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EFFECTS OF THERMOCYCLING ON SOME PROPERTIES OF POLYAMIDE RESINS IN COMPARISON WITH POLYMETHYL METACRYLATE

POLİ METİL METAKRİLAT İLE KARŞILAŞTIRILDIĞINDA POLİAMİD REZİNLERİN BAZI ÖZELLİKLERİ ÜZERİNE TERMOSİKLASYONUN ETKİLERİ

Hatice AĞAN [1], Gülay KANSU [2]

[1] Acıbadem Mehmet Ali Aydınlar University, Vocational School of Health Services, Istanbul, Turkey
[2] Ankara University, Faculty of Dentistry, Retired Professor

ABSTRACT
Increasing number of products is marketing as flexible, polyamide denture base materials. However, there is limited scientific investigation supporting the application of these materials and studies are needed for the clinical usage of these materials. The aim of this study was to compare these polyamide denture base materials with conventional PMMA. In this research, four PA based denture base materials (Bre-flex, Tcrystal, Valplast, Deflex) as an alternative of conventional denture base resin material (Meliodent, Heat Cure) were examined by in vitro evaluating the contact angle, surface roughness, water sorption and solubility, microbial adhesion of C.albicans and S.mutans before and after thermocycling procedure. Polyamides showed statistically significant differences among the groups for contact angel, surface roughness. After TC except one PA group, contact angle decreases in all groups; surface roughness decreased in PMMA group while PA groups exhibited increased and decreased Ra values.
From the results obtained, both conventional PMMA and PA materials are acceptable for one-year use, as a denture base materials. It can be concluded that polyamide denture base resins will be a good alternative to conventional poly(methyl methacrylate) resins for long-term provisional removable dentures. However careful case selection and clinical judgment is required to use polyamide dentures in appropriate situations in order to obtain a successful treatment outcome.

Keywords: Polyamide, Denture Base, Thermocycling

ÖZET
Artan sayıda ürün fleksibl, poliamid protez kaide materyalleri olarak pazarlanmaktadır. Ancak bu materyallerin uygulanmasını destekleyen sınırlı sayıda bilimsel araştırma vardır ve bu materyallerin klinik kullanımı için çalışmalara ihtiyaç vardır. Bu çalışmanın amacı, bu poliamid protez kaide materyallerini geleneksel PMMA ile karşılaştırmaktı. Bu araştırmada, konvansiyonel protez kaide reçine materyaline (Meliodent, Heat Cure) alternatif olarak dört adet PA bazlı protez kaide materyali (Bre-flex, Tcrystal, Valplast, Deflex) temas açısı değerlendirilerek in vitro olarak incelendi, C.albicans ve S.mutans'ın termosikl işlemi öncesi ve sonrası yüzey pürüzlülüğü, su emilimi ve çözünürlüğü, mikrobiyal adezyonu incelendi. Poliamidler, temas açısı, yüzey pürüzlülüğü açısından gruplar arasında istatistiksel olarak anlamlı farklılıklar göstermiştir. TC'den sonra bir PA grubu hariç tüm gruplarda temas açısı azalır; PMMA grubunda yüzey pürüzlülüğü azalırken, PA gruplarında Ra değerleri artmış ve azalmıştır. Elde edilen sonuçlardan, hem konvansiyonel PMMA hem de PA materyallerinin protez kaide materyali olarak bir yıllık kullanım için kabul edilebilir olduğu görülmüştür. Poliamid protez kaide reçinelerinin, uzun süreli geçici hareketli protezler için geleneksel poli(metil metakrilat) reçinelere iyi bir alternatif olacağı sonucuna varılabilir. Bununla birlikte, başarılı bir tedavi sonucu elde etmek için poliamid protezlerin uygun durumlarda kullanılması için dikkatli vaka seçimi ve klinik muhakeme gereklidir.

Anahtar Kelimeler: Poliamid, Protez Kaidesi, Isıl Döngü

Sorumlu Yazar / Corresponding Author: Hatice AĞAN, Acıbadem Mehmet Ali Aydınlar University, Vocational School of Health Services, Istanbul, Turkey. **E-mail:** aganhatice1@gmail.com

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INTRODUCTION

Since 1937 when acrylic resins were introduced, the plastic industry has undergone a lot of changes in search of new materials. A clinical problem commonly encountered is the inability to choose a suitable path of insertion of PMMA removable partial dentures while maintaining close adaptation to the tissues in the presence of soft and hard tissue undercuts especially for geriatric and disabled denture wearers" (Anusavıce ,2003; Abuzar, et. all., 2010). Nylon was introduced in 1950's as a flexible denture base material, proving to be entirely unsatisfactory owing to its poor ability to resist oral conditions (Khindria, Mittal,& Sukhija, 2009). Development of alternative materials such as polyamides has also been reported in the literature. In the past, these polyamides exhibited specific problems, such as warpage, water sorption, surface roughness and difficulty in polishing (Hargreaves, 1971; Watt, 1955; Munss, 1962). Modified polyamide denture base materials have become available with improved physical and chemical aspects (Yunus, et. All., 2005).

Flexible denture base resins were utilized for the construction of provisional removable prostheses (Goiato, 2008). and mostly used for anterior retention with esthetic requirements, due to their inherient translucency and a natural appearance without laboratorial characterization (Yavuz& Aykent, 2012).

Polyamide resin can offer advantages for some patients since it can be used for patients allergic to PMMA resin (MacGregor, 1984); does not use metallic clasps; is esthetically pleasing; feels comfortable for the wearer since it is thin; and does not fracture easily (Statford &Handley, 1975). Metal-free restorations and prosthesis are future of dentistry due to the increasing aesthetic concerns of patients.

