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Original article

EFFECT OF DIFFERENT CLEANING PROTOCOLS ON THE HARDNESS OF FLEXIBLE DENTURE BASE MATERIAL "THERMOSENS"

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ABSTRACT

Introduction. The growing use of flexible dentures in everyday dental practice calls for further studies on how various disinfection methods influence their mechanical properties, particularly their hardness.

Purpose. The aim of the study was to evaluate how different cleaning techniques under varying conditions affect the hardness (HVN) of the "ThermoSens" denture base material.

Materials and Methods. Forty flexible denture samples, measuring 10 mm in width and 3 mm in height, were made and grouped into ten sets (T1-T10) based on the disinfection method applied. For 30 days, all samples were submerged in artificial saliva and cleaned with common products (soap, toothpaste, Protefix, and Corega tablets). Each sample was then evaluated in five surface areas using the Vickers hardness test, with the data statistically analyzed using IBM SPSS Statistics 26, Excel 2015, and EdrawMax 7.

Results. No statistically significant difference was found between the individual groups using different disinfection methods and protocols compared to the control group. Only in **group 2**, daily cleaning with Corega tablets (9.3 HVN) resulted in a statistically significant increase in hardness compared to the control group. When comparing experimental **group 2** with the other groups, a statistically significant difference was found with all groups except **group 3** (9.0 HVN) and **group 4** (9.1 HVN). Groups 2, 3, and 4 exhibited the highest hardness.

Conclusion. The use of different conventional cleaning methods does not alter the hardness of the flexible ThermoSens denture base material.

Keywords: disinfection, flexible denture, hardness, polyamide, ThermoSens,

INTRODUCTION

Denture base materials have evolved significantly to meet diverse patient needs, with conventional polymethyl methacrylate (PMMA) and newer flexible materials like Vertex "ThermoSens" representing two distinct treatment approaches. PMMA, long considered the "gold standard" for removable dentures, is known for its rigidity, ease of processing, and cost-effectiveness. However, its brittleness, potential for residual monomer allergies, and discomfort for some patients have driven the development of flexible alternatives [1, 2].

"ThermoSens", a monomer-free microcrystalline polyamide-based thermoplastic material, offers notable advantages, including enhanced flexibility, superior impact resistance, and biocompatibility, making it ideal for patients with allergies to PMMA [3] or those requiring lightweight, comfortable removable partial dentures (RPDs). Its flexibility allows for better adaptation to oral tissues, improved aesthetics due to translucent clasps, and increased patient satisfaction in cases where traditional dentures may be unsuitable, such as in patients with irregular undercuts or sensitive mucosa [4].

Despite these benefits, flexible denture materials like "ThermoSens" typically exhibit lower hardness compared to conventional PMMA, which often demonstrates higher resistance to indentation and wear due to its denser polymer structure. Hardness, a critical mechanical property, directly influences a denture's durability, resistance to scratching, and susceptibility to microbial colonization. [5].

The maintenance of dentures relies heavily on cleaning protocols, which include mechanical methods (e.g., brushing) and chemical methods (e.g., immersion in cleansers like Corega or Protefix). These protocols, while essential for hygiene, can alter the surface properties of denture materials, potentially compromising hardness through abrasion, chemical degradation, or water sorption [6].

For "ThermoSens", with its higher water absorption and less rigid composition compared to PMMA, the impact of cleaning methods on hardness is particularly significant and warrants thorough investigation [7].

The **aim** of this study is to investigate the effects of various cleaning protocols on the hardness of Vertex "ThermoSens".

The **null hypothesis** is that the commonly available cleaning methods would not have an effect on the hardness of the "ThermoSens" denture base material.

MATERIALS AND METHODS

A total of 40 test samples with a thickness of 3 mm and a diameter of 10 mm were prepared. They were divided into ten groups (11-14, 21-104) based on the experimental cleaning conditions applied.

Ten experimental setups were designed to simulate real cleaning and storage methods for flexible dentures. The prototypes of the test samples were produced using standard wax elimination, packaging, and injection molding techniques of thermoplastic material under pressure.

