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The Surface roughness of acrylic denture base immersed with herbal denture cleanser

Hadfi Dhaky Chairuly [1], Renata Jasmine Ramadhanty Felisha Tandra [1], Gilang Ratri Sakti [1], Devin Elysia Dhywinanda [1], Sinta Nuriyah Dien [1], Ratri Maya Sitalaksmi [2, *] and Nadia Kartikasari [2]

[1] *Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia.*
[2] *Department of Prosthodontics, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia.*

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Abstract

Background: Plaque accumulation on dentures can be prevented through daily denture cleaning. Currently, commercially available denture cleansers, such as the chemical-based product (Polident), may increase the surface roughness of acrylic resin denture bases, potentially enhancing microorganism adherence. *Graptophyllum pictum* leaf extract (GPLE 50%) concentration is emerging as a strong candidate for an herbal denture cleanser due to its potent fungicidal activity. However, to date, no studies have reported the effects of GPLE 50% on surface roughness.

Objective: This study aims to investigate the effects of *Graptophyllum pictum* leaf extract at a 50% concentration as a denture cleaning agent on the surface roughness of acrylic denture bases, with immersion conducted for 5 minutes daily over periods of one, two, three, and four weeks.

Methods: Nine acrylic resin base samples, each measuring 20mm x 10mm x 10mm, were divided into three groups: two control groups (Polident and distilled water) and one treatment group (GPLE 50%), with each group replicated three times. All samples were immersed for five minutes daily over a period of one, two, three, and four weeks. Surface roughness was measured using Atomic Force Microscopy (AFM) and statistically analyzed.

Result: There was no significant difference between the surface roughness of acrylic denture bases before and after treatment (One-Way ANOVA; $p>0.05$).

Conclusion: GPLE 50% did not have a significant effect on the surface roughness of the acrylic resin denture base.

Keywords: *Graptophyllum pictum*; Denture cleanser; Surface roughness; Atomic force microscopy

1. Introduction

Tooth loss refers to the condition which one or more teeth are detached from their sockets and supporting structures [1]. Common factors contributing to tooth loss include dental caries, periodontal disease, trauma, and orthodontic extractions [2]. This condition can lead to functional, aesthetic, and social impairments, ultimately affecting an individual's quality of life [3]. The use of dentures is one of the primary solutions to treat tooth loss. Dentures are medical devices consisting of a base and artificial teeth designed to replace the hard and soft tissue structures within the oral cavity [4]. Acrylic is the most commonly used material for denture bases due to its favorable physical properties, aesthetic, ease of fabrication, and flexibility [5]. However, acrylic denture bases have a high porosity, which facilitates plaque accumulation [4]. Plaque accumulation in denture wearers has been associated with an increased risk of denture stomatitis [6]. Denture stomatitis is characterized by inflammation and erythema with diffuse or localized margins in

* Corresponding author: Ratri Maya Sitalaksmi

the areas supporting the denture. The most dominant species involved in the etiopathogenesis of denture stomatitis is Candida albicans [5]. Candida-associated denture stomatitis (CADS) is the most prevalent form of oral candidiasis among elderly individuals, affecting approximately 65% of denture wearers [7]. Previous research has demonstrated that plaque accumulation can be prevented through daily denture cleaning practices [8].

Denture cleaning can be performed using mechanical or chemical methods. Chemical cleaning involves immersing dentures in chemical cleaning agents [8]. Most commercially available denture cleaners are chemical-based, with Polident being one of the most commonly used brands. However, these chemical-based cleaners have a notable disadvantage, they can increase surface roughness, which in turn enhances the adhesion of microorganisms (bacteria and fungi), plaque, and food debris [9, 10, 11, 12]. Previous studies have suggested that traditional materials, such as *Graptophyllum pictum* leaf extract at 50% (GPLE 50%) concentration, are safer to use and exhibit fungicidal activity, belonging the criteria for an ideal denture cleaning agent [9, 11, 13]. *Graptophyllum pictum L. Griff* possesses multiple pharmacological properties, including anti-inflammatory, antibacterial, antifungal, antioxidant, anti-implantation, antidiabetic, anti-hemorrhoidal, photoprotective, nephroprotective, and immunomodulatory effects [14, 15].