Nylon or polyamide is a family of condensation polymers that result from the reaction of a diacid with a diamine to give a variety of polyamides whose physical and mechanical properties depend on the linking groups between the acid or amin groups (O'Brien, 2002).

These monomers are trapped into the polymer structure and their release into water should be minor. Many denture wearers fail to maintain a satisfactory level of hygiene, since increased porosity of resin materials may lead microbial colonization (Phoenix, 2004; Parr& Rueggeberg, 2002). These disadvantages are associated with surface rougness, water sorption and solubility properties of acrylic resin polymers. However, it has been reported that the wettability of a solid material is influenced by the surface roughness of the solid material itself (Wenzel, 1936; . Nishioka , 2006; Lampin, et. all., 1997).

The wettability of a solid by a liquid is determined by measuring the contact angle between a drop of the liquid and the plane surface of the solid (Zissis, 2001). Wettability of denture base materials is one of the most important properties for denture retantion, because it provides a condition in oral liquids will spread over the surface (Monsénégo , 1989). In the oral cavity, dental materials are exposed to permanent humidity, repeated temperature changes may take place intraorally particularly during ingestion; these circumstances have been simulated by thermal cycling (Hahnel, 2009).

Mechanical, physical and biological properties of PMMA is well documented but have not been studied for polyamide denture base materials. Previous studies of a polyamide denture base resin have investigated microhardness, surface roughness, color stability, flexure strength, candida adhesion, cytotoxicity, effect of dental cleansers and the bonding strength of autopolymerizing resin to polyamide denture base polymer (Abuzar, et. all., 2010; Kurtulmuş, 2010; Goiato, 2010; 2013; . Ali&Raghdaa, 2011; Takabayashi, 2010; Ucar, Akova, Aysan, 2012; Lai, Lui, Lee, 2003, Uzun, et. all., 2013). The purpose of this study was to evaluate the effect of thermocycling on four polyamide based resins in comparison to conventional heat-polymerized poly[methyl metacrylate] resin in some properties such as microbial adhesion, surface roughness, wettability, water sorption and solubility

MATERIALS AND METHODS

Specimen Preparation

Round specimen were prepared in the desired shape from five denture base materials (Table 1) according to the guidelines provided by the manufacturers. Specimens were fabricated by wax loosing method. After the wax was softened and eliminated with boiling water, PMMA specimens were prepared by conventional pressure pack technique while PA specimens were produced by injection moulding technique.

Table 1. Five Denture Base Materials

Group	Material	Polymerization method	Manufacturer
M	Meliodent	Conventional Moulding Heat Cure PMMA	Heraeus Kulzer, GERMANY
B	Bre-flex	Injection moulding PA	Bredent GmbH&Co. KG,Senden GERMANY
D	Deflex	Injection moulding PA	Nuxen SRL, Buenos Aires, ARGENTINA
T	T-crystal	Injection moulding PA	Perflex LTD,Netanya, ISRAEL
V	Valplast	Injection moulding PA	Valplast International Corp., Long Island City, NY,USA

Artificial Ageing

After manufacturing, half of the specimens selected randomly were subjected to 10.000 thermocycles with a dwell time of 30 sec, between 5 to 55ºC.

Surface Roughness and Contact Angle

For surface roughness and contact angle, measurements were carried out with twelve round specimens (diameter 10 mm, thickness 2 mm). Prior and after thermos cycling, surface roughness and contact angles were measured. Peak-to-valley surface roughness (Ra) was determined at three randomly selected spots of each specimen (two at the margins, one in central position) using a profile metric contact surface measurement device (Mahr Perthometer M2, Mahr GmbH, Gottingen, Germany). A distance of 5 mm was measured and a cut off level of 0.25. Each single measurements have been repeated three times and a mean value was calculated.

For the evaluation of surface hydrophobicity, all materials were ultrasonically cleaned in distilled water for 10 minutes. Then the surfaces of the specimens were carefully cleaned using ethanol, and contact angles (bidistilled water) were determined using the sessile drop method and a drop shape analysis (DSA) system (DSA30, Drop Shape Analysis System, Krüss GmbH, Hamburg, Germany). The volume of each water drop syringed on test material surface was 12 µl. Photographs of the drops were taken immediately and contact angle were meascred automatically. This procedure was carried out three times for each specimen and the mean value was calculated.

Water Sorption and Solubility

Five specimens of each material (diameter of 50 mm, thickness of 0,5 mm]) were prepared for the measurements of water sorption and solubility, according to the description of ISO Specification 1567 (ISO, 1999). After processing and thermocycling, specimens were weighed on an analytical balance (Type 2462, Sartorius Werke GMBH, Götingen, Germany), the specimens were placed in distilled water, and dark stored in 37º C for 1 day and weighed (M1). The specimens were placed vertically to not to touch each other, inside a dessicator with 0,4 kg freshly dried silica gel. The dessicator was placed in an oven at 37º C for 23 hours then the dessicator was removed from the owen and placed in room temperature for 1 hour. The specimens were stored in distilled water for 1 week at 37 C then they were weighed again (M2). The specimens were dried and weighed again (M3). Daily weights of the dessicated specimens were obtained until a stable weight reading (±0.001g) was obtained. Volume was calculated using an average of eight diameter and thickness readings. Volume was calculated according to formula: $\pi r^2 h$. The values for water sorption (Wsp) and solubility (Wsl), in µg/mm^3 for each of the specimens were calculated using the following equations: Wsp=M2-M3/V and Wsl=M1-M3/V.

