Effect of Two Cleansing Agents on Water Sorption and Solubility of Two Thermoplastic Denture Base Materials

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Abstract Aim: Some patients experience adverse reactions to poly (methyl methacrylate)-based (PMMA) dentures. Polyamide (PA) as an alternative to PMMA has, however, not been well documented regarding water sorption and water solubility. The aim of this in vitro study was to evaluate the effect of two different cleansing agents on water sorption and solubility of two different thermoplastic denture base materials. Materials and methods: A total of 60 samples were fabricated from two different thermoplastic denture base materials (i.e. vertex thermosens and breflex). The samples were divided into 3 groups. Each group was including 20 samples, 10 samples from each denture base material. Samples of Group I were subjected to the distilled water as a control group. While samples of Group II were subjected to the Corega as a cleansing agent and samples of Group III were subjected to Fitty dent as the other cleansing agent. Effect of the two cleansing agents on the two-different thermoplastic denture base materials were evaluated and compared with regards water sorption and solubility. Results: Non-significant results were found regarding water sorption and solubility. The fittydent cleansing agent had a slight more non-significant effect on color stability of vertex thermosens and breflex denture base materials than corega cleansing agent and water. The corega and fittydent cleansing agents had a nonsignificant effect on water sorption and solubility of vertex thermosens and breflex denture base materials. Conclusion: Corega and fittydent cleansing agents could be used safely for disinfecting denture base materials (vertex thermosens and breflex) as they had non-significant effect on color stability, water sorption and solubility.

Keywords Polyamide, Cleansing Agents, Water Sorption, Water Solubility

1. Introduction

Many resins have been used for denture base

construction. These materials include heat-activated (polymerized using a water bath or microwave oven), chemically activated (cold polymerized resins), and light-activated denture base acrylic resins. A cross-linking agent may also be added to the monomer component to improve its susceptibility to solvent crazing¹.

Nylon is a generic name for certain types of thermoplastic polymers known as polyamides. Nylon is a crystalline polymer. This crystalline nature lack of solubility in solvents, high heat resistance, and high strength coupled with ductility².

Water sorption and solubility causes dimensional instability, subjecting the material to internal stresses (by the molecules interred the structure of the material from water, cleansing agent etc.) that may result in crack formation which cause fractures of the denture (decrease strength of the material). Because water interacts with the polymer chains, it may lead to effective plasticization of the structure (as in acrylic resin), solvation or reversible rupture of weak inter-chain bonds, and irreversible disruption of the polymer matrix³.

Water molecules spread between the macromolecules of the material, forcing them apart. This behavior affects dimensional behavior and denture stability; therefore, water sorption and solubility of these materials should be as low as possible³.

Water sorption of a denture base resin may cause discoloration, halitosis which alters patient satisfaction. In other words, a higher water sorption rate tends to affect the material properties and consequently reduce the service life of a denture within the oral cavity; therefore, it is preferred to use materials with minimum possible water sorption rates^{4,5}.

Disinfection method should be effective without detrimental effects on the properties of materials used for fabrication of denture base. Everyday use of denture cleansers is recommended to prevent microbial colonization on denture and promote good oral health. Daily use of denture cleansers can affect the physical and mechanical properties of denture base material. In

choosing a disinfectant for a dental prosthesis, consideration should be given to its compatibility with the type of material to be disinfected to avoid adverse effects^{6,7}.

The Aim of this study was that there would be no effect of two different cleansing agents on two different thermoplastic denture base materials (vertex thermosens and breflex) with regards to water sorption and solubility.

2. Materials and Methods

In this in-vitro study, a total of 60 samples were made from two different thermoplastic denture base materials (vertex thermosens, Vertex-Dental B.V. Headquarters Netherlands) and (breflex, bredent Weissenhorner Germany). The samples were divided into 3 groups. Each group included 20 samples, 10 samples from each denture base material. Samples of Group I was subjected to the distilled water as a control group. While samples of Group II were subjected to the Corega as a cleansing agent and samples of Group III were subjected to Fitty dent as the other cleansing agent. The effect of the two cleansing agents on the two-different thermoplastic denture base materials were evaluated and compared with regards to color stability and water sorption and solubility.