This study aims to evaluate the surafe roughness of acrylic denture base immersed with GPLE 50% as a denture cleaning agent, with immersion conducted for 5 minutes daily over periods of one, two, three, and four weeks.

2. Material and methods

This study is a quantitative, laboratory-based experimental research employing a post-test-only control group design. GPLE 50% was prepared by diluting GPLE at 100% concentration. The extraction process involved macerating the powdered *Graptophyllum pictum* leaf in 70% ethanol for 24 hours. To achieve a 50% concentration, 5 ml of 100% GPLE was mixed with 5 ml of Sabouraud Dextrose Broth (SDB). The research utilized nine heat-cured acrylic resin samples in the form of rectangular blocks measuring 20 mm x 10 mm x 10 mm. The polymerization process involved thermal curing by immersion in a water bath. The acrylic resin samples used in the study were selected based on specific criteria, including being non-porous with parallel and smooth surfaces.

Samples were divided into five groups based on the treatment received: C (-) as the negative control group using aquadest, C (+) as the positive control group using the chemical-based product (Polident), T1 treated with GPLE 50% for 1 week, T2 treated with GPLE 50% for 2 weeks, T3 treated with GPLE 50% for 3 weeks, and T4 treated with GPLE 50% for 4 weeks. The immersion process was conducted by preparing a container filled with a solution of chemical-based cleaners, distilled water, and 50% GPLE, ensuring the entire surface of the acrylic resin was submerged. The acrylic resin samples were immersed for five minutes, followed by rinsing with running water and dry it using tissue. All samples were immersed daily for five minutes over periods of one, two, three, and four weeks.

Surface roughness evaluation assessed two key parameters: arithmetic mean height (Sa) and root mean square height (Sq), all measured in nanometers (nm). Surface roughness testing was conducted using an Atomic Force Microscopy (AFM) device (Bruker-Nano N8 NEOS, Bruker Corp, Billerica, MA, USA). AFM testing procedure follows the method described by [12]. First, the sample must be clean and dry. Placed the sample in the designated holder on the device. At this stage, it is crucial to ensure that the cantilever tip (probe) is correctly positioned on the surface of the acrylic resin specimen. Next, the device and computer display are activated, and surface roughness measurements are conducted using AFM with a 10 × 10 μm scale and three-dimensional imaging. During scanning, the cantilever tip moves back and forth across the specimen's surface. Each detected deflection is reflected in a specific direction using a laser, which passes through a laser mirror toward the photodiode. The results are displayed on the computer screen.

All data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0 for Windows (IBM Corporation, Illinois, Chicago, USA). The normality test was conducted using the Shapiro-Wilk test, while the homogeneity test was performed using Levene's test, with a $p > 0.05$ indicating homogeneity. If the data did not meet the assumption of normality, non-parametric analysis was performed using the Kruskal-Wallis test. However, if the data met the assumption with a $p > 0.05$, a one-way analysis of variance (ANOVA) was used to assess differences between test groups. Differences were considered statistically significant if the $p < 0.05$ in the Kruskal-Wallis or one-way ANOVA tests.

3. Results and discussion

The AFM test results are interpreted based on the observed color variations, where bright colors represent areas with elevated surface heights, dark colors indicate areas with lower surface heights, and brownish-yellow hues denote intermediate surface levels. Surface roughness was evaluated using two critical parameters: the arithmetic mean height (Sa) and the root mean square height (Sq). The mean values and standard deviations of the surface roughness measurements for the acrylic resin base samples are summarized in Tabel 1.