Microbial Adhesion

In order to produce comparable smooth surface, fourteen specimens from each material (diameter 10mm and thickness 2mm) were prepared against glass for each microbial adhesion tests. Half of the randomly selected specimens were used after processing and the other half were used after thermocycling. Glass was pressed onto dental stone in the half part of the flask. After stone had set, wax disks were placed on top of the glass. Another half part of the flask was placed in position and the dental stone was poured over the discs (Bulad, 2004). A frozen (-70ºC) preculture of the strain S. mutans RSKK 676\07033 and C.albicans RSKK 95071\06020 ATCC 10231 (Refik Saydam Hıfzısıhha Enstitüsü, Ulusal Kültür Koleksiyonu, Turkey) was established, and bacteria were transferred onto an agar plate and reactivated for 48 h. at 37 ºC. A single colony of each microorganism were incubated with sterile Trypticase Soy yeast extract medium and Sabouraud dextrose broth at 37 ºC for 24 h, and subsequently kept at 4 ºC. The day before the experiment 1 ml of S. mutans and C. albicans suspensions were inoculated with 250 ml of sterile medium, and incubated for 24 h at 37ºC. Cells were harvested by centrifugation (6000 rpm, 19º C, 15 min; Nüve RF 800, Turkey), washed twice with phosphate buffered saline (PBS; one tablet dissolved in 200 ml of deionized water yields 0.01 M phosphate buffer, 0.0027 M potassium chloride and 0.137 M sodium chloride [pH of 7.4 at 25 ºC]; Sigma–Aldrich, St. Louis, MO, USA) and resuspended in the same buffer the optical density of the bacteria suspension was adjusted to 0.3 at 550 nm for S.mutans and 0.5 at 540 nm for C.albicans (Versa Max Microplate Reader, Sunnyvale, CA 94089 USA).

All resin specimens were stored in distilled water for seven days after manufacturing to minimize potential influences of residual monomer of resin samples (Waltimo, Vallittu & Haapasalo, 2001; Miettinen, Narva &Vallittu, 1999). Before microbial adhesion test specimens were steriled with %70 ethyl alchol for 30 min. then washed with sterile distile water and stored in distiled water for 24 hours. Specimens for each material were transferred to 24 well cell clusters and were incubated with 1 ml of S.mutans and C.albicans suspension. After an incubation time of 2,5 hours, specimens were gently rinsed twice with PBS for removing unbound microorganisms. Than specimens were transferred to test tubes including 1 ml sterile PBS and vortexed for 60 seconds. The sonicated solutions were serially diluted in PBS, for 5 times and the previously prepared petri plates were inoculated with the dripping method. The plates were incubated at 37°C under aerobic conditions for 24-48 hours. Than breeding colonies on the plates were counted visually in the day light with the help of magnifying glass and the results were expressed in colony-forming units (CFU) per area.

Statistical Analysis

Data analysis was performed using SPSS for Windows 11.5 package program. Close to normal distribution of continuous variables measured whether the Shapiro Wilk test homogeneity of variances Levene test was investigated. Descriptive statistics were shown as mean ± standard deviation. Before and after aging aging of materials in each group of measurements, due to the aging of the amount of water absorption and water solubility change whether or not a statistically significant difference between the Wilcoxon signed rank test was investigated. The change in the amount of different conditions, depending on the aging of the material in terms of whether or not a statistically significant difference between the groups were analyzed by Kruskal-Wallis test. If there is no significant difference as a result of Kruskal-Wallis test statistic Conover difference by using the non-parametric multiple comparison test cases that were detected. To see if there is significant difference between conventional material and the others, four Mann-Whitney U tests were performed as post hoc tests with Bonferroni corrections for significance for each test. [0,05/4=0,0125]

RESULTS

Contact Angle

Kruskal-Wallis Test revealed that there are statistically significant differences among the contact angle levels of five materials before the thermo-cycling procedure [$H_{[4]}$= 21,56 p<0,01] and after the thermo-cycling procedure [$H_{[4]}$= 15,92 p<0,01]

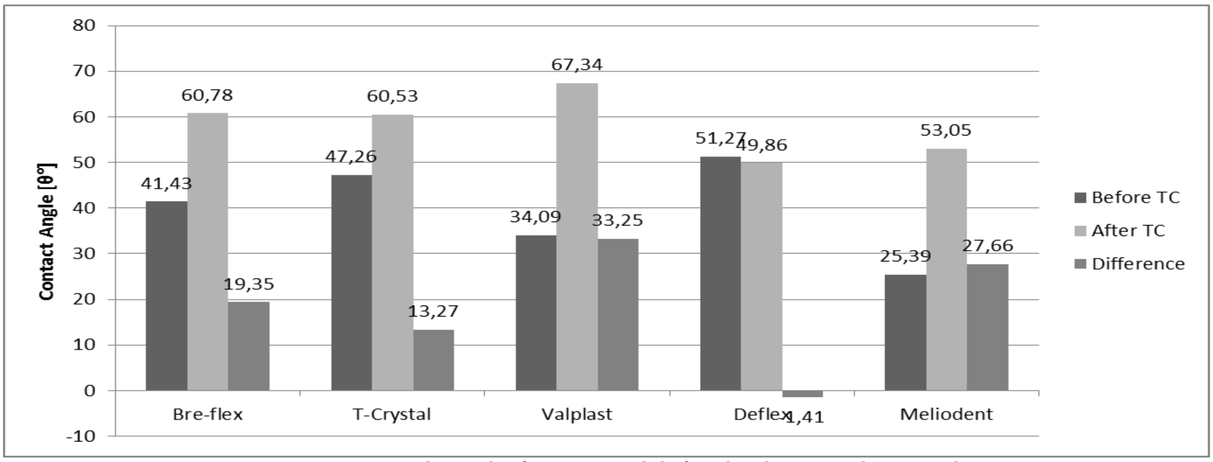

Figure 1. Contact Angle Levels of Five Materials before the Thermo-Cycling Procedure

