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Impact of different cleaning methods on the flexural strength of "ThermoSens" denture base materials

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Abstract

A variety of thermoplastic materials, including "ThermoSens", a nylon-based denture base material, can be used in the fabrication of removable partial dentures. Assessing the mechanical properties of these materials is crucial, as they directly impact the function and longevity of the dentures. Thermoplastic polyamides, known as nylons, represent an excellent alternative that can be used for treatment of partially edentulous patients with removable dentures.

Aim. The aim of this study was to evaluate the impact of ten distinct cleaning methods on the flexural strength of "ThermoSens", using a classical three-point bending test.

Materials and methods. The study involved 50 standardized "ThermoSens" test specimens divided into ten groups, subjected to varied cleaning protocols including Corega and Protefix tablets, soft toothbrush with toothpaste or soap, and no cleaning (control). Cleaning frequency and duration differed across groups, with all specimens stored in artificial saliva at 37°C for 24 hours. The flexural strength test was carried out using a stand type MultiTest 2,5i (Mecmesin, UK), calculating the force required to break the test bodies, following standard testing specifics. Statistical analysis was performed using ANOVA ($p=0.018$) to assess differences between groups.

Results. The results indicate that cleaning methods affect "ThermoSens" flexural strength, with Groups 5 and 6 (using Protefix tablets) showing a statistically significant difference with the control group.

Conclusion. All cleaning methods lead to an increase in the flexural strength of the thermoplastic material, though further research is needed to refine cleaning protocols.

Keywords: denture base material, nylon, flexural strength, polyamide, "ThermoSens", denture cleansers, disinfection

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Introduction

Flexible denture base materials, such as thermoplastic polyamides, have gained popularity in prosthodontics due to their enhanced comfort, aesthetics, and biocompatibility compared to traditional rigid acrylic resins. “ThermoSens” (Vertex Dental, Netherlands), a thermoplastic polyamide-based material, is specifically designed for injection-molded flexible dentures, offering advantages like high impact resistance, low water absorption, and monomer-free composition, which reduce the risk of allergic reactions and improve patient satisfaction (1–3). However, the long-term performance of these materials is influenced by daily maintenance practices, particularly cleaning methods, which are essential for oral hygiene and preventing microbial colonization, staining, or degradation (4–6).

Flexural strength, a critical mechanical property, measures a material's ability to withstand bending forces without fracturing, simulating the masticatory stresses experienced by dentures in the oral environment (7,8). Reduced flexural strength can lead to denture fractures, compromising functionality and necessitating repairs or replacements. Previous studies have indicated that chemical cleaning agents, mechanical brushing, and storage conditions may alter the surface integrity and molecular structure of polyamide-based materials, potentially through plasticization, abrasion, or chemical interactions (4,9). For instance, effervescent tablets like Corega and Protefix, commonly used for denture cleansing, contain oxidizing agents and enzymes that could affect material properties over time, while mechanical methods involving brushes and abrasives might cause micro-scratches or wear (10,11).

Despite the widespread use of “ThermoSens”, limited research exists on how various cleaning protocols influences its flexural strength, especially under simulated daily use conditions. This study aims to evaluate the effects of different cleaning methods—including effervescent tablets at varying frequencies and durations, as well as mechanical brushing with toothpaste or soap—on the three-point bending strength of “ThermoSens” samples.

By comparing experimental groups to a control, the investigation seeks to identify cleaning practices that maintain or enhance material durability, providing evidence-based recommendations for clinicians and patients to optimize denture longevity.

Aim

The aim of this study was to evaluate the impact of ten distinct cleaning methods on the flexural strength of “ThermoSens”, using a classical three-point bending test.

Materials and Methods

For the three-point bending strength tests, 50 parallelepiped bodies were prepared with the corresponding dimensions for length, width, and height: 65x10x2.5 mm, following ADA Specification No. 12 (as of 2013 - ISO 20795-1:2013).