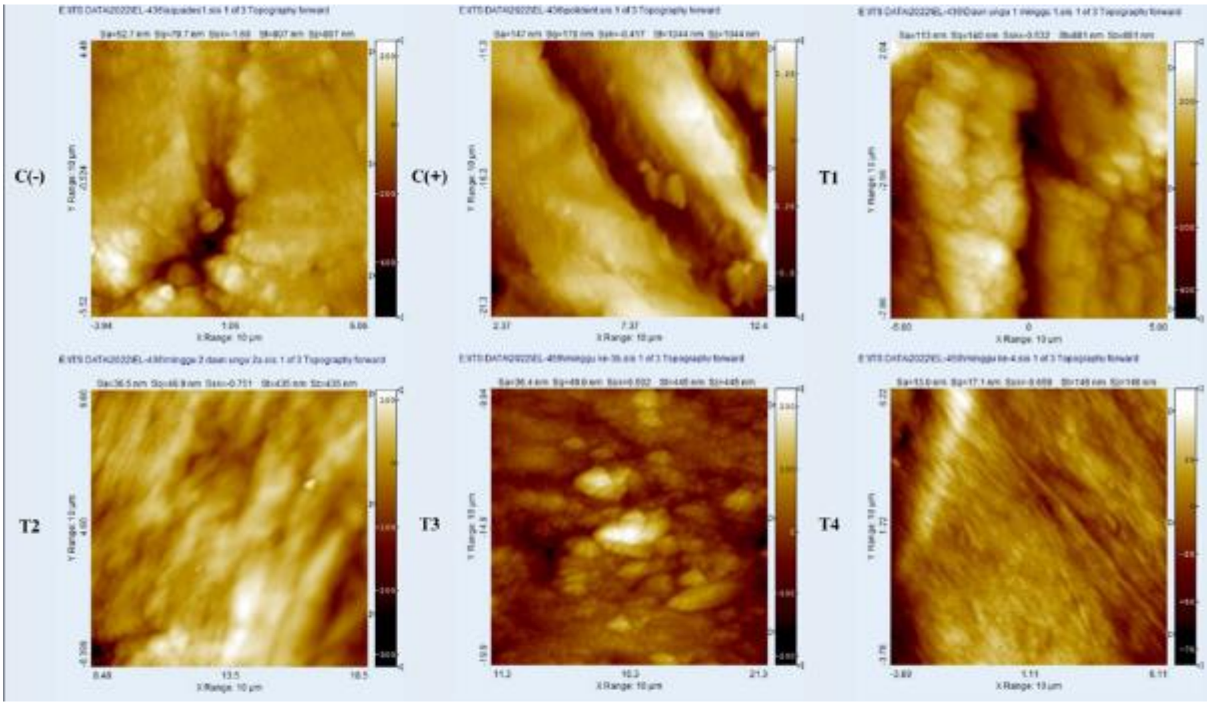

Figure 1 The representative of AFM test results on acrylic resin base samples with 3D shape and forward topography, immersed for five minutes per day using C (-) treated with aquadest, C (+) treated with chemical-based product, T1 is treated with GPLE 50% for 1 week, T2 with GPLE 50% for 2 weeks, T3 with GPLE 50% for 3 weeks, and T4 with GPLE 50% for 4 weeks.