For material B,T,V,M contact angle level after thermo-cycling procedure is significantly higher than the contact angle level before the thermo-cycling procedure [$p<0,01$]. For material D, there is no statistically significant difference between contact angle level before the thermo-cycling procedure and after the thermo-cycling procedure ($p>0,05$). Before the thermo-cycling procedure, there is no significant difference between contact angle levels of M and B [U=29,00, r= -0,51]; M and V [U=40,00, r= -0,38]. However contact angle level of material M is significantly less than contact angle level of material T [U=19,00, r= -0,62] and material D [U=18,00, r= -0,64]. After the thermo-cycling procedure, there is no significant difference between contact angle levels of M and B [U=35,00, r= -0,44]; M and T [U=40,00, r= -0,38]; M and D [U=54,00, r= -0,21]; but contact angle levels of material M is significantly less than the contact angle level of material V [U=22,00, r= -0,59]

Surface Roughness

Kruskal-Wallis Test revealed that there are statistically significant differences among the surface roughness levels of five materials before the thermo-cycling procedure [$H_{[4]}$= 45,08 $p<0,01$] and after the thermo-cycling procedure [$H_{[4]}$= 35,93 $p<0,01$].

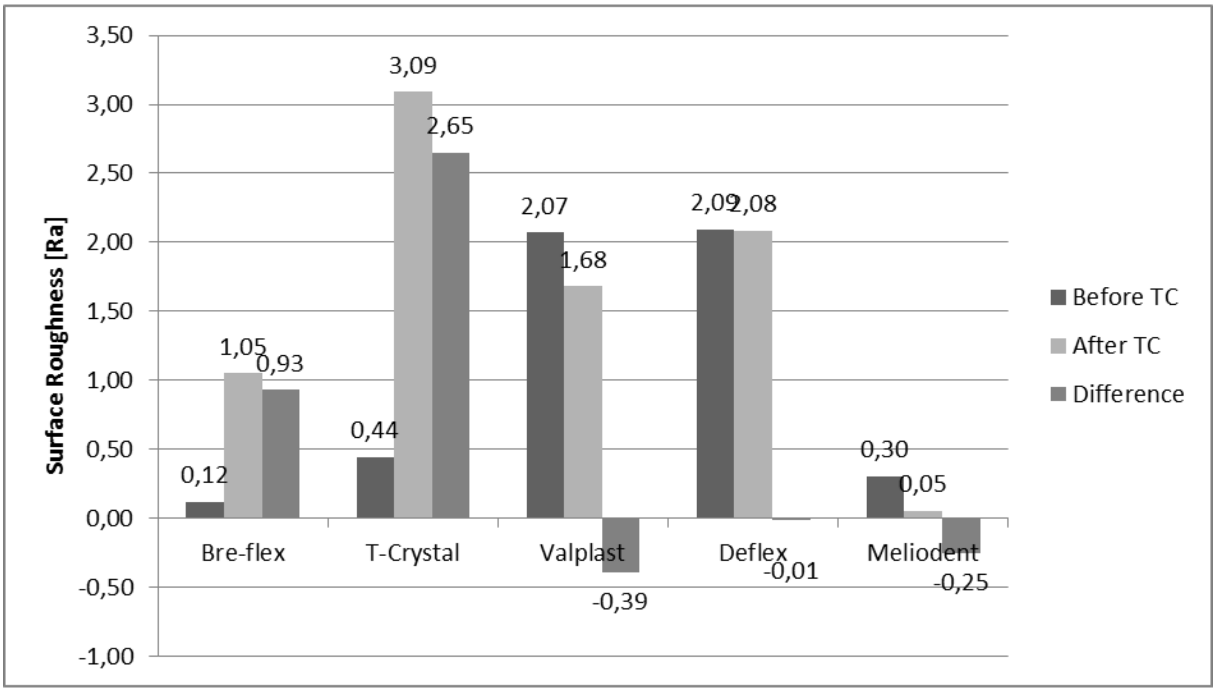

Figure 2. Surface Roughness Levels of Five Materials before the Thermo-Cycling Procedure

For material B (p<0,05), and T (p<0,05) contact angle level after thermo-cycling procedure is significantly higher than the contact angle level before the thermo-cycling procedure. For material V and D, there is no statistically significant difference between surface roughness level before the thermo-cycling procedure and after the thermo-cycling procedure (p>0,05). For material M, surface roughness level after thermo-cycling procedure is significantly less than the surface roughness level before the thermo-cycling procedure (p<0,01). Before the thermo-cycling procedure, there is no significant difference between surface roughness levels of M and B [U=35,00, r=-0,44], M and T [U=55,00, r=-0,02]. However surface roughness levels of material M is significantly less than surface roughness level of material V [U=00,00, r= -0,85] and D [U=00,00, r= -0,85]. After the thermo-cycling procedure surface roughness levels of material M is significantly less than surface roughness level of material B [U=12,00, r= -0,71], T [U=00,00, r= -0,85], V [U=00,00, r= -0,85] and D [U=1,00, r= -0,84].

Water Sorption and Solubility

Kruskal-Wallis Test revealed that there are statistically significant differences among the water sorption levels of the five materials before [H[4]= 11,28 p<0,05] and after the thermo-cycling procedure [H[4]= 10,09 p<0,05].

