

THE INFLUENCE OF DIFFERENT CLEANING METHODS ON THE SURFACE ROUGHNESS OF “THERMOSENS” DENTURE BASE MATERIAL

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Abstract

The increased use of flexible dentures in the daily dental practice requires additional research regarding how different disinfection protocols affect the dentures surface characteristics. The aim of this study was to evaluate how different cleaning techniques under varying conditions affect the surface roughness (Ra) of “ThermoSens” denture base material. Forty flexible denture specimens with dimensions $\varnothing$ 10 mm were fabricated. They were divided into ten groups (T1-T10) depending on which disinfection method was used. All the specimens were immersed in artificial saliva over the course of 30 days and were cleaned using accessible products (soap, toothpaste, Protefix and Corega tablets). Each test body was then analyzed in four different surface areas using atomic force microscopy (AFM), the results were statistically prepared using IBM SPSS Statistics 26, Excel 2015 and EdrawMax 7. The control group (T1) showed the lowest Ra with average value of 17.4 nm. The use of cleaning tablets Protefix daily (T5) yielded mean values of 46.8 nm, which is more than double than that of the control group. The highest roughness was observed when using a soft brush and toothpaste daily (T8), five times higher (mean 100.6 nm) than that of the control group. The surface roughness of flexible denture base material “ThermoSens” significantly changes depending on the different cleaning protocol used.

Key words: flexible denture, polyamide, “ThermoSens”, surface roughness, disinfection

Introduction. The development of new technologies in dental medicine aimed at improving the quality of life for patients with removable dentures has led to the creation and advancement of new materials and methods [1, 2]. The introduction and incorporation of flexible resins (such as the polyamide denture base material “ThermoSens”) into the daily dental practice are expected to overcome some of the disadvantages associated with the use of conventional resins and facilitate the overall treatment process [3, 4].

The polyamide denture base material “ThermoSens” offers a variety of advantages over the acrylic resin used in the daily practice when it comes to biocompatibility, comfort and aesthetics [5]. Despite the listed advantages over acrylic resin base materials, the flexible resins have demonstrated some disadvantages as reported by some authors [6, 7]. The main disadvantage of the thermoplastic polyamides is their surface characteristics, which predispose easier damage to the surface of the denture, as well as discolouration and loss of gloss [8, 9].

There are numerous products available for denture cleaning (soap, toothpaste, denture cleanser tablets), which can be categorized into mechanical and chemical cleaning products. The most common and accessible denture cleansers on the Bulgarian market are Corega and Protefix cleaning tablets. The Corega cleaning tablets belong to the group of the alkaline peroxides and represent the most used denture cleansers [10]. The use of different cleaning methods and denture cleansers has an effect on the dentures surface roughness, which consequently could influence the dentures lifetime and patient satisfaction and prevent the development of denture stomatitis [7, 8, 11].

One of the most accurate methods for determining the surface roughness of certain materials is the use of atomic force microscopy, which is non-invasive and can successfully be used on different types of resins [12].

We consider it is important for the general dental practitioners to have a good understanding of how their patients are cleaning their dentures and how the different cleaning methods influence the surface characteristics of their dentures.

The aim of this in vitro study is to determine how different cleaning protocols, using widely available products, affect the surface roughness of the “ThermoSens” denture base resin.

The null hypothesis is that the commonly available cleaning methods would not have an effect on the surface roughness of the “ThermoSens” denture base material.

Materials and methods. Forty test specimens were fabricated from polyamide material “ThermoSens” with a thickness of 3 mm and a diameter of 10 mm. They were divided into ten (T1-T10) groups based on the experimental cleaning conditions under which they were placed, as shown in Fig. 1. After the respective cleaning procedure, the test specimens were stored in artificial saliva at 37 °C.

Experimental groups based on experimental conditions.

T1	Control	• Without cleaning • + 24 h in artificial saliva at 37 °C
T2	Corega	• Cleaning every day • 5 min + 24 h in artificial saliva at 37 °C
T3	Corega	• Cleaning three times per week • 5 min + 24 h in artificial saliva at 37 °C
T4	Protefix	• Cleaning every day • 10 min + 24 h in artificial saliva at 37 °C
T5	Protefix	• Cleaning every day • 8 h + 16 h in artificial saliva at 37 °C
T6	Protefix	• Cleaning three times per week • 10 min + 24 h in artificial saliva at 37 °C
T7	Protefix	• Cleaning three times per week • 8 h + 16 h in artificial saliva at 37 °C
T8	Soft brush with toothpaste	• Cleaning every day • + 24 h in artificial saliva at 37 °C
T9	Soft brush with toothpaste	• Cleaning three times per week • + 24 h in artificial saliva at 37 °C
T10	Soft brush with soap	• Cleaning every day • + 24 h in artificial saliva at 37 °C

Fig. 1. Schematic representation of the experimental setup, T1(test specimen 1), T2 (test specimen 2), ..., T10 (test specimen 10) – methods of treating the test specimens

Composition of the artificial saliva used for storing the test specimens. Sodium carboxymethylcellulose (stabilizer, improving consistency and viscosity), Potassium chloride (KCl), Sodium chloride (NaCl), Magnesium chloride (MgCl₂), Calcium chloride (CaCl₂), Di-potassium hydrogen orthophosphate (K₂HPO₄), Potassium di-hydrogen orthophosphate (KH₂PO₄), Sodium fluoride (NaF), Sorbitol, Methyl p-hydroxybenzoate (chemical stabilizer, preservative).