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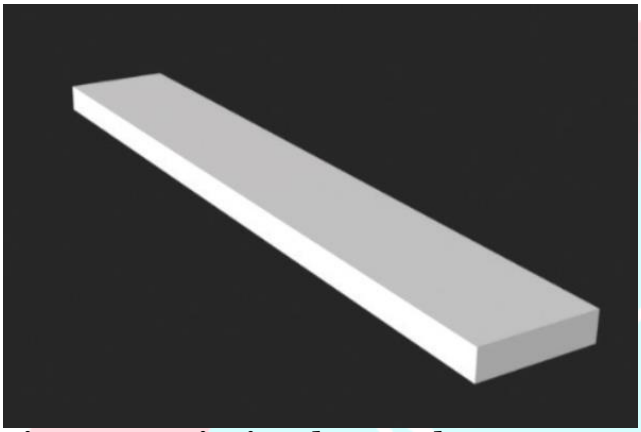

Due to the lack of possibility for direct fabrication of test specimens with the above dimensions from the "ThermoSens" material, owing to the technical specifics of the extrusion method, it was necessary to create a template with these dimensions.

This template was designed using the "Meshmixer" program and corresponds to the given dimensions: 65x10x2.5 mm (Fig. 1).

Figure 1: Designing the template

After creating this virtual prototype, it was sent to a dental laboratory, where it was milled from white plastic using a CAD/CAM machine. The template dimensions were checked after milling (Fig. 2).

Three similar templates were created using the above method. In the next stage, these templates were delivered to a dental laboratory to be packed in special flasks used for fabricating "ThermoSens" dentures. During the packing process, silicone is used to create the shape of the test specimens.

Figure 2: Checking the length of the template

After closing the flask, it is placed in a special press, where the molten thermoplastic polyamide is extruded and then pressed under pressure. The melting of the polyamide is performed in a specialized furnace. After applying the material and pressing, the flask is allowed to cool and then opened (Fig. 3).

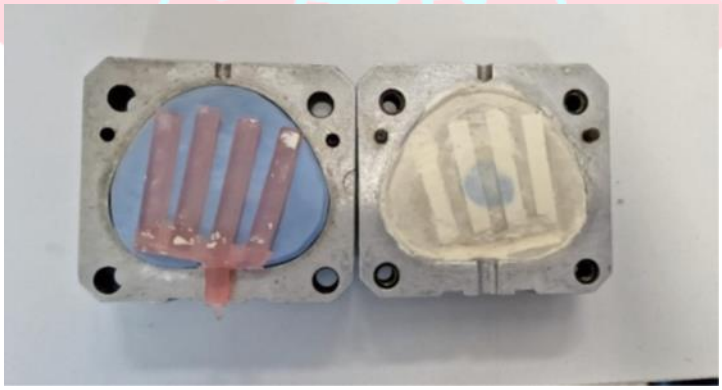

Figure 3: The two halves of the flask with already hardened thermoplastic polyamide "ThermoSens"

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After removing the test specimens from the flask, following their separation from the casting sprue and channel. Defects and deformations on the specimens themselves are monitored; if there are irregularities and defects, they are corrected. The test specimens are measured in the same way as the pre-made templates in white plastic.
Using the above method, a total of 50 test specimens were fabricated.

Experimental groups:
The test specimens are divided into groups depending on the cleaning method used and whether they are part of the control or experimental group (groups A (11-15) and B (21-105).
- First group (A) – 5 test specimens made from thermoplastic polyamide "ThermoSens" – control group;
- Second group (B) – 45 test specimens made from thermoplastic polyamide "ThermoSens" – experimental group;

For executing this sub-objective, the fabricated test specimens were placed under ten (10) experimental setups depending on the cleaning agents used and storage methods for different denture materials.

Experimental groups based on experimental conditions:
- First group (control group, samples A11-15): No cleaning, storage for 24 hours in artificial saliva at 37°C.
- Second group (samples B21-25): Daily cleaning with Corega cleaning tablets (GlaxoSmithKline, UK) for 5 minutes, storage for 24 hours in artificial saliva at 37°C.
- Third group (samples B31-35): Cleaning three times a week with Corega cleaning tablets (GlaxoSmithKline, UK) for 5 minutes, storage for 24 hours in artificial saliva at 37°C.
- Fourth group (samples B41-45): Daily cleaning with Protefix cleaning tablets (Queisser Pharma, Germany) for 10 minutes, storage for 24 hours in artificial saliva at 37°C.
- Fifth group (samples B51-55): Daily cleaning with Protefix cleaning tablets (Queisser Pharma, Germany) for 8 hours, storage for 24 hours in artificial saliva at 37°C.
- Sixth group (samples B61-65): 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.
- Seventh group (samples B71-75): 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.
- Eighth group (samples B81-85): Daily cleaning with a soft brush and toothpaste for 5 seconds per sample, storage for 24 hours in artificial saliva at 37°C.
- Ninth group (samples B91-95): 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.
- Tenth group (samples B101-105): Daily cleaning with a soft brush and soap for 5 seconds per sample, storage for 24 hours in artificial saliva at 37°C.