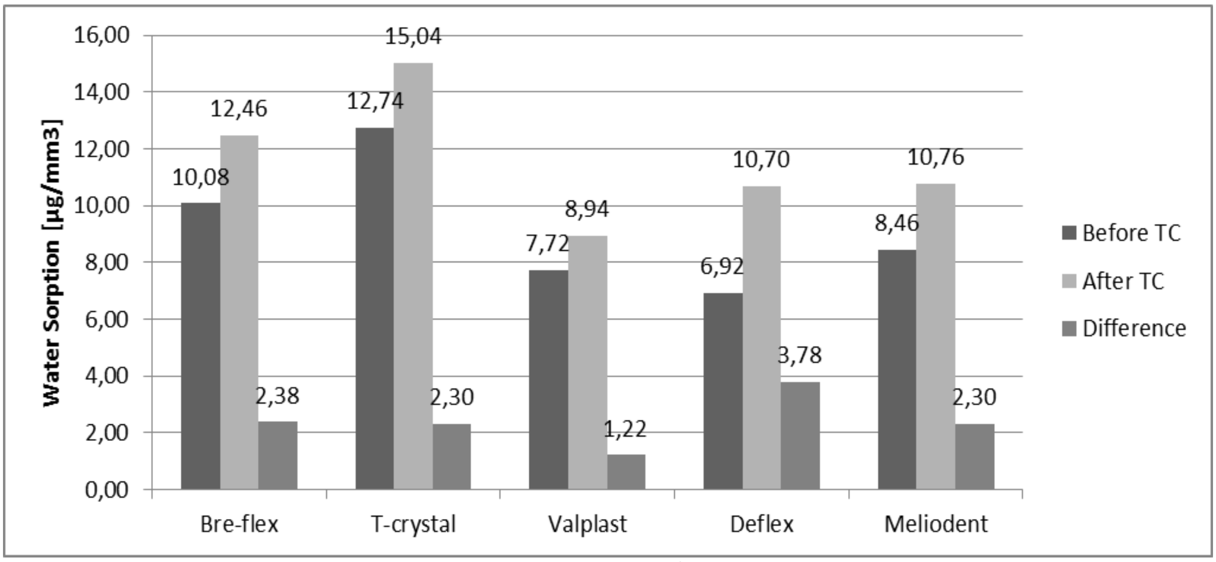

Figure 3. Water Sorption Levels of the Five Materials

For material B,T, D and M water sorption level after thermo-cycling procedure is significantly higher than the water sorption level before the thermo-cycling procedure (p<0,05). However for material V, there is no statistically significant difference between water sorption level before the and after the thermo-cycling procedure (p>0,05).Before and after the thermo-cycling procedure, there is no significant difference between water sorption level of M and B [U=7,00, r= -0,36], [U=10,00, r= -0,17]; M and T [U=2,00, r= -0,69], [U=2,00, r= -0,69]; M and V [U=11,00, r= -0,10], [U=8,00, r= -0,30]; M and D [U=6,00, r= -0,43], [U=11,00, r= -0,10].

Solubility

Kruskal-Wallis Test revealed that there are statistically significant differences among the solubility levels of the five materials before the thermo-cycling procedure [H[4]= 16,16, p<0,01] However there is no statistically significant differences among the solubility levels of the five materials after the thermo-cycling procedure [H[4]= 6,93, p>0,05]. For material B,T,D and M solubility level after thermo-cycling procedure is significantly higher than the solubility level before the thermo-cycling procedure (p<0,05). However for material V, there is no statistically significant difference between solubility level before the and after the thermo-cycling procedure (p>0,05). Before the thermo-cycling procedure, solubility level of M is significantly higher than B [U=0,00, r= -0,83],T [U=0,00, r= -0,83] and V [U=0,00, r= -0,83] However there is no significant difference between solubility level of material M and D [U=1,00, r= -0,76].

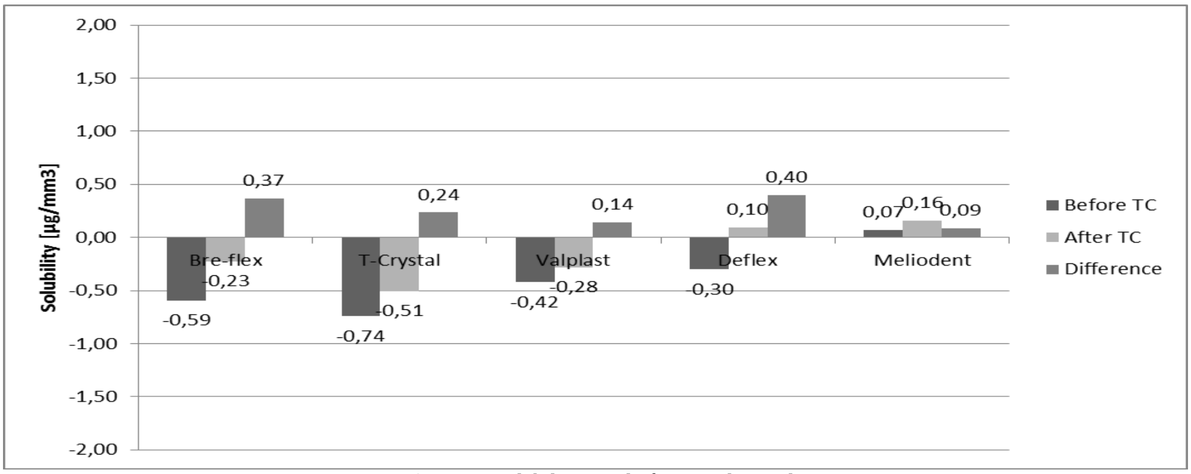

Figure 4. Solubility Level of Material M and D

C.albicans Adhesion

Kruskal-Wallis Test revealed that there are statistically significant differences among the surface roughness levels of five materials before the thermo-cycling procedure [H[4]= 12,05 p<0,05; after the thermo-cycling procedure [H[4]= 11,76 p<0,05].