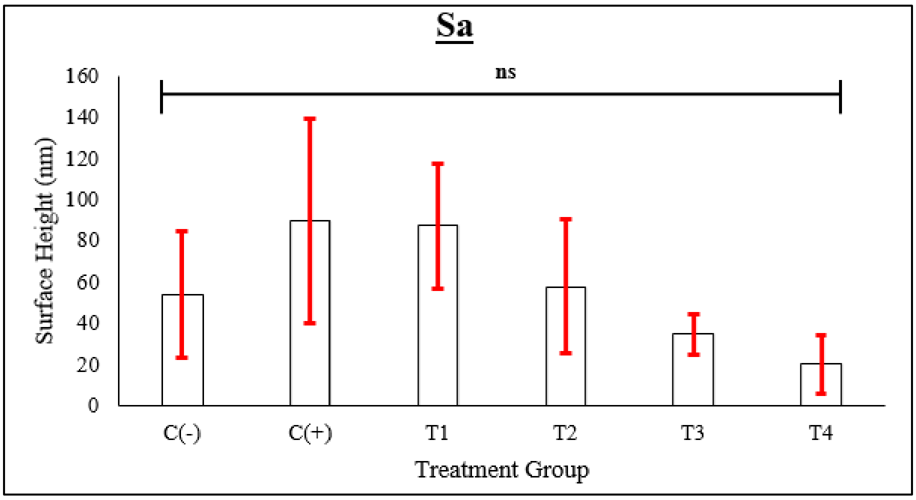

Figure 2 Data are presented as mean ± standard deviation (SD) (n = 3) for the Sa indicator. No statistically significant differences were observed among the groups (ns) ($p > 0.05$; one-way ANOVA).C (-) represents the negative control group treated with aquadest, C (+) represents the positive control group treated with chemical-based product, T1 is treated with GPLE 50% for 1 week, T2 with GPLE 50% for 2 weeks, T3 with GPLE 50% for 3 weeks, and T4 with GPLE 50% for 4 weeks.

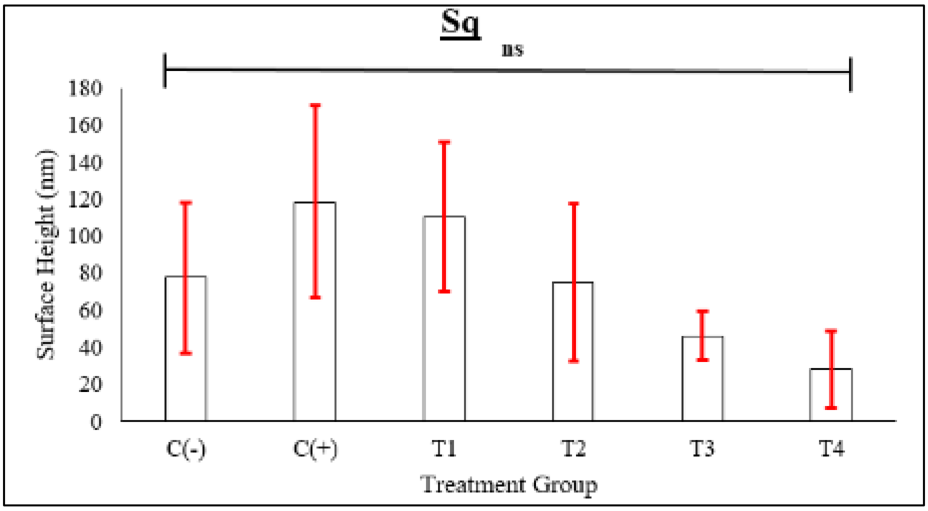

Figure 3 Data are presented as mean ± standard deviation (SD) (n = 3) for the Sq indicator. No statistically significant differences were observed among the groups (ns) ($p > 0.05$; one-way ANOVA).C (-) represents the negative control group treated with aquadest, C (+) represents the positive control group treated with chemical-based product, T1 is treated with GPLE 50% for 1 week, T2 with GPLE 50% for 2 weeks, T3 with GPLE 50% for 3 weeks, and T4 with GPLE 50% for 4 weeks.

Previous studies have demonstrated that immersing dentures in chemical-based denture cleaning solutions effectively eliminates microorganisms but has adverse effects on increasing the surface roughness of the denture base [16]. Changes in the surface roughness of acrylic resin bases after immersing in alkaline peroxide are attributed to the chemical reaction that occurs when sodium perborate comes into contact with water. This reaction produces an alkaline peroxide solution that decomposes into nascent oxygen (oxidizing agent), leading to an increase in the surface roughness of the acrylic resin base [17]. The use of natural products as denture cleansers presents a better alternative in terms of cost, feasibility, non-toxicity, chemical-free composition, stability, acceptability, aesthetics, and minimal side effects. Phytochemicals found in herbs provide a range of synergistic effects, including anti-inflammatory, antiviral, antibacterial, antifungal, antioxidant, anticariogenic, wound healing, immunomodulatory, and anticarcinogenic properties [18]. One potential herbal candidate for use as a denture cleanser is *Graptophyllum pictum L. Griff.*

The results of the study indicate that the surface roughness values of acrylic resin immersed in chemical-based cleaners, serving as the positive control group, and aquades, as the negative control group, exhibit significant differences in the Sa and Sq parameters. The positive control group C(+) demonstrated higher values compared to the negative control group C(-), indicating greater surface roughness. Comparisons of surface roughness values between the positive control group C(+) and the group immersed in 50% GPLE for one week (T1) revealed minimal differences, with T1 showing slightly lower surface roughness than C(+). Notably, the surface roughness values of acrylic resin immersed in 50% GPLE for two weeks (T2), three weeks (T3), and four weeks (T4) demonstrated a progressive decrease. Lower surface roughness values of resin acrylic denture bases correspond to a reduced potential for plaque accumulation on the denture base.