The test for determining three-point bending strength was performed on a MultiTest 2.5i stand (Mecmesin, UK) under the following testing conditions:
- Inter-support distance – 40 ÷ 46 mm,
- Crosshead speed – 1 mm/min;
- Ambient temperature – 23 °C;
- Sampling rate – 50 Hz.

The inter-support distance of the fixture for positioning the sample is specifically recalculated and adjusted before experimental loading. The collection of test results starts from the initial contact

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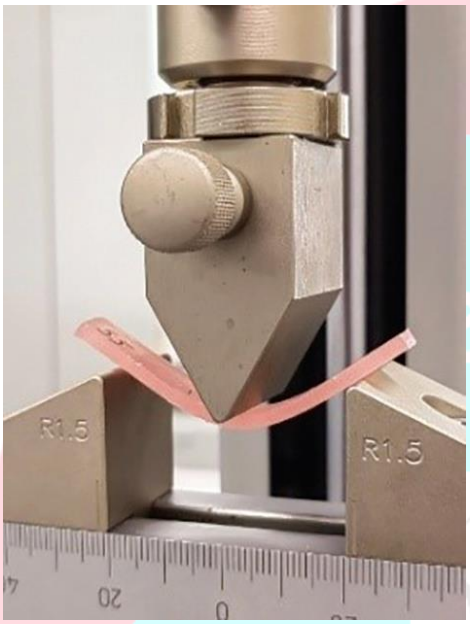
of the loading pin and continues (Fig. 4) until a visibly sustained decrease in the resistance force of the test specimen.



To calculate the maximum bending strength under three-point loading for a specific test specimen, the following formula is applied:

σfM = (3FL)/(2bh2) [MPa]

- F is the measured maximum resistance force [N];
- L – value of the inter-support distance [mm];
- b – width of the test specimen (the larger value of the section dimensions) [mm];
- h – thickness of the test specimen (the smaller value of the section dimensions) [mm].

From the corresponding test file with stored displacement and force data, the necessary values are extracted to be applied in the formula.

Figure 4: Test specimen subjected to three-point bending test.

Results

The effect of disinfection methods on three-point flexural strength expressed as σfM is evaluated. For this purpose, 10 groups of 5 test specimens were compared, with one group serving as the control. The mean flexural strength of the control group is 53.8 MPa. With the exception of experimental Group 10 (51.4 MPa), all other groups demonstrate higher mean flexural strength. The highest value among them is observed in experimental Group 6 with a flexural strength of 57.8 MPa (Fig. 5).