Experimental groups based on experimental conditions:

1. **First group** (control group, samples 11-14): No cleaning, storage for 24 hours in artificial saliva at 37°C.
2. **Second group** (samples 21-24): Daily cleaning with Corega cleaning tablets (GlaxoSmithKline, UK) for 5 minutes, storage for 24 hours in artificial saliva at 37°C.
3. **Third group** (samples 31-34): Cleaning three times a week with Corega cleaning tablets (GlaxoSmithKline, UK) for 5 minutes, storage for 24 hours in artificial saliva at 37°C.
4. **Fourth group** (samples 41-44): Daily cleaning with Protefix cleaning tablets (Queisser Pharma, Germany) for 10 minutes, storage for 24 hours in artificial saliva at 37°C.
5. **Fifth group** (samples 51-54): Daily cleaning with Protefix cleaning tablets (Queisser Pharma, Germany) for 8 hours, storage for 24 hours in artificial saliva at 37°C.
6. **Sixth group** (samples 61-64): Cleaning three times a week with Protefix cleaning tablets (Queisser Pharma, Germany) for 10 minutes, storage for 24 hours in artificial saliva at 37°C.
7. **Seventh group** (samples 71-74): Cleaning three times a week with Protefix cleaning tablets (Queisser Pharma, Germany) for 8 hours, storage for 24 hours in artificial saliva at 37°C.
8. **Eighth group** (samples 81-84): Daily cleaning with a soft brush and toothpaste for 5 seconds per sample, storage for 24 hours in artificial saliva at 37°C.
9. **Ninth group** (samples 91-94): Cleaning three times a week with a soft brush and toothpaste for 5 seconds per sample, storage for 24 hours in artificial saliva at 37°C.
10. **Tenth group** (samples 101-104): Daily cleaning with a soft brush and soap for 5 seconds per sample, storage for 24 hours in artificial saliva at 37°C.

Each rest specimen from each group was tested at five different points using the **Vickers hardness method**.

The determination of hardness using the Vickers method was carried out on a ZHVμ-M stand (Zwick/Roell, England) under the following test conditions:

1. Applied force – 0.5 kg (5 N);
2. Duration of impact – 10 s;
3. Ambient temperature – 23°C;
4. Number of measurements per test sample – 5

When selecting the measurement point, the requirements for sufficient spacing between the indentations and from the edge of the test sample were followed. During the experimental measurements, the symmetry of the arms of the visible optical cross was also monitored.

RESULTS

In this study, the effect of disinfection methods on hardness, expressed as Vickers hardness, is investigated. For this purpose, 10 groups of 4 samples each, tested at 5 points, are compared, with one group serving as the control. If a significant change in hardness is observed in any experimental group compared to the control group, it indicates that the disinfection method used in that group has a substantial impact on hardness. Whether such groups exist will be determined through statistical hypothesis testing.

The average hardness of the control group is 8.7 HVN. The same hardness is observed in the 5th, 9th, and 10th experimental groups. All other groups, to a greater or lesser extent, have higher hardness levels, with the highest being in group 2 (9.3 HVN) (Table 1)

Table 1. Results of the test for differences in hardness between the control group and the experimental group.

Evaluated groups	**Characteristics**		
	Average	**±SD**	**N**
Control group	8.7^{AVE}	±0.57	20
Experimental group 2	9.3^{B}	±0.47	20
Experimental group 3	9.0^{EBG}	±0.56	20
Experimental group 4	9.1^{AB}	±0.51	20
Experimental group 5	8.7^{VG}	±0.67	20
Experimental group 6	8.6^{V}	±0.82	20
Experimental group 7	8.8^{AGV}	±0.70	20
Experimental group 8	$8.8^{ÀGV}$	±0.70	20
Experimental group 9	8.7^{AGV}	±0.47	20
Experimental group 10	8.7^{AGV}	±0.47	20
ANOVA test	**p=0.007**		

* For groups marked with the same letter, no statistically significant difference was observed.

