the wax patterns were built into the appropriate shape and size as follows: wax designs that are rectangular, and have 65mm in length,10mm in width and 2.5mm in thickness were used to fabricated acrylic (Khudhair, 2024), as shown in Figure1.

Flask mold preparation

The mold was prepared using the full traditional flasking procedure for the entire denture. The dental plaster was combined with water in a rubber bowl per the manufacturer's directions, and it was then put in a vibrator to clear out all gases. Then, it was put into the flask's lower half after the separating medium had been applied. After inserting the experimental specimen design in the center of the plaster surface, the flask's upper half was centered over its antagonist half, surfeited with dental plaster through an opening in the upper half, and covered, then the two halves were left for another one hour until it completely set (Abdul jabbar et al., 2023).

Dough mixture preparation

A standard ratio was used for combining the polymer and monomer. Following the manufacturer's instructions, the part of powder to monomer was 3/1. The mixture of 10 ml monomer and 22 g polymer was combined, then left to stand at room temperature in a covered container until the dough stage was achieved.

Packing and curing

Finally, when it reached the dough stage the acrylic resin was packed. After that, the substance made of acrylic resin was rolled and put into the mold. After assembling both of the flask's components, a hydraulic press was used to gradually apply pressure (100 kg/cm^2) for five minutes (Oliveira et al., 2014). A thermostatically regulated water bath was utilized for the curing process, following the manufacturer's guidelines (70 °C heat-degree for 90 minutes, then raising it to 100 °C for an additional 30 minutes). After then, the flask was allowed to cool to ambient temperature for half an hour, and then it was completely cooled with tap water for fifteen minutes before being de-flasked. The acrylic specimen was finally taken out of the flask after it had been opened.

Finishing and polishing

The finishing burs used to remove all flashes of acrylic and followed by sand paper for smoothing surface. Except for the surface facing the reline material, all of the acrylic specimen's surfaces were polished using a rag wheel pumice, and a lathe polishing machine **(**Ayash, 2021), as shown in Figure (2)

Immersion of Samples

The specimens of both groups were exposed into different immersion times. The first group was submerged in 100 milliliters of distilled water, while another group was submerged in 100 milliliters of solution containing peppermint oil: 50 milliliters of peppermint oil, and 0.05ml of tween 80 to dilute it in 49.95 milliliters of distilled water. Three distinct time periods were covered: one day, one week, and three weeks. A daily immersion routine was adhered to during these immersion durations. This required 8 hours of immersion in the immersion solution and 16 hours of immersion in artificial saliva (Lata et al., 2010; Deyab et al., 2018), as shown in Figure (3).

Surface Hardness test:

The Duromter hardness device, type (shore D) scales, was used to measure the hardness of every specimen in accordance with ASTM D2240. specimens placed beneath the indenter region with a depressing time of 10 seconds, and testing loads applied equally to 50 N. The digital share D device's 0.8mm diameter indicator taper to a 1.6mm cylinder. The

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indicator was firmly pressed, and the digital scale provided the reading (Cevik et al., 2015). Hardness numbers range from 0 to 100 for each scale; a higher number denotes a tougher material (Cevik et al., 2015). The hardness readings were recorded three times, (the first reading in the middle, the second from the right, and the third from the left) and average readings were calculated for each specimen (Cevik et al., 2015), as shown in Figure (4).

Results

Descriptive statistics including Mean values, SD and SE are presented in Table (1) for hardness values. The lowest mean value was obtained in group distilled water immersion for 1day (69.00 ± 1.247), whereas the highest mean was obtained in group peppermint oil for 3weeks (75.10 ± 1.853).

The effects of immersion type and time on surface hardness were analyzed using Two-way ANOVA, as shown in Table 2. The results demonstrated a statistically significant effect of immersion type on surface hardness ($F = 116.337$, $p < 0.001$). Time also showed a statistically significant effect on surface hardness ($F = 17.907$, $p < 0.001$). However, the interaction between immersion type and time was not statistically significant ($F = 1.708$, $p = 0.191$). The model explained a substantial proportion of the variance in surface hardness ($R^2 = 0.742$).