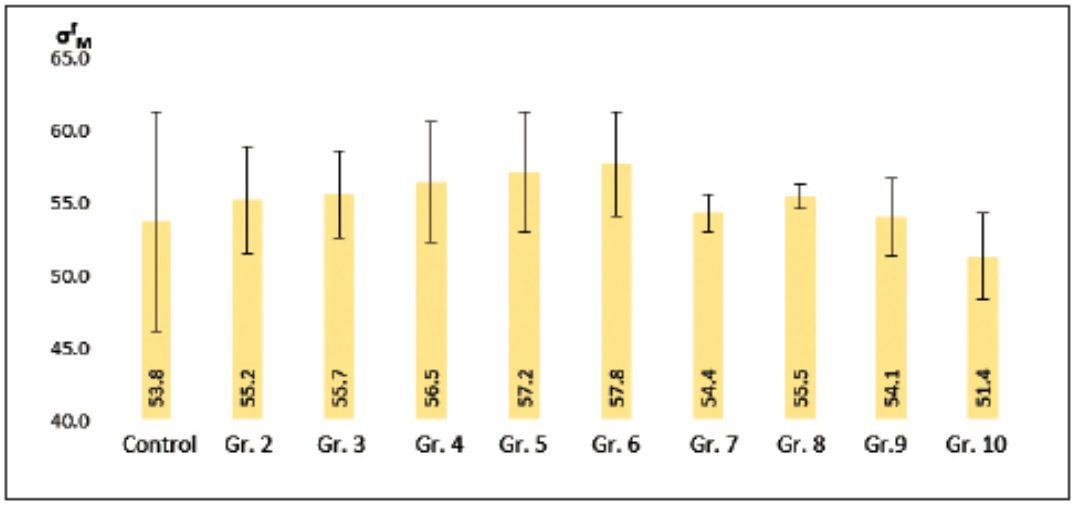


Figure 5: Mean flexural strength levels in the control and experimental groups

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In all experimental groups except Group 10, an increase in flexural strength compared to the control group is observed.
The results fall into the expected range for extremely flexible resin materials of 40-55 MPa, following the ISO 20795-1:2013 standard for flexural strength of flexible denture base materials.
When comparing the flexural strength obtained in all experimental groups with that of the control group, it is concluded that a statistically significant difference is observed only in Group 5 and Group 6. These conclusions can be asserted with 95% confidence.

Discussion

The present study evaluated the impact of various disinfection and cleaning protocols on the three-point flexural strength (σfM) of ThermoSens thermoplastic polyamide specimens over a simulated 30-day period in artificial saliva at 37°C. Notably, most experimental groups exhibited an increase in flexural strength compared to the control (no cleaning, storage only), indicating reduced flexibility (increased stiffness) of the material following exposure to chemical cleansers. This trend aligns with observations that chemical disinfection agents can alter the mechanical behavior of flexible denture base polymers, often through surface interactions, plasticization effects, or minor cross-linking changes (10,12).
The control group's mean flexural strength (53.8 MPa) was lower than that of groups treated with peroxide-based (Corega) or hypochlorite-based (Protefix) tablets, consistent with findings by Singh et al. (2018) (13), who reported reduced flexural properties in untreated or saliva-stored thermoplastic polyamide specimens relative to those exposed to cleansers. Similarly, Salman et al. (2011) (14) documented decreased flexibility (implying increased stiffness or strength in some contexts) in thermoplastic polyamides after immersion in denture cleaning tablets. Our results for Corega-treated groups (mean 55.2 MPa in daily short immersion) closely mirror those of Motawea et al. (15), who reported 53.78 MPa under comparable conditions, supporting the reproducibility of mild strengthening or stabilization effects from peroxide-based agents at short exposures.
In contrast, prolonged or specific hypochlorite exposures (e.g., Protefix protocols in Groups 5 and 6) yielded the highest strengths (57.2–57.8 MPa), yet literature on alkaline hypochlorites, such as Ozyilmaz et al. (2019) (10), suggests potential deterioration in mechanical properties of polyamides due to surface roughness increases and hardness reductions. The apparent difference may stem from differences in exposure duration, concentration, or material-specific responses, as our shorter intermittent protocols appeared beneficial rather than deleterious. Mechanical cleaning methods (brushing with toothpaste or soap) generally preserved strength near control levels, with soap-based daily brushing showing a slight decrease (51.4 MPa), though not statistically significant versus control in most comparisons.
The currently available literature lacks direct data on mechanical brushing effects on flexural strength in thermoplastic polyamides, highlighting a gap that our findings begin to address.
Limitations of the present study
This study has several limitations that should be considered when interpreting the results. First, as an in vitro investigation, the experimental conditions only partially simulate the complex intraoral environment. Second, the study focused exclusively on one thermoplastic polyamide material

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("ThermoSens"). The observed changes in flexural strength may not be generalizable to other polyamide-based denture base resins or different brands, as variations in polymer composition, processing techniques, and additives can lead to differing responses to cleaning agents. Third, the sample size per group (n=5) was modest, which, while sufficient to detect statistically significant differences in Groups 5 and 6, may have limited the power to identify subtler effects in other groups. These limitations underscore the importance of future in vivo or longer-term in vitro studies to validate the clinical relevance of the observed effects and to refine evidence-based cleaning recommendations for thermoplastic polyamide dentures.

Conclusion

The majority of the tested cleaning methods resulted in an increase in flexural strength (ranging from 51.4 to 57.8 MPa) relative to the control group (53.8 MPa), except for Group T10 (daily cleaning with a soft brush and soap, 51.4 MPa), which showed a slightly lower value. Statistically significant increases in flexural strength were observed specifically in Group T5 (daily immersion in Protefix tablets for 10 minutes) and Group T6 (immersion in Protefix tablets three times per week for 10 minutes).