No statistically significant difference was found between the individual groups using different disinfection methods and protocols compared to the control group. Only in group 2 was a statistically significant increase in hardness observed. When comparing experimental group 2 with the other groups, a statistically significant difference was found with all groups except group 3 and group 4. Groups 2, 3, and 4 exhibited the highest hardness. Experimental group 3 (9.0 HVN) showed a statistically significant difference only with group 6 (8.6 HVN).

The hardness obtained in group 4 (9.1 HVN) showed a statistically significant difference compared to group 5 (8.7 HVN) and group 6 (8.6 HVN). Group 5 showed a difference with groups 2 and 4, while group 6 showed a difference with groups 2, 3, and 4. For groups 7–10, a difference was found only compared to experimental group 2. These conclusions can be asserted with a 95% probability.

DISCUSSION

Hardness is a fundamental mechanical property that significantly influences the suitability of acrylic and polyamide materials, such as polyamide 12 (PA12) and specifically the "ThermoSens" material, for dental prosthetic constructions [8]. This property reflects a material's ability to withstand occlusal forces encountered during chewing, as well as its resistance to surface damage such as scratching and abrasion [9]. The hardness of a material is closely tied to its molecular structure, degree of polymerization, and cross-linking density, which collectively determine its durability and performance in clinical applications [10].

In technical terms, hardness is defined as the resistance of a material to permanent deformation or penetration by a harder body, typically measured by the depth or size of an indentation created under controlled conditions. Several standardized methods exist for measuring hardness, each suited to specific materials and applications. The most commonly employed methods include Vickers, Knoop, Brinell, Shore, and Rockwell [11].

These methods differ in the geometry of the indenter, the applied load, and the measurement technique. For dental materials, particularly thermoplastic polymers like polyamides, the Vickers and Knoop hardness tests are preferred due to their precision in measuring micro-hardness on small or thin samples [12].

The Vickers hardness test method uses a diamond indenter in the shape of a square-based pyramid. A specified load is applied, and the hardness is calculated based on the average length of the two diagonals of the resulting indentation. The Vickers test is advantageous for its versatility across a wide range of materials and its ability to provide accurate and reproducible results, even on brittle or thin samples [13]. The Vickers method was selected for the study in question due to its reliability in assessing the hardness of thermoplastic polymers like "ThermoSens". The test's ability to measure both diagonals of the indentation ensures greater accuracy, particularly for materials with complex surface characteristics.

Research on polyamide denture base materials, which include ThermoSens, has shown that chemical cleansers can significantly alter mechanical properties. A study published in 2019 [14] evaluated the impact of various denture cleansers, including Corega and Protefix, on polyamide resins. The study involved immersing specimens in these cleansers for 8 hours daily over 140 days, simulating prolonged exposure. Results indicated a significant decrease in hardness for polyamide, with baseline hardness at 14.3 HVN dropping to approximately 10.5 HVN for Corega and Protefix, compared to a control group immersed in distilled water. This decrease is likely due to the chemical interaction of the cleansers, which may degrade the polyamide structure over time.

The study also noted that effervescent tablets like Corega and Protefix significantly altered hardness compared to Curaprox, another cleanser, suggesting that the chemical composition, including oxidants and acids, plays a role in this effect. Given ThermoSens's polyamide nature, it is reasonable to extrapolate that similar exposure to Corega and Protefix would decrease its hardness, potentially benefiting its flexibility by preventing undesirable hardening. However, it's important to consider that the study's prolonged immersion may not reflect typical usage, where cleansers are often used for 15-30 minutes daily.

A study by Altarawneh et al. [15] focused on Polident, another cleanser, and found a decrease in flexural modulus but no significant change in hardness after shorter exposures. This suggests that the extent of hardness reduction may depend on exposure duration and cleanser type, with Corega and Protefix potentially having a more pronounced effect due to their formulation.