To further evaluate the differences between time intervals, multiple comparisons were performed using the Tukey HSD test (Table 3). The results revealed a statistically significant difference between 1 day and 1 week of immersion ($p < 0.001$), as well as between 1 day and 3 weeks of immersion ($p < 0.001$). However, the difference between 1 week and 3 weeks was not statistically significant ($p = 0.314$).

In addition, comparisons between the two-immersion media at each time interval were performed using the student's t-test, as shown in Table 4. A statistically significant difference was found between distilled water and peppermint oil after 1 day of immersion ($t = 2.283$, $p = 0.035$). However, no statistically significant differences were observed between the two-immersion media after 1 week ($p = 0.131$) or after 3 weeks of immersion ($p = 0.594$).

Discussion

Because of its appropriate mechanical properties, simple process of fabrication and low price relatively, PMMA was clinically used as material of choice for removable denture base materials, temporary resin crowns and orthodontic appliance in last 70 years (El Bahra et al., 2013).

This study designated to evaluated the effects of different immersion time of plant extract (peppermint) on surface hardness of heat cured acrylic resin.

Eight hours were spent submerged in the storage medium, and then sixteen hours were spent submerged in artificial saliva. This approach was designed to replicate the standard procedure of wearing a denture for the remainder of the day after soaking it for eight hours at night (Lata et al., 2010).

This study assessed how antiseptic treatments affected the denture base resin's hardness following extended preservation in oil. The information gathered for this investigation supported the theory that the kind of disinfectant and the length of time the denture base resin is stored in oil can have an impact on its hardness (Neppelenbroek et al., 2015).

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The hardness readings were collected after immersion in both solutions (distilled water and peppermint oil) in different immersion periods, the mean values were demonstrated an increase in hardness. The increase in acrylic hardness after immersion in plant oil solutions can be attributed to several chemical and physical changes within the acrylic material (polymethyl methacrylate or PMMA), which often involves a reduction in the material's plasticizer content and potential additional cross-linking or polymerization (Alamen et al., 2020). Other explanation may be the hardening effect could depend on the type of plant oil, its concentration, immersion time, and the specific composition of the acrylic material. Generally, a decrease in the material's original plasticizer or an increase in cross-linking leads to greater hardness (Zhang et al., 2024). This result agreed with previous study that was found that all the specimens exhibited change in Shore D surface hardness of all specimens of denture base material immersed in different denture cleansers solution sodium perborate, thymus oil, and Ozonated water for 180 days of immersion. But statistically non-significant change between all groups (Punia et al., 2023). In a study revealed by Jaffer and Abdullah in 2020, they found that surface hardness changes in resin were not significant after immersion in thyme oil–based denture cleanser. Furthermore, some of the specimens exhibited an increase in surface hardness of resin after immersion in denture cleansers (Jaffer and Abdullah, 2020). On the other hands, another study was indicated that the surface hardness of resin for the Polident immersion group exhibited the greatest mean values, while the thyme immersion group had the lowest mean values in comparison with distilled water immersion but statistically was not significant (Aziz et al., 2025). The results of present study indicated there was a significant increase in hardness regarding to the immersion period in comparison between one day and one week, as well as, between one day and three weeks. But no variation was occurred between one week and three weeks, this outcome disagreed with study that demonstrated heat-cured acrylic resins exhibited reduction in hardness after the immersion protocol which was simulated six months of routine disinfection in denture cleansers solution (Khasraw & Abdulkareem, 2025). Research by Ali et al. in 2022, they tested the hardness that was carried out after storing the samples at 37°C for 7, 30, 60, 90 and 120 days and they maintained no statistically significant differences were found between the material and the immersion solutions (Ali et al., 2022). While, other studies who concluded after 3 weeks of soaking, the hardness reached its peak levels (Machado et al., 2009; Goiato et al., 2013). The current study's findings also concurred with those of the Neppelenbroek et al., in 2015, they showed material hardness levels increased steadily over the first 60 days of water storage, after which there was no discernible change (Neppelenbroek et al., 2015). In contrast, with search by McReynolds et al. (2023), which they concluded after aging, there was a steady decline in hardness was noted in two microwave sterilization cycles and 90 days of water immersion had no influence on the hardness of the majority of the acrylic resin denture teeth (McReynolds et al., 2023). It was demonstrated that the hardness of both layers of Vivodent teeth decreased steadily over a period of 30 days when soaked in various solutions. Also, Tawfeeq and Al-Khafaji, in 2023, they assessed the effects of ozonated water

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on the hardness and surface roughness of heat-cured acrylic resin using the immersion technique. Ozonized water did not negatively impact, however, at a concentration of 2 mg/L for 10 and 20 minutes, it did result in a statistically significant but clinically tolerable drop in hardness (Tawfeeq & Al-Khafaji, 2023).