References

1. Ardelean L, Bortun CM, Podariu AC, Rusu LC. Thermoplastic Resins used in Dentistry. In: Thermoplastic Elastomers - Synthesis and Applications. InTech; 2015. doi:10.5772/60931
2. Chuchulska B, Yankov S, Hristov I, Aleksandrov S. Thermoplastic Materials in the Dental Practice: A Review. International Journal of Science and Research (IJSR). 2017 Dec 5;6(12):1074–6. doi:10.21275/ART20178727
3. Singh K, Aeran H, Kumar N, Gupta N. Flexible thermoplastic denture base materials for aesthetical removable partial denture framework. J Clin Diagn Res. 2013 Oct;7(10):2372-3. doi: 10.7860/JCDR/2013/5020.3527. Epub 2013 Oct 5. PMID: 24298532; PMCID: PMC3843478.
4. Žilinskas J, Junevičius J, Česaitis K, Junevičiūtė G. The effect of cleaning substances on the surface of denture base material. Medical Science Monitor. 2013;19:1142–5. doi:10.12659/MSM.889568
5. Porojan L, Vasiliu RD, Porojan SD, Bîrdeanu MI. Surface Quality Evaluation of Removable Thermoplastic Dental Appliances Related to Staining Beverages and Cleaning Agents. Polymers (Basel). 2020 Aug 3;12(8):1736. doi:10.3390/polym12081736
6. Radev R, Apostolov N, Radeva E, Yankova M. The Influence of Different Cleaning Methods on the Surface Roughness of "ThermoSens" Denture Base Material. Proceedings of the Bulgarian Academy of Sciences. 2025 Jul 17;78(7). doi:10.7546/CRABS.2025.07.14
7. Hamanaka I, Takahashi Y, Shimizu H. Mechanical properties of injection-molded thermoplastic denture base resins. Acta Odontol Scand. 2011 Mar 27;69(2):75–9. doi:10.3109/00016357.2010.517557
8. Ucar Y, Akova T, Aysan I. Mechanical Properties of Polyamide Versus Different PMMA Denture Base Materials. Journal of Prosthodontics. 2012 Apr;21(3):173–6. doi:10.1111/j.1532-849X.2011.00804.x
9. 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 May 30;32(3):367–75. doi:10.4012/dmj.2012-110 PubMed PMID: 23718995.

DOI: 10.18044/MEDINFORM.2026131.2382 ISSUE 1, 2026

10. Ozyilmaz OY, Akin C. Effect of cleansers on denture base resins' structural properties. J Appl Biomater Funct Mater. 2019 Jan 25;17(1):228080001982779. doi:10.1177/2280800019827797
11. Ozyilmaz OY, Kara O, Akin C. Evaluation of various denture cleansers on color stability and surface topography of polyetherketoneketone, polyamide, and polymethylmethacrylate. Microsc Res Tech. 2021 Jan 5;84(1):3–11. doi:10.1002/jemt.23558
12. Porwal A, Khandelwal M, Punia V, Sharma V. Effect of denture cleansers on color stability, surface roughness, and hardness of different denture base resins. The Journal of Indian Prosthodontic Society. 2017;17(1):61. doi:10.4103/0972-4052.197940
13. Singh S, Parlani S, Agarwal B, Malaiya A. Evaluation of Flexural Modulus of Flexible Denture Base Material kept in Water, Denture Cleanser, Artificial Saliva, and Open Air for Different Time Intervals: An in vitro Study . International Journal of Prosthodontics and Restorative Dentistry. 2018 Jun;8(2):54–8. doi:10.5005/jp-journals-10019-1204
14. Salman, Mohamad and Shatha Saleem. "Effect of different denture cleanser solutions on some mechanical and physical properties of nylon and acrylic denture base materials." Journal of baghdad college of dentistry 23 (2011): 19-24.
15. Motawea I, Gamal El Deen H, Eltayeb H. Effect of Denture Cleansers on Flexural Strength, Color Stability and Surface Roughness of Flexible and Microwave cured Acrylic Resin. Al-Azhar Dental Journal for Girls. 2017 Jul 1;4(3):311–23. doi:10.21608/adjg.2017.5272

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