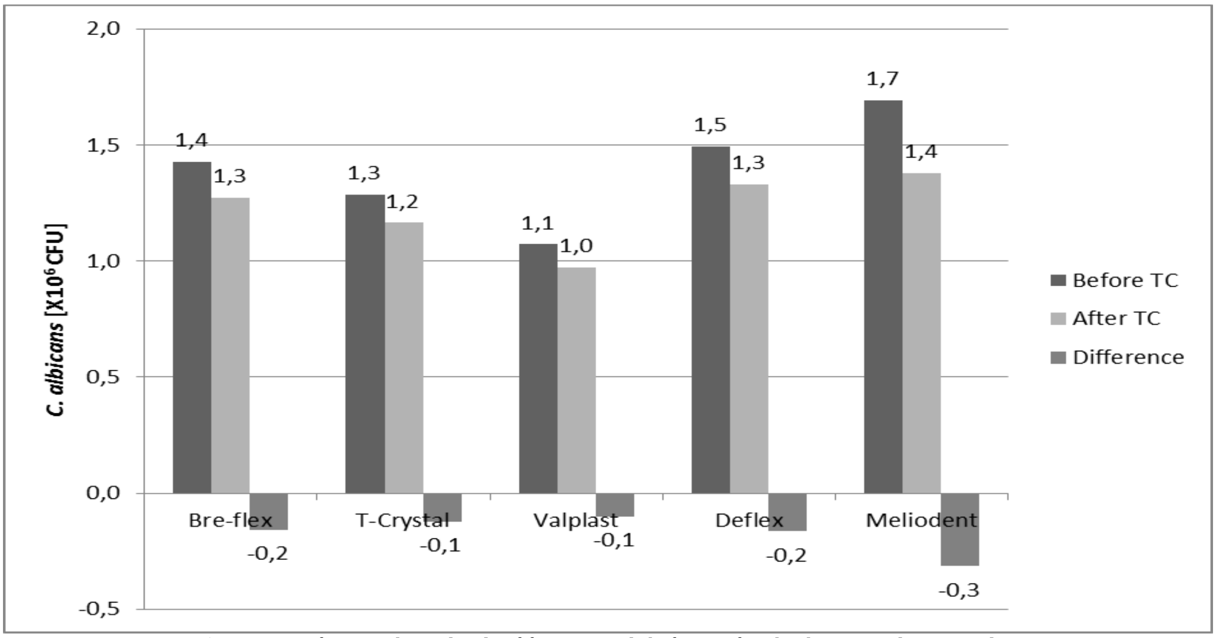

Figure 5. Surface roughness levels of five materials before &after the thermo-cycling procedure

For material B and M, microbial adhesion level of C. albicans after thermo-cycling procedure is significantly less than the adhesion level of C. albicans level before the thermo-cycling procedure (p<0,05). For material T,V and D there is no statistically significant difference between microbial adhesion levels of C. albicans before the thermo-cycling procedure (p>0,05). Before and after the thermo-cycling procedure, there is no significant difference between microbial adhesion levels of C. albicans for material M and B [U=6,50, r= -0,62], [U=10,00, r= -0,50]; M and T [U=5,00, r= -0,67], [U=9,50, r= -0,52]; M and D [U=14,00 r= -0,36], [U=18,50 r= -0,21]. However microbial adhesion levels of C albicans for M is significantly higher than V [U=4,00, r= -0,70].

S.mutans Adhesion

Kruskal-Wallis Test revealed that there are statistically significant differences among the microbial adhesion levels of S. mutans for five materials before the thermo-cycling procedure [H[4]= 16,44 p<0,01] and after the thermo-cycling procedure [H[4]= 19,30 p<0,01]. For material T microbial adhesion level of S. mutans after thermo-cycling procedure is significantly less than the adhesion level of S. mutans while for material V is significantly higher before the thermo-cycling procedure ($p<0,05$). For material B, D and M, there is no statistically significant difference between microbial adhesion levels of S. mutans before and after the thermo-cycling procedure ($p>0,05$). Before the thermo-cycling procedure, there is no significant difference between microbial adhesion levels of S.mutans for M and B [U=7,00, r= -0,60]. However microbial adhesion levels of S.mutans for material M is significantly higher than T [U=0,00, r= -0,84], V [U=0,00, r= -0,84] and D [U=0,00, r= -0,84]. After the thermo-cycling procedure, there is no significant difference between microbial adhesion levels of S. mutans for material M and B [U=7,50, r= -0,58], M and V [U=12,00, r= -0,43]. However microbial adhesion levels of S mutans for material M is significantly higher than T [U=0,00, r= -0,84] and D [U=4,00, r= -0,70].