Preparation of metal discs

Metal disc shape patterns for water sorption and water solubility (50±1 mm in diameter and 0.5±0.05 mm in thickness) were fabricated from a private engineering works by laser cutting according to ADA specification no. 12⁸. These metal disks were used to prepare the samples for the two denture base materials.

Preparation of samples

Samples of this study were prepared according to the manufacture instructions by injecting thermoplastic materials into special flasks with holes to receive the capsule that contained the powder of thermoplastic material⁹.

The flask filled with plaster then the (metal disk) was put in the flask to make a mould(as a trial denture in denture processing procedure). The sprue of the soft wax was applied to the injection channel of the flask contained the metal disk (to create the pathway for injecting the thermoplastic denture base material later.).

The two halves of the flask were assembled and fastened with screws. The plaster was let to harden. The flasks were placed for 10 minutes in 70°C water to soften the wax. The flasks were opened, and the wax were removed and cleaned with boiling water. The plaster was separated with Thermo-Flow isolation. The flasks were preheated for 15 minutes in water at a temperature higher than 90°C and were put in the machine just before injection. The injection with 6.5 bars of pressure was started after 16 minutes of preheating of the cartridge at 250°C. The complete flasks

were placed in an oven (>100°C) or in boiling water for 30 minutes. In order to achieve optimal quality of the material, the flasks were bench cooling for 20 minutes and it was then opened.

The samples were taken carefully, and the injection channel was cut off. The edges were ground with the cross standard bur. The surface was polished with silicone polishers. Thermo-Gloss and a microfiber polishing brush were used for finishing. The final finish was completed with the brush felt cloth.

Water sorption

Water sorption testing was accomplished by creating ten disks using each material. Finishing of the samples was performed to ensure that the surfaces of these disks were flat and parallel. Abrasive papers were flooded with water throughout the grinding procedures.

Upon completion of finishing procedures, disks were dried (conditioned) in a desiccator containing anhydrous calcium sulfate at 37 ± 2°C for 24 hours fig (1). This cycle was repeated until the weight loss of each disk was not more than 0.5mg in any 24 hours period.

Disks were immersed in distilled water, corega, fittydent cleansing agents for 30 hours which simulated 360 days of cleansing by the patient since the patient cleans the denture only for 5 minute/day, At the end of this period, individual disks were removed from the water with forceps, wiped with a clean dry towel, permitted to air dry for 15 second, and weighed fig (2). Water sorption for each disk was calculated using the formula:

Sorption [mg/mm³] = [mass after immersion (mg)-dry mass (mg)] / volume (mm³)

Water solubility

The disks were used to determine solubility values. The disks were reconditioned to constant weight using the desiccation techniques previously described. Solubility for each disk was determined using the formula:

Solubility (mg/mm³) = [dry mass(mg)- reconditioned mass(mg)] / volume(mm³)

All data collected, tabulated and statically analyzed using one way ANOVA analysis of IBM SPSS software version 22.

Figure 1. (IV-1).Samples in desiccator

Figure 2. Sample weight by electronic balance

3. Results

Sorption

The values of sorption (mg/mm^3) of vertex thermosens and breflex when using water were $0.1171 \pm 0.0496 \text{ mg}/\text{mm}^3$ and $0.1152 \pm 0.0445 \text{ mg}/\text{mm}^3$, in comparison between the values of sorption of both denture bases showed no significant difference ($p\text{-value} = 0.9461$) fig (V-3)

The values of sorption (mg/mm^3) of Vertex thermosens and Breflex when using corega were $0.1492 \pm 0.084 \text{ mg}/\text{mm}^3$ and $0.1533 \pm 0.0554 \text{ mg}/\text{mm}^3$, in comparison between the values of sorption of both denture bases showed no significant difference ($p\text{-value} = 0.9211$) Fig (3).