After 30 days of treatment, the surface of each test specimen was examined using atomic force microscopy. By examining the test specimens, we sought changes in their surface characteristics, i.e. changes in roughness. The roughness of the denture surface is measured using three indicators: Ra – average roughness

(arithmetic mean); Rq – root mean square roughness (standard deviation); Rmax – the difference between the highest and lowest scanning points (peak-to-valley). Among these parameters, Ra has the greatest practical application.

Statistical methods. The statistical methods used in the analysis of the research results were as follows:

1. Descriptive statistics – calculation of the arithmetic mean (Mean), determination of the number of units – absolute (N); determination of relative share or percentage (relative %).
2. Exploratory analysis.
3. Statistical hypothesis testing:
 - Kolmogorov–Smirnov test for testing normal distribution;
 - Kruskal–Wallis test for differences between more than two independent groups.

The level of significance was determined at a risk of error of 5% ($\alpha = 0.05$) and a confidence level of 95%.

Results. The results of the conducted experiment showed that the control group (T1) had the lowest level of roughness (Ra mean 17.4 nm). The group using Protefix every day + 24 hours in artificial saliva at 37 °C: 8 hours (T5) exhibited double the average roughness (Ra mean 46.8 nm). The highest roughness was found when using a soft brush and paste every day + 24 hours in artificial saliva at 37 °C (T8). It was nearly 5 times higher (mean 100.6 nm) than that of the control group, as shown in Fig. 2.

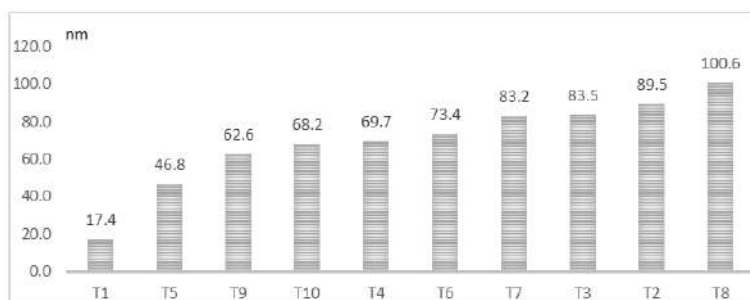


Fig. 2. Mean values of the Ra parameter (nm) depending on the treatment methods

Compared to the control group (T1), all other treatment methods have a statistically significantly higher level of roughness. Treatment with Protefix every day + 24 hours in artificial saliva at 37 °C for 10 min (T5) is closest to having no difference with the control group [p -value = 0.042], but the level is still lower than the error rate [$\alpha = 5.0\%$]. This same fifth setup also has statistically lower roughness than setups T2, T3, T7, and T8. This suggests that setup T5 is indeed very close to the control group, which in turn is statistically significantly smoother than the other setups. There is only one more significant difference, and it is between

setup T8 and T10, in favour of greater roughness for T10. These conclusions can be asserted with a 95% probability, (Fig. 3).

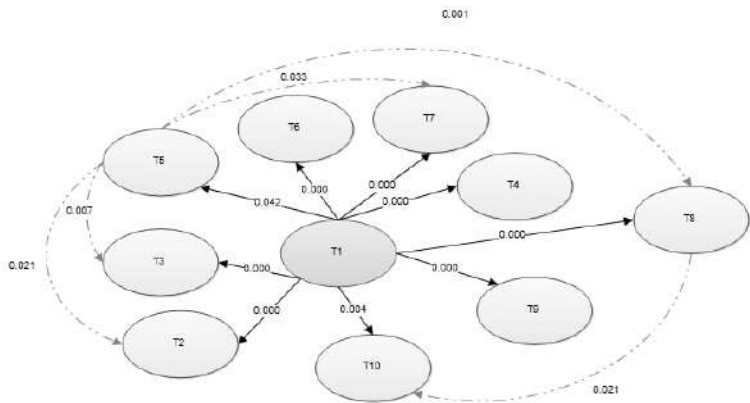


Fig. 3. Detailed distribution of differences between experimental groups – level of significance (p)