A 2022 study by Tullbah et al. further supports the notion that chemical cleaning agents generally do not significantly alter the hardness of polyamide-based removable prostheses [16]. The authors attributed this stability to the inherent mechanical resilience of thermoplastic polyamides, which are known for their high toughness and resistance to chemical degradation [17,18]. ThermoSens, as a specialized PA12 material, likely benefits from these properties, potentially explaining the minimal hardness increase in most experimental groups.

The literature on the effects of disinfection methods on polyamide-based dental materials is limited, particularly for PA12 and "ThermoSens". However, studies on other polyamides, such as Valplast, provide some context. Research has shown that disinfection with chemical agents like Corega or Protefix tablets typically results in no significant change when it comes to the hardness of the polyamide material [19].

For conventional brushing with soap and toothpaste, direct evidence specific to ThermoSens is scarce. A 2021 study by Chang et al. [20] included polyamide resins and subjected them to 50,000 strokes of brushing, simulating 5 years of cleaning. The study measured hardness using the Vickers hardness test after brushing, reporting a value of 9.11 HVN for polyamide, but did not provide baseline hardness, making it difficult to assess changes. It concluded that brushing increased surface roughness significantly but found no correlation between hardness and wear, suggesting that hardness might not be significantly affected by brushing alone. Our findings also suggest that brushing did not affect the hardness of the test specimens.

A 2015 study by Panariello et al. [21] found that brushing with dentifrice did not significantly affect hardness, unlike brushing with chemical agents like sodium hypochlorite and Corega Tabs, which decreased hardness. Given "ThermoSens" different material composition, brushing with soap and toothpaste likely has a minimal impact on hardness, primarily affecting surface properties like roughness, as mechanical abrasion is less likely to penetrate the bulk material compared to chemical degradation.

Manufacturer recommendations also guide cleaning practices. A 2022 overview, by Mylonas et al. [6], emphasized tailoring cleaning methods to denture materials, noting that flexible dentures require specific silicone-bristled brushes to avoid damage. This suggests that brushing with standard toothbrushes and abrasive toothpaste could increase surface roughness, potentially affecting wear resistance, but the impact on hardness remains underexplored for "ThermoSens "specifically.

CONCLUSION

These findings highlight the need to carefully evaluate disinfection protocols for flexible dental materials to avoid unintended changes in their mechanical properties. The results show that the majority of conventional methods used for cleaning the denture surface, such as soap, toothpaste, and a brush, do not significantly increase the hardness of the "ThermoSens" test specimens. The use of different chemical methods for disinfection demonstrates that the peroxide based Corega denture cleansers lead to àn increase in the hardness of the material compared to the Protefix tablets. This increase in hardness requires further studies to understand better the effect of chemical denture cleansers on the polyamide 12 denture base material.

REFERENCES:

1. Barraclough O, Gray D, Ali Z, Nattres B. Modern partial dentures - part 1: novel manufacturing techniques. *Br Dent J*. 2021 May;230(10):651–657. [PubMed]

2. Chuchulska B, Yankov S, Hristov I, Aleksandrov, S. Thermoplastic Materials in the Dental Practice: A Review. *Int J Sci Research (IJSR)*. 2017 Dec;6(12):1074–1076. [Crossref]

3. Lim GS, Buzayan MM, Elkezza AH, Sekar K. The development of flexible denture materials and concept: a narrative review. *Jummec*. 2021; 24(1):23-29. [Internet]

4. Bana K, Shadab S, Hakeem S. Ilyas F. Comparing Oral Health-related Quality of Life (OHIP-14) and Masticatory Efficiency with Complete Denture Treatment. *J Coll Physicians Surg Pak*. 2021 Jun;31(6): 694-698. [PubMed]

5. Gomaa A, Lamfon H, Maher Y. Microbiological and immunological effects of monomer free thermosens and nano zirconia oxide reinforced denture base resins on controlled diabetic denture wearers. *Egypt Dent J*. 2019 Jan;65(1):563-577. [Crossref]