The values of water sorption (mg/mm^3) of vertex thermosens and breflex when using fittydent as cleansing agent were $0.1491 \pm 0.084 \text{ mg}/\text{mm}^3$ and $0.1532 \pm 0.0554 \text{ mg}/\text{mm}^3$, in comparison between the values of sorption of both denture bases showed no significant difference ($p\text{-value} = 0.9211$) Fig (V-3).

Figure 3. Showing bar chart showing the mean values of sorption (mg/mm^3) for different groups.

Solubility

The results of solubility (mg/mm^3) of vertex

thermosens and breflex when using water were $0.0905 \pm 0.0115 \text{ mg}/\text{mm}^3$ for both groups. Comparison between the values of sorption of both denture bases showed no significant difference ($p\text{-value} = 1$) Fig (4).

The values of solubility (mg/mm^3) of vertex thermosens and breflex when using corega were $0.1201 \pm 0.0482 \text{ mg}/\text{mm}^3$ and $0.1381 \pm 0.053 \text{ mg}/\text{mm}^3$, in comparison between the values of sorption of both denture bases showed no significant difference ($p\text{-value} = 0.5091$) Fig (4).

The values of solubility (mg/mm^3) of vertex thermosens and breflex when using fittydent were $0.0989 \pm 0.0612 \text{ mg}/\text{mm}^3$ and $0.0946 \pm 0.0595 \text{ mg}/\text{mm}^3$, in comparison between the values of sorption of both denture bases showed no significant difference ($p\text{-value} = 0.8950$) Fig (4).

Figure 4. Bar chart showing the mean values of solubility (mg/mm^3) for different groups

4. Discussion

Nylon with relatively low water sorption levels and melting points, were developed to overcome earlier forms of denture base materials. It was further modified by reinforcement with glass fiber and glass spheres to increase its potential use as a denture base material. This improvised material showed better strength, stiffness, dimensional stability and lower water sorption¹⁰.

The vertex thermosens and breflex were used as a denture base materials in this study as these new materials are rigid as they have structure of along chains and molecular arrangement order as more carbon hydrogen bonds that decrease the liability for water molecules to inter an desruct the chemical structural of the denture base material which affect water sorption and solubility of the denture base material improved the mechanical and chemical properties^{11,12}.

In this study, the water sorption and solubility were measured. The water sorption was determined according to increase in mass per unit volume. The samples size was ($50 \pm 1 \text{ mm} \times 0.5 \pm 0.05 \text{ mm}$) according to ADA no 12 specifications for water sorption and solubility test. 4 digits electronic balance was used for accurate records⁸.

The nylon denture base material molecules are hygroscopic, its moisture content varying slowly with the surrounding conditions. Hargreaves found that the frequency of amide groups along the chain affects the water sorption and the chemical properties of each type of nylon. Thus, as 610 nylon has the most widely spaced amide groups, it absorbs the least water and has the best chemical resistance. The same author observed that nylons 11 and 12 both contain very long methylene chains and have relatively low melting points and water absorption levels¹³.

Kurtulmus et al¹⁴, showed no significant difference in mean values of liquid sorption among polymerization methods of some heat-polymerized and nylon resins; however, they found that the denture base material containing cross-linking agents absorbed fewer solutions than the materials without cross-linking agents.

The result of the present study may differ from the results of last studies as the denture base material used in this study is of rigid form of thermoplastic denture materials and we used thinner section so little finishing of the samples size

The amide groups are polar and may form intra- and inter-chain hydrogen bonds. Hydrogen bonds may also be formed between thermoplastic materials and water molecules, and nylon material will absorb some water. The polarity of nylon material will vary with the chain length between the amide groups, the shorter the chain, the more hydrophilic is the material as in the recent types of denture base that used in this study (vertex thermosens and breflex). Thus, a polyamide 6 material will be more hydrophilic than a polyamide 12 material, and higher water sorption may be expected¹⁵.