All surface roughness data of the acrylic resin base obtained were analyzed using a parametric test, One-Way ANOVA, as the data were normally distributed and homogeneous. The One-Way ANOVA test was conducted by comparing all surface roughness data across groups. Based on the results of the One-Way ANOVA test, a significance value of 0.098 was obtained for the Sa indicator, and 0.077 for the Sq indicator ($p>0.05$), indicating no significant differences between the groups. Therefore, it can be assumed that there is no significant difference in the surface roughness of acrylic resin bases between the control group and the treatment group. The surface roughness parameters Sa and Sq indicate that chemical-based cleaners exhibits slightly higher roughness levels compared to GPLE 50% and distilled water. The increase in roughness observed with chemical-based cleaners is attributed to the presence of peroxide base in its formulation. Alkaline peroxide decomposes into H_2O (hydrogen peroxide), $2H_2O_2$ (alkali), and 2O (nascent oxygen). The free radicals generated from hydrogen peroxide can damage polyamide bonds, while the high oxidation levels contribute to an increase in surface roughness. In contrast, GPLE 50% demonstrates slightly lower surface roughness compared to chemical-based product, but marginally higher than distilled water. The increase in surface roughness observed with GPLE 50% is attributed to its flavonoid content. Phytochemical analysis revealed that the dominant component in *G. pictum* leaves is flavonoids, with a concentration of 4340.30 mg/100 QE wb, classified as phenolic compounds. The high phenolic content can enhance the acrylic polarity acidity, potentially breaking acrylic polymer chains and causing damage to the resin. Additionally, the high acid levels may hydrolyze esters within the polymer, further increasing surface roughness. However, no significant differences in surface roughness were observed among all tested groups. Thus, GPLE 50% does not have a significant effect on changes in the surface roughness of acrylic resin.

4. Conclusion

Graptophyllum pictum L. Griff demonstrates potential as a candidate for herbal biomaterial-based denture cleansers. GPLE 50% does not significantly affect the surface roughness of acrylic resin denture bases. Further research is needed to evaluate the effect of GPLE 50% on the color stability of acrylic resin denture bases and to conduct in vivo analysis.

Compliance with ethical standards

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Conflict of interest statement

Authors have no conflict of interest.

References

[1] Saito M, Shimazaki Y, Fukai K, Furuta M, Aida J, Ando Y, et al. Risk factors for tooth loss in adult Japanese dental patients: 8020 promotion foundation study. Journal of Investigative and Clinical Dentistry. 2019 Jan 24;10(2). doi:10.1111/jicd.12392

[2] Gabiec K, Bagińska J, Łaguna W, Rodakowska E, Kamińska I, Stachurska Z, et al. Factors associated with tooth loss in general population of Bialystok, Poland. International Journal of Environmental Research and Public Health. 2022 Feb 18;19(4):2369. doi:10.3390/ijerph19042369

[3] Silva Junior MF, Batista MJ, de Sousa M da. Correction: Risk factors for tooth loss in adults: A population-based prospective cohort study. PLOS ONE. 2019 Dec 16;14(12). doi:10.1371/journal.pone.0226794

[4] Mylonas P, Milward P, McAndrew R. Denture cleanliness and hygiene: An overview. British Dental Journal. 2022 Jul 8;233(1):20–6. doi:10.1038/s41415-022-4397-1

[5] McReynolds DE, Moorthy A, Moneley JO, Jabra-Rizk MA, Sultan AS. Denture stomatitis—an interdisciplinary clinical review. Journal of Prosthodontics. 2023 Apr 18;32(7):560–70. doi:10.1111/jopr.13687