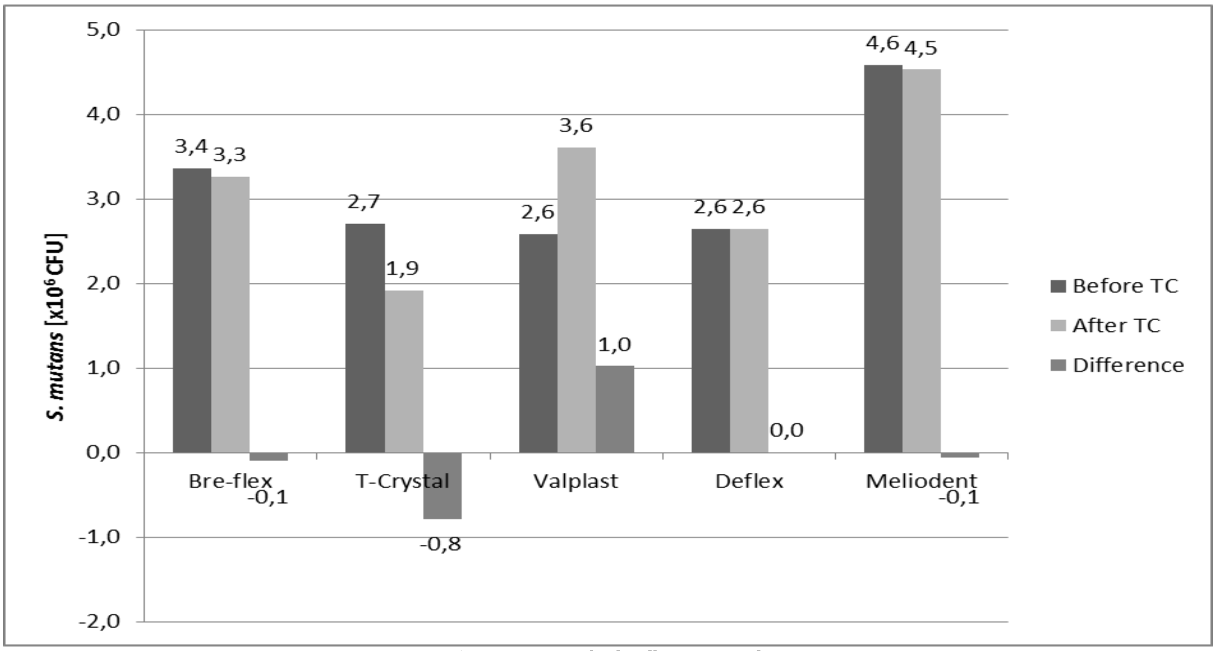

Figure 6. Microbial Adhesion Levels

DISCUSSION

PMMA has been used as a denture base material since many years. Acrylic dentures have their own advantages and disadvantages. Some problems with these prostheses are still difficult to handle such as insertion in undercut areas, brittleness of methyl methacrylate which leads to fracture, and allergy to methyl methacrylate monomer (Anusavıce ,2003; Singh, et. all., 2011). Metal free restorations are gaining popularity in restorative dentistry. Direct, indirect retainers, major and minor connectors are the metal components of conventional removable partial dentures. Flexible resins such as acetal resins and polyamides are being marketed for the construction of retantive and supportive components of removable partial dentures. By this, removable denture may be fabricated without metal alloys (Goiato, 2010; Wu, et. all., 2003).

The functional advantages of the flexible materials are somewhat less obvious. The key to the functional benefit is in the flexibility of the material that helps to shift the burden of force control from the design features of the appliance to the properties of the base material. A lever is more efficient if it is made from a rigid material. Leverage is the critical component of the conventional RPD design that can be controlled using flexible materials. A flexible lever does not work well as a lever. Therefore, a flexible partial denture reduces the leverage effects of its extensions without compromising good retention and support (Thakral , 2012).

Removable partial denture should not only rehabilitate function, esthetic and fonation but also preserve remaining teeth and oral tissues. A clinician should be aware of the advantages and disadvantages of denture base materials to find the best alternative to enhance patient’s comfort and satisfaction. But before clinical use, new technologies always need preliminary in vitro tests for both the methods and materials (Gale& Darvell, 1999). Laboratory simulations of clinical service are often performed because clinical trials are costly and time-consuming (Gale& Darvell, 1999). Thermal cycling, UV radiation and storage in chemical liquids have widely been used in previous studies investigating the influence of artificial ageing of dental materials.

Thermal cycling is an in vivo process often represented in these simulations, but the regimens used vary considerably (Gale& Darvell, 1999; Rossomando& Wendt, 1995, Peterson, Phillips, , Swartz, 1966) The frequency of cycles in vivo remains undetermined and in the absence of this information, it was proposed that on the basis that such cycles might occur between 20 and 50 times in a day, some 10.000 cycles might represent a service year (Gale& Darvell, 1999; Mandras, Retief, Russell, 1991; Morley&Stockwel, 1977). Acrylic resin dentures contain methyl methacrylate (MMA) as residual monomer. MMA has the potential to elicit irritation, inflammation and allergic response of the oral mucosa (Taira, et. all., 2000). Released MMA from acrylic denture may cause mucosal irritations and stomatitis (Keyf& Keyf, 1998). Polyamide denture base materials can be used for patients susceptible to allergic reactions and requiring removable dentures.

Regarding the relationship between surface roughness and wettability, Nishioka (2006), reported that increases in the surface roughness of solids increases the surface area, and the affinity of solids with liquid is enhanced by measuring the contact angle of tar on glass plates and whinstone. Therefore, in hydrophilic solids, hydrophilicity increases with increase in surface roughness; whereas in hydrophobic solids, hydrophobicity increases with increase in surface roughness. High water sorption and solubility of denture base materials cause dimensional chance, discoloration and bad odor. Water sorption depends on the degree of hydrophobicity and porosity of the material (Kasuga, et. all., 2008; Hayakawa, et. all., 2003).