The present study showed that corega cleansing agent had the highest value of sorption and solubility when compared to water and fittydent, but the differences were insignificant and this may be due to that corega cleansing agent contain potassium carboxylate citric acid, sodium carbonate, tetra acetyl ethylene diamine, sodium carbonate peroxide, sodium lauryl sulfocetate and sodium benzoate which is not contained in fittydent that may cause slight oxidation of carbon hydrogen bonds of the amide groups of the denture base materials used in this study. The oxidation of these bonds may be led to sorption and solubility.

5. Conclusions

Based on the results of this study, we can conclude that:

1. Cleansing agents had no noticeable effect on the physical properties of the recent denture base materials (vertex thermosens and breflex).
2. Nonsignificant differences were found between vertex thermosens and breflex denture base materials with the use of different cleansing agents

(corega, fittydent, water) regarding color stability, water sorption and solubility.

REFERENCES

- [1] Jorge H, Giampaolo T, Machado L. Cytotoxicity of denture base acrylic resins: A literature review. *J Prosthet Dent* 2003; 90:190-193.
- [2] Yunnus N, Rashid A, Azmil L. Some flexural properties of a nylon denture base polymer. *J Oral Rehabil* 2005; 32:65-71.
- [3] Katsumata Y, Hojo S, Hamano N, Watanabe T, Yamaguchi H, Okada S, Teranaka T, Ino S. Bonding strength of autopolymerizing resin to nylon denture base polymer. *Dent Mater J* 2009; 28:409-418.
- [4] Hiromori K, Fujii K, Inoue K. Viscoelastic properties of denture base resins obtained by underwater test. *J Oral Rehabil* 2000; 27:522-531.
- [5] Farzin M, Bahrani F, Adelpour E. Comparison of the effect of two denture cleansers on tensile bond strength of a denture liner. *J Dent Shiraz Univ Med Sci* 2013; 14:130-135.
- [6] Machado L, Giampaolo T, Vergani E, Souza F, Jorge H. Changes in roughness of denture base and reline materials by chemical disinfection or microwave irradiation: Surface roughness of denture base and reline materials *J Appl Oral Sci* 2011; 19:508-528.
- [7] Neppelenbroek H, Pavarina C, Vergani E, Giampaolo T. Hardness of heat - polymerized acrylic resins after disinfection and long-term water immersion. *J Prosthet Dent* 2005; 93:171-176.
- [8] Aubrey C, Swaney A, George C, Paffenbarger D, Harold J, Caul B and Sweeney. American dental association specification no. 12 for denture base resin: second revision. *J Americ Dent Assoc*. 1953; 46:54-66.
- [9] Singh K, Gupta N. Injection molding technique for fabrication of flexible prosthesis from flexible thermoplastic denture base materials. *World J Dent (JADA)* 2012; 4:303-307.
- [10] Douglas M. Nylon as a Denture Base Material. *The Dent Pract Dent Rec* 1962; 13:142-144.
- [11] Kohli S, Bhatia S. Polyamides in dentistry. *Int J Scient Stud* 2013; 1:20-23.
- [12] Robinson J, McCabe J, Storer R. Denture bases: the effects of various treatments on clarity, strength and structure. *J Dent* 1987; 15:159-165.
- [13] Hargreaves A. Nylon as a denture-base material. *Dent Pract Dent Rec* 1971; 22:122-128.
- [14] Kurtulmus H, Kumbuloglu O, Aktas R. Effects of saliva and nasal secretion on some physical properties of four different resin materials. *Med Oral Patol Oral Cir Bucal* 2010; 15:969-997.
- [15] Zissis A, Yannikakis S, Polyzois G. A longterm study on residual monomer release from denture materials. *Eur J Prosthodont Restor Dent* 2008; 16:81-84.