[6] Natasya C, Miftahullaila M, Sinamo S, Nurul N, Griselda J. Pengaruh Waktu Perendaman plat resin akrilik dalam perasan Murni Bawang Putih Terhadap Jumlah Koloni candida albicans. Jurnal Kedokteran dan Kesehatan Publikasi Ilmiah Fakultas Kedokteran Universitas Sriwijaya. 2020 Oct 5;7(3):25–30. doi:10.32539/jkk.v7i3.11483

[7] Sugio CY, Garcia AA, Albach T, Moraes GS, Bonfante EA, Urban VM, et al. Candida-associated denture stomatitis and murine models: What is the importance and scientific evidence? Journal of Fungi. 2020 May 23;6(2):70. doi:10.3390/jof6020070

[8] Al-Thobity AM, Gad M, ArRejaie A, Alnassar T, Al-Khalifa KS. Impact of denture cleansing solution immersion on some properties of different denture base materials: An in vitro study. Journal of Prosthodontics. 2017 Jun 9;28(8):913–9. doi:10.1111/jopr.12649

[9] Song Y-G, Lee S-H. Efficacy of newly developed denture cleaning device on physical properties of denture material and candida biofilm. Journal of Dental Sciences. 2019 Sept;14(3):248–54. doi:10.1016/j.jds.2019.01.011

[10] Winardhi A, Saputra D, Puspitasari D. Perbandingan Nilai Kekasaran Permukaan Resin Termoplastik Poliamida Yang Direndam Larutan Sodium Hipoklorit dan Alkalin Peroksida. Dentino Jurnal Kedokteran Gigi. 2017;1(1):45–9. doi: https://doi.org/10.20527/dentin.v1i1.336

[11] Dewi TP. In vitro study comparison of purple leaf extract as denture cleanser at different concentration towards S. Mutans growth on flexible denture. Bali Medical Journal. 2020 Nov 5;9(3):716–20. doi:10.15562/bmj.v9i3.2019

[12] Sofya S, Sofya PA, Sukma AT. The effect of denture cleanser 48% sodium bicarbonate on surface roughness changes of heat-cured acrylic resin. Journal of Syiah Kuala Dentistry Society. 2022 Jan 4;5(1):19–23. doi:10.24815/jds.v5i1.18424

[13] Dien SN. Aktivitas Fungisidal Graptophyllum Pictum L. Griff Terhadap Candida Albicans Sebagai Kandidat Denture Cleanser [thesis]. [Surabaya]: Repository Universitas Airlangga; 2023. p. 1–72.

[14] Makkiyah F, Rahmi EP, Revina R, Susantiningsih T, Setyaningsih Y. Graptophyllum pictum (L.) griff. (syn: Justicia Picta Linn.) and its effectiveness: A well-known Indonesian plant. Pharmacognosy Journal. 2021 May 5;13(3):835–8. doi:10.5530/pj.2021.13.106

[15] Dhywinanda DE, Dien SN, Chairuly HD, Sakti GR, Tandra RJ, Kartikasari N, et al. Essential of Graptophyllum Pictum for the medical and dental purposes. Indonesian Journal of Dental Medicine. 2023 Aug 31;6(2):83–8. doi:10.20473/ijdm.v6i2.2023.83-88

[16] Costa RT, Pellizzer EP, Vasconcelos BC, Gomes JM, Lemos CA, de Moraes SL. Surface roughness of acrylic resins used for denture base after chemical disinfection: A systematic review and meta-analysis. Gerodontology. 2021 Jan 6;38(3):242–51. doi:10.1111/ger.12529

[17] Ferro AC, Spavieri JH, Ribas BR, Scabelo L, Jorge JH. Do denture cleansers influence the surface roughness and adhesion and biofilm formation of candida albicans on acrylic resin? systematic review and meta-analysis. Journal of Prosthodontic Research. 2023;67(2):164–72. doi:10.2186/jpr.jpr_d_22_00077

[18] Shrestha S, Shrestha B. Denture cleansing the natural way: A Review. Journal of Nepalese Prosthodontic Society. 2023 Dec 31;6(2):85–91. doi:10.3126/jnprossoc.v6i2.64708