6. Mylonas P, Milward P, McAndrew R. Denture cleanliness and hygiene: an overview. *Br Dent J*. 2022 Jul;233(1):20–26. [PubMed]

7. Ucar Y, Akova T, Aysan I. Mechanical Properties of Polyamide Versus Different PMMA Denture Base Materials. *J Prosthodont*. 2012 Apr;21(3):173–176. [PubMed]

8. Radev R, Apostolov N. Chemical structure of the flexible material Vertex "ThermoSens". *Medinform*. 2025; 12(2):2053-2253. [Internet]

9. Mansour MM, Wagner WC, Chu TG. Effect of Mica Reinforcement on the Flexural Strength and Microhardness of Polymethyl Methacrylate Denture Resin. *J Prosthodont*. 2013 Apr;22(3):179–183. [PubMed]

10. Parr GR, Rueggeberg FA. In vitro hardness, water sorption, and resin solubility of laboratory-processed and autopolymerized long-term resilient denture liners over one year of water storage. *J Prosthet Dent.* 2002 Aug;88(2):139–144. [PubMed]

11. Germak A, Herrmann K, Low S. Traceability in hardness measurements: from the definition to industry. *Metrologia.* 2010;47(2):S59–S66. [Crossref]

12. Li K, Xue D. Hardness of materials: studies at levels from atoms to crystals. *Chin Sci Bull*. 2009 Jan;54(1):131–136. [Crossref]

13. Duymus ZY, Ozdogan A, Ulu H, Ozbayram O. Evaluation the Vickers Hardness of Denture Base Materials. *Open J Stomatol*. 2016; 06(04):114–119. [Crossref]

14. Ozyilmaz OY, Akin C. Effect of cleansers on denture base resins' structural properties. *J Appl Biomater Funct Mater.* 2019 Jan-Mar;17(1):

228080001982779. [PubMed]

15. Mofreh Altarawneh H, Nasser Alhajj M, Mohd Salleh N, Elkezza A, Adida Mahmood, W. Effect of Denture Cleanser on the Physico-Mechanical Properties of Injection-Molded Thermoplastic Polyamides Denture Base Material: A preliminary Study. *Acta Stomatol Croat.* 2023 Dec;57(4):329–338. [PubMed]

16. Tulbah HI. Anticandidal efficacy on polymide based denture resin using Photodynamic therapy, chemical and herbal disinfectants and their effect on surface roughness and hardness. *Photodiagnosis Photodyn Ther.* 2022 Sep;39:102874. [PubMed]

17. Pinto Lde R, Acosta EJ, Távora FF, da Silva PM, Porto VC. Effect of repeated cycles of chemical disinfection on the roughness and hardness of hard reline acrylic resins. *Gerodontology.* 2010 Jun;27(2):147-53. [PubMed]

18. Porwal A, Khandelwal M, Punia V, Sharma V. Effect of denture cleansers on color stability, surface roughness, and hardness of different denture base resins. *J Indian Prosthodont Soc.* 2017 Jan-Mar; 17(1):61-67. [PubMed]

19. Durkan R, Ayaz EA, Bagis B, Gurbuz A, Ozturk N, Korkmaz FM. Comparative effects of denture cleansers on physical properties of polyamide and polymethyl methacrylate base polymers. *Dent Mater J.* 2013; 32(3):367-75. [PubMed]

20. Chang YH, Lee CY, Hsu MS, DU JK, Chen KK, Wu JH. Effect of toothbrush/dentifrice abrasion on weight variation, surface roughness, surface morphology and hardness of conventional and CAD/CAM denture base materials. *Dent Mater J.* 2021 Jan 31;40(1):220–227. [PubMed]

21. Panariello BH, Izumida FE, Moffa EB, Pavarina A, Jorge J, Giampaolo E. Effects of short-term immersion and brushing with different denture cleansers on the roughness, hardness, and color of two types of acrylic resin. *Am J Dent.* 2015 Jun;28(3):150-6. [PubMed]

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