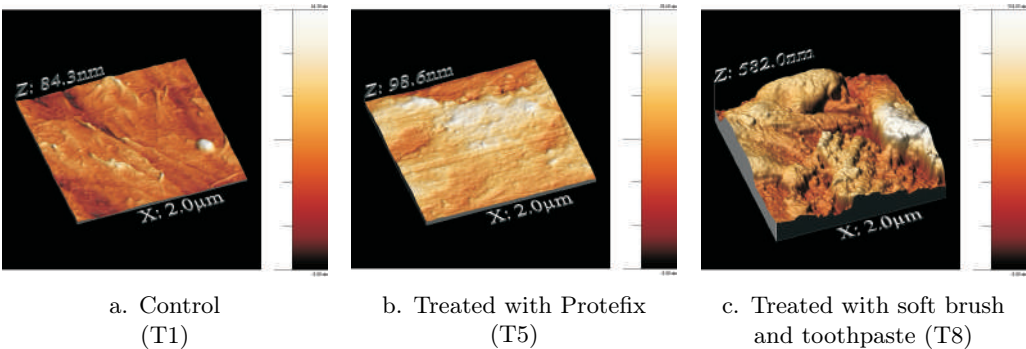


Fig. 4. AFM images from experimental setups T5 and T8

Discussion. When it comes to the disinfection of their removable dentures, the patient has to be well instructed and educated [13]. This means that the clinician should have extensive knowledge regarding which method of disinfection to recommend [11]. Regarding the disinfection of flexible dentures and more specifically “ThermoSens” removable dentures, Bulgarian clinicians recommend the use of cleaning tablets (44%) followed by soap and brush (31%) and toothpaste and brush (19%) [14], this trend is confirmed by other authors [11]. Most of the manufacturers of the base material used in flexible dentures also manufacture their own brand of cleaning agents, which are to be used with the corresponding base material. Atomic Force Microscopy (AFM) is a modern and widely applicable method in the field of nanotechnology for studying the surface structure and topography of various test specimens, providing high precision and resolution in the

nanometer scale.

The two test groups regarding the use of Corega cleaning tablets demonstrated significantly higher mean surface roughness (T2 – 89.5 nm, T3 – 83.5 nm) when compared to the values presented in the control group (T1 – 17.4 nm). Both test groups were submerged for 5 min, following the manufacturer guidelines [15]. A study done by SARAF et al. [16] came to a similar conclusion that the peroxide denture cleanser increased the Ra of the flexible denture base resin, unlike a study by MOTAWEA et al. [17] that concluded that the use of Corega tablets does not affect the surface roughness of the material. The increased Ra could be the result from the exposure to the oxygen and enzymes, which are the main products, released from the Corega tablets [10, 18].

OZYILMAZ and AKIN [19] consider that the daily use of Protefix denture cleaning tablets leads to the increase of surface roughness of the flexible denture base materials. The results we obtained regarding the effect of Protefix cleaning tablets on the surface roughness of the test samples are compared to the other test and control groups and reject the null hypothesis. They confirm the observations of some authors [17, 18]. Although in the present study it was found that these cleaning tablets have the least negative impact on the Ra of the test samples (T1 – average 17.4 nm / T5 – average 46.8 nm). Groups T4 and T6 were submerged for 10 min, as per the manufacturer guidelines, while groups T5 and T7 were submerged for 8 hours, replicating what most patients practically do when it comes to the use of these tablets [20].

The use of soap and toothbrush as a method to clean the removable dentures remains popular amongst patients [11, 14]. From our study, tested group T10 showed an average Ra of 68.2 nm, almost four times higher than the control group. This is mainly due to the abrasive effect of the toothbrush rather than the composition of the used standard hand soap [9]. The results we obtained in both tested groups, where a cleaning combination of soft brush and toothpaste was used, confirm that all mechanical cleaning techniques involving the use of a toothbrush have a negative effect on the denture base material surface [9], and that daily use (T8 – 100.6 nm) leads to a six-fold increase of the Ra compared to the control group (T1 – 17.4 nm).

After analyzing the results in the present study we rejected the null hypothesis, that the various cleaning methods would not have a negative effect on the Ra of the tested material. The results show that when it comes to flexible dentures the clinicians would recommend the use of soap and brush over the use of toothpaste and brush. This can possibly be linked to the presence of abrasive particles in the toothpaste which could damage the dentures surface [8].

Although the use of Protefix cleaning tablets resulted in an increase in the surface roughness of the test samples, the protocol involving the daily nightly use of these cleaning tablets in combination with the use of a brush and soap three times a week appeared to be the most appropriate as it would prevent

the colonization of microorganisms with minimal damage to the surface of the “ThermoSens” polyamide material.

This in vitro study has several limitations. It did not account for decontamination with mouth rinsing solution changes in pH and temperature in the oral cavity, factors that could potentially influence the roughness of polyamide materials. Additionally, this study did not analyze the ageing of the materials as a factor that could be significant, considering the impact of the oral environment over time. All of these factors could affect the findings and applicability of the results in this study. Further research in a controlled clinical setting would enrich the findings obtained in this study.

Conclusion. Within the limitations of this study, it can be concluded that the treatment methods significantly alter the roughness of the removable dentures. The cleaning protocol using Protefix tablets every day for 8 hours (overnight) demonstrates relatively minimal impact on the roughness of the polyamide material and in this regard, it may be recommended as the most suitable method for cleaning “ThermoSens” dentures.

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