For any dental material, long-term survival under oral conditions is of great concern; for evaluating the ageing behaviour of dental materials, the clinical ageing process is most commonly simulated in vitro. Numerous in vitro studies have been focussing on the influence of artificial ageing on the mechanical performance of denture base materials. However, no evidence is available on the chemical, physical properties and the adhesion of oral microorganisms to the surfaces of artificially aged polyamide denture base materials (Hahnel, et. all., 2010).

Glass side of the specimens simulate the polished surface and stone side simulate the mucosal side of the denture as in the clinical situation as closely as possible. a reduction in surface roughness may help to reduce the destructive effects of abrasion on the soft tissues by reducing friction (Anusavıce, 2003). Surface rouhgness has been found to be one of the most important surface properties influencing microbial adhesion (Hahnel, et. all., 2010). Polyamides have been reported as being difficult to finish and polish due to their low melting temperature and early researchers recommended careful wax-up and minimal adjustment to the dentures after processing (Munss, 1962).

The degree of surface roughness has a considerable influence on the amount of microbial adhesion, with small increases in roughness producing maximal adhesion. However, surfaces with larger pits and gullies corresponding to an increased Ra value did not have the ability to retain bacteria as effectively. These effects were still apparent despite the presence of a conditioning film. Information relating the cell size, degree of attachment and surface topography of materials may be beneficial to industry and medicine where a smooth surface cannot always be guaranteed and where the limits of tolerance of surface roughness need to be defined (Taylor, Maryan, Verran, 1998).

Increased Ra theoretically will give rise to a larger surface area. However, the results obtained in a previous study did not parallel this relationship completely, suggesting that specific types of roughness may enhance retention of a specific species (Taylor, Maryan, Verran, 1998; Taylor, et. all. 1998). There is also no direct relation between increased Ra values and microbial colonization in this study.

This study has shown that thermos cycling had no significant effect on C.albicans colonization and there is no statistically difference in C.albicans adhesion to PMMA and PA specimens (p=0,263). However, a recent study has found that Candida biofilms demonstrated significantly higher growth on PA resin compared with PMMA resin (Freitas Fernandes et. all., 2011). In that study one PA resin showed significantly higher, one PA resin showed significantly lower S.mutans adhesion than PMMA specimens (p<0,01) and two PA resin demonstrated similar bacterial growth compared with PMMA. Branting et al. (1998), showed that adhesion of C.albicans to acrylic surfaces was enhanced when the yeast was incubated simultaneously with S.mutans. In this study S. mutans and C. albicans adhesion were examined separately.

The influence that surface roughness has on polymer characteristics would also depend on the composition of the polymer. The roughening of thermoplastics with additives may result in alterations to the surface chemistry and the release into the immediate environment of chemicals which may affect bacterial adhesion (Taylor et. all., 1998). The chemical composition of the surface is important for microbial adhesion, particularly when the surface possesses components which are either beneficial or detrimental to the adhering population (Quirynen, 1994).

It is generally accepted that surfaces with water contact angles higher than 90º are referred to as hydrophobic, whereas surfaces with water contact angles lower than 90º are described as hydrophilic. With regard to this aspect, all materials tested in this study were hydrophilic.

The contact angle is a characteristic of the substances in the system due to the surface tension of the liquid and the surface energy of the solid. Low contact angle indicates good wettability. As the contact angle increases, the wettability decreases (Jin et. all., 2009). The sessile drop technique, an optical contact angle method, is generally used to estimate wetting properties of a localized region on a solid surface (Kwok, 1998).

The water sorption was determined according to increase in mass per unit volume. Also, water solubility was determined according to lose of mass from polymers (Miettinen, Narva, Vallittu, 1999; Tuna, et. all., 2008). The maximum ISO standard values for water sorption is 32µg/mm^3 and water solubility is 1.6 µg/mm^3 for heat cured materials. All materials tested in this study is acceptable according to these limits. PA resins were exhibited negative water solubility values. Unlike PA materials had not dissolved in water, they sorbed water. A resin matrix that is polymerized to a greater degree would have less water sorption because the greater resin density reduces diffusion of water into the matrix (Parr & Rueggeberg, 2002). PA specimens showed a mass increase in distile water after thermos cycling. The in vitro nature of the present study does not fully match the daily use. However, these results provide important data for polyamide denture base materials for clinical use there is a lack of studies about the effect of thermo cycling on denture base materials.

CONCLUSIONS

Following conclusion can be drawn, after the aging process, simulating one service year, change of the contact angle decreased in one PA group, while other PA groups and PMMA resin increased so the hydrophilicity of these materials decreased. Both before and after TC process, some PA resins exhibited higher Ra values than conventional PMMA and the other PA resins showed similar Ra values. In contrast to previous study about the higher water sorption of PA resin, water sorption and solubility of PA materials before and after TC, were below the accepted threshold value and there is no statistically difference in comparison with PMMA group. The measurements undertaken within this study have demonstrated conventional pressure packed PMMA resin not to be superior in terms of microbial adhesion to PA resins.

Within the limitations of this study, it is hard to reach a general conclusion about polyamide denture base materials, this may be explained by the difference in the chemical composition and physical properties between the polyamide denture base materials. From the results obtained, both conventional PMMA and PA materials are acceptable for one-year use, as a denture ase materials. It can be concluded that polyamide denture base resins will be a good alternative to conventional poly(methyl methacrylate) resins for long-term provisional removable dentures. However careful case selection and clinical judgment is required to use polyamide dentures in appropriate situations in order to obtain a successful treatment outcome.

Author Contributions

Plan, design: HA, GK; Material, methods and data collection: HA; Data analysis and comments:. HA; Writing and corrections: HA.

Conflict of interest

The authors declare that they have no conflict of interest

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