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Učinak ponovljenih mikrovalnih dezinfekcija na dimenzijsku stabilnost akrilatnih proteza

The Effect of Repeated Microwaving Disinfection on the Dimensional Stability of Acrylic Dentures

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Sažetak
Svrha: Željeli smo istražiti i procijeniti učinak ponovljenih mikrovalnih dezinfekcija na dimenzijsku stabilnost akrilatnih proteza. **Materijali i metode:** Testirane su tri grupe proteza napravljene od toplinski polimerizirajućeg akrilata. Prva skupina – kontrolna, čuvala se u hladnoj vodi. Druga skupina proteza svaki je dan bila podvrgnuta mikrovalnoj dezinfekciji u vodi (mokra dezinfekcija), a treća skupina proteza nije se uranjala u vodu (suha dezinfekcija). Mjerenja su obavljena na tri referentne točke i to u dva puta: nakon stvrdnjavanja akrilata i 24-satnog uranjanja, te poslije tjedan dana. Dobiveni podatci analizirani su jednosmjernom analizom varijabilnosti (ANOVA) i Scheffeovim testom višestrukih raspona. **Rezultati:** Rezultati su pokazali da mokra i suha mikrovalna dezinfekcija uzrokuju iste dimenzijske promjene (skvrčavanje). Proteze koje su bile podvrgnute mokroj dezinfekciji najviše su se skvrčile ($p < 0,05$). **Zaključak:** Mikrovalna dezinfekcija može prouzročiti dimenzijske promjene (skvrčavanje) na akrilatnim protezama. Mikrovalna *suha dezinfekcija* može biti svakodnevna jer ne uzrokuje klinički značajne dimenzijske promjene.

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Ključne riječi
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Uvod

Tijekom izrade proteza uvijek je moguća uzajamna zaraza između pacijenta, kliničara i dentalnih tehničara. Zbog toga je u svakodnevnoj praksi potrebno jednostavnim sterilizacijsko-dezinfekcijskim metodama zaštititi osoblje koje radi s protezama i pacijente (1 – 6).

Preporučuje se mnogo sterilizacijsko-dezinfekcijskih metoda kao, primjerice, desetominutno uranjanje u 2-postotni bazični glutaraldehid ili u 1-postotni natrijev hipoklorit 10 do 30 minuta te polusatno uranjanje u 3-postotnu vodenu otopinu formaldehida (3). Metoda koja također učinkovito dezinficira proteze jest petominutno uranjanje u otopinu 5,25-postotnog natrijeva hipoklorita (7). No ove kemijske metode imaju i nekoliko nedostataka – sterilizacija predugo traje, proteza mijenja boju, otopine imaju rok trajanja, a moguća je i reakcija oralnoga tkiva (8 – 10). I još nešto: otopine kemikalija mogu uzrokovati određene fizičko-mehaničke promjene na protezi (11 – 13). Mikrovalna energija pokazala se kao alternativa navedenim tra-

Introduction

Dentures in all stages of their construction are potential sources of cross contamination to and from patients, clinical personnel and dental technicians. Thus, dental clinic personnel and technicians should protect both themselves and patients applying relatively simple sterilization-disinfection procedures in everyday practice (1-6).

Many disinfection-sterilization methods have been suggested such as: immersion in 2% alkaline glutaraldehyde for 10 minutes, immersion in 1% sodium hypochlorite for 10 to 30 minutes, and immersion in 3% aqueous formaldehyde for 30 minutes (3). Also, immersion in a solution of 5.25% sodium hypochlorite for 5 minutes can sterilize a denture (7). Nevertheless, these chemical disinfection methods hold some disadvantages e.g. time-consuming, denture bleaching and staining, expiration date and possible oral tissue reaction (8-10). Furthermore, the chemical solutions may alter some physical-mechanical properties of denture base materials (11-13). Microwave energy is claimed to be an alter-

dicionalnim metodama dezinfekcije i sterilizacije proteza, a osim toga pouzdana je, jeftina i brza te izvrsno dezinficira (8, 14 – 22).

Pri mikrovalnoj metodi dezinfekcije proteza se stavlja u vodu (mokra dezinfekcija) ili se dezinficira na suhome (suha dezinfekcija), a ljestvica se na mikrovalnoj podešava na vrijednosti između 450 i 650 W. Ekspozicija mikrovalovima varira između dvije i deset minuta.

Istraživanje koje je proveo Rohrer sa suradnicima. (8) pokazalo je da mikrovalna ekspozicija od osam minuta snage 720 W, u suhim uvjetima može sterilizirati akrilatnu protezu inficiranu aerobnim bakterijama i bakterijom *Candida albicans*. Webb i njegovi kolege (14) istaknuli su da mikrovalna ekspozicija na 604 W (± 92) ili 331 W (± 34) tijekom šest minuta sterilizira suhe totalne proteze inficirane bakterijama *Candida albicans* i *S. gordonii*.