Conclusions

Immersion in peppermint oil and distilled water increases the hardness characteristic of the acrylic.

Conflict of interest

The authors reported that they have no conflicts of interest.

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Table (1): Detailed surface hardness information for every category.

Source of variation	Type III Sum of Squares	df	Mean Square	F-test	P-value
Immersion groups	228.150	1	228.150	116.337	0.000*
Time	70.233	2	35.117	17.907	0.000*
Immersion groups × Time	6.700	2	3.350	1.708	0.191
*. The mean difference is significant at the .05 level.					

Table (2): Two-way ANOVA table representing two main factors with correlation between immersion and time by type III sum of squares.

Groups	T-test	P-value
1day immersion in distilled water & 1day immersion in peppermint oil	2.283	0.035*
1week immersion in distilled water & 1week immersion in peppermint oil	1.581	0.131
3week immersion in distilled water & 3week immersion in peppermint oil	0.542	0.594
*. The mean difference is significant at the .05 level.		

Table (3): Post hoc comparisons Tukey test among groups at different time.

Multiple Comparaisons							
	(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1day	1week	-1.90*	0.443	0.000	-2.97	-0.83
		3week	-2.55*	0.443	0.000	-3.62	-1.48
	1week	3week	-0.65	0.443	0.314	-1.72	0.42
*. The mean difference is significant at the .05 level.							

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Table (4): Student T-test for comparison between two types of immersion (distilled water and peppermint oil).

Studied groups		Mean	Std. Deviation	Mini. values	Maxi. values
Distilled water immersion	1day immersion in distilled water	69.00	1.247	67	70
	1week immersion in distilled water	71.00	1.333	69	73
	3 weeks immersion in distilled water	74.70	1.418	73	77
Peppermint oil immersion	1day immersion in peppermint oil	70.10	0.876	69	71
	1week immersion in peppermint oil	72.00	1.491	70	74
	3 weeks immersion in peppermint oil	75.10	1.853	73	78

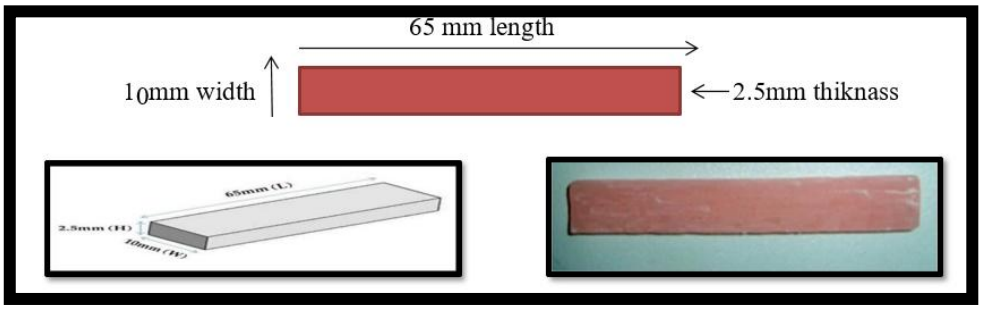

Figure (1): Sample dimension and design

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Figure (2): Samples for study Control and experimental groups.

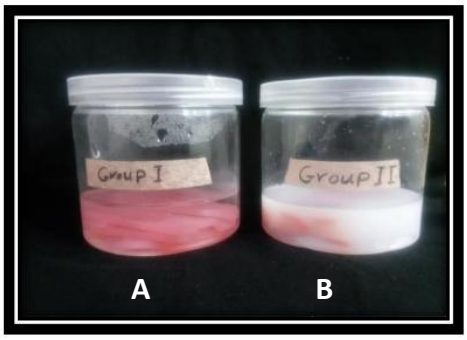

Figure (3): A. immersion of samples in distilled water, B. immerse the samples in peppermint oil solution.

Figure (4): Sample under surface hardness test.