Silva i suradnici (16) priopćili su da su potpuno sterilizirali totalne proteze inficirane bakterijama *C.* albicans i *S. aureus* koristeći se šest minuta mikrovalovima snage 650 W. Mima i njegovi kolege. (17) objavili su da se mikrovalna energija snage 650 W u trajanju od tri minute može primijeniti za sterilizaciju mase za podlaganje proteza. Nedavno su Senna i suradnici (22) ustanovili da mikrovalovi snage 450 W u trajanju od tri minute ili 450 W u trajanju od dvije ili tri minute, u kombinaciji s bazičnim peroksidom i enzimima, mogu dezinficirati protezu inficiranu bakterijom *C. albicans*. U svim navedenim istraživanjima (16, 17, 22) dezinfekcija/sterilizacija proteze na 650 W ili 450 W obavljala se u vodi. Pregledom literature otkrili smo da, iako su provedena mnoga istraživanja kako bi se procijenio učinak mikrovalne dezinfekcije na fizičko-mehanička svojstva proteze (23 – 31), malo je podataka o učinku ponovljenih dezinfekcija mikrovalovima na dimenzijske promjene baze proteze (30 –32), posebice u suhim uvjetima (13).

Svrha ovog istraživanja bila je procijeniti učinak ponovljene uporabe mikrovalne dezinfekcije na dimenzijsku stabilnost akrilatnih proteza.

Materijali i metode

Izrađen je trajni otisak od silikonskog elastomera (Panadent Ltd, London, Velika Britanija) kojim je otisnut mjedeni kalup kako bi simulirao bezubi alveolarni greben. Mjedeni kalup bio je indeksiran trima rupama na specifičnim mjestima (33) [(na lijevoj i desnoj posteriornoj regiji (A, B) te na lokaciji središnjih inciziva (C)]. Dobiveno je osamnaest gipsanih odljeva (Vel-Mix Stone, Kerr Mfg Co, MIIn) i svaki je navoštan 3-milimetarskom voštanom folijom (Tenatex red Associated Dental Products Ltd, Purton, Swindon, Wiltshire SNS 4HT, Velika Britanija). Izrađeno je osamnaest baza proteza od toplinski polimerizirajućeg akrilata (Paladon 65, Kulzer, GmbH, Njemačka) držeći se polimerizacijskog ciklusa na 74 °C u trajanju od sedam sati te jednog sata na 100 °C u vodenoj kupki (Slika 1.)

Proteze su nasumce podijeljene u tri grupe prema proceduri dezinfekcije:

- grupa I.: proteze su tijekom eksperimenta čuvane u destiliranoj vodi (37 °C) (kontrolna skupina);

native to these traditional sterilization-disinfection methods and has been reported to be a reliable, cost effective and time saving method for complete denture disinfection (8, 14-22).

When using the microwave disinfection method, a denture is placed either into water (wet disinfection) or not (dry disinfection) and the microwave oven irradiation is mainly between 450 and 650 W. Furthermore, the time periods of irradiation range from 2 to 10 min.

A study conducted by Rohrer et al. (8) has shown that microwave irradiation at 720 W for 8 minutes, in dry conditions, can sterilize acrylic dentures contaminated with aerobic bacteria and Candida albicans. Webb et al. (14) reported that microwave irradiation at 604 W (±92) or 331 W (±34) for 6 minutes produced sterilization of dry complete upper dentures contaminated by Candida albicans and S. gordonii.

Silva et al. *(*16) reported that complete dentures contaminated with Candida albicans and S. aureus were sterilized after microwave irradiation at 650 W for 6 minutes. Mima et al. (17) revealed that microwave energy at 650 W for 3 minutes can be used for hard chairside reline resin sterilization. Recently, Senna et al. (22) showed that microwave irradiation at 450 W for 3 minutes or 450 W for 2 or 3 minutes combined with alkaline peroxide containing enzyme denture cleanser is an effective method for disinfection of dentures contaminated with Candida albicans. In all the above mentioned studies (16, 17, 22) for the disinfection/sterilization procedure at 650 or 450W all dentures were placed into water. A review of the literature revealed that although many studies have been conducted to evaluate the effect of microwave disinfection on the physical-mechanical properties of denture base resins (23-31), little information is available on the effect of repeated microwave disinfections on the dimensional changes of denture base materials (30-32), particularly in dry conditions (13).

The aim of this study was to evaluate the effect of repeated microwave disinfections on the dimensional stability of acrylic denture bases.

Materials and methods

A permanent silicone elastomer mold was made (Panadent Ltd, London, England) from a standard brass die simulating an upper edentulous ridge where index marks had been incorporated by drilling holes in specific locations (33) (in the right and left posterior area (A, B) respectively and the central incisor region (C)). Eighteen casts were obtained by pouring dental stone (Vel-Mix Stone, Kerr Mfg Co, MI-In). Each stone cast was waxed up with a 3 mm thick wax sheet (Tenatex red Associated Dental Products Ltd, Purton, Swindon, Wiltshire SNS 4HT, UK). Eighteen denture bases were constructed using a heat polymerized resin (Paladon 65, Kulzer, GmbH, Germany) following a curing cycle at 74°C for 7 hours and 1 hour at 100°C in water bath (Figure 1).

The denture bases were randomly divided into 3 groups according to the disinfection procedure:

Group I: the denture bases were kept in distilled water (37°C) during the experiment period (control group).

- grupa II.: proteze su pojedinačno tjedan dana bile podvrgnute mikrovalovima po šest minuta na 650 W; tijekom dezinfekcije bile su uronjene u 150 ml destilirane vode (mokra dezinfekcija);
- grupa III.: proteze su pojedinačno bile podvrgnute mikrovalovima kao i proteze u grupi II., ali nisu bile uronjene u vodu (suha dezinfekcija).

Proteze iz grupe II. i III. bile su podvrgnute mikrovalovima svaki dan u isto vrijeme i to u mikrovalnoj pećnici za kućanstvo (Model HF 1210, Siemens GmbH, Njemačka). Kako bi se spriječilo oštećenje pećnice, u nju je bila tijekom suhe sterilizacije (grupa III.) stavljena plastična čaša sa 150 ml vode. Između dnevnih dezinfekcija sve baze proteza čuvale su se u destiliranoj vodi na 37 °C.

Metode mjerenja

Izmjerene su udaljenosti AB, AC I BC digitalnim mikrometrom preciznosti 0,01 mm (Mitutoyo, Tokio, Japan). Svaka se udaljenost pet puta mjerila te je izračunata srednja vrijednost. Koeficijent varijabilnosti za ponovljeni eksperiment nije premašio 0,9 posto. Tijekom mjerenja je vrh mikrometra bio umetnut u sredinu indeksiranih točaka (slika 1.).

Mjerenje je bilo obavljeno dva puta: nakon stvrdnjavanja akrilata i 24-satnog uranjanja u vodu (početna vrijednost) te poslije tjedan dana.

Statistička analiza

Dobiveni podatci analizirani su jednosmjernom analizom varijabilnosti (ANOVA) i Scheffeovim testom višestrukih raspona.

Group II: the denture bases were individually microwaved for 6 minutes at 650 W daily for one week. During disinfection the dentures were immersed in 150 ml of distilled water (wet disinfection).

Group III: the dentures were individually microwaved following the same procedure as group II without immersing them in water (dry disinfection).

Denture bases of group II and III were microwaved every day at the same time using a domestic microwave oven (Model HF 1210, Siemens GmbH, Germany). A plastic cup, filled with 150 ml of water, was placed into the microwave oven during dry disinfection (group III), to protect the device from damage. All denture bases were kept in distilled water at 37°C between the disinfection procedures.

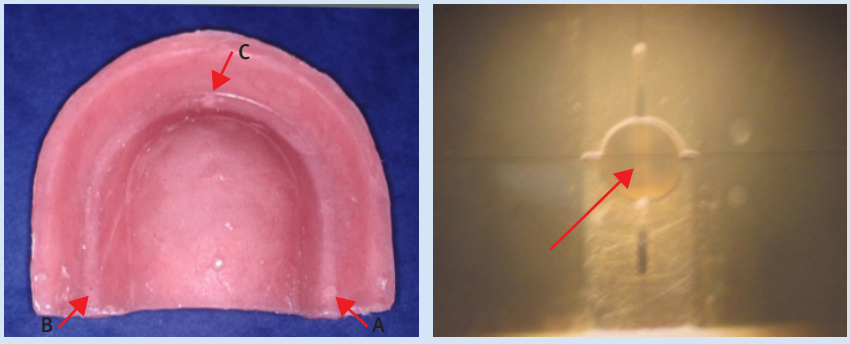
Method of measurement

Measurements were taken across the dimensions AB, AC, and BC, with a digital micrometer accurate to 0.01 mm (Mitutoyo, Tokyo, Japan). For each dimension, five readings were made and the mean value was calculated. The coefficient of variation for the repeated measurements did not exceed 0.9%. In order to take the measurements, the tip of the micrometer was placed on the centre of the index marks (Figure 1).

The measurements were taken on two occasions: after curing and immersion in water for 24 hours (considered to be the starting point), and one week later.

Statistical analysis

Data obtained were analyzed using one-way analysis of variance (ANOVA) and Scheffe's multiple range test.



Slika 1. Baza proteze s indeksiranim oznakama
Figure 1 Denture base with index marks.

Rezultati

Rezultati ovog istraživanja predstavljeni su na slikama od 2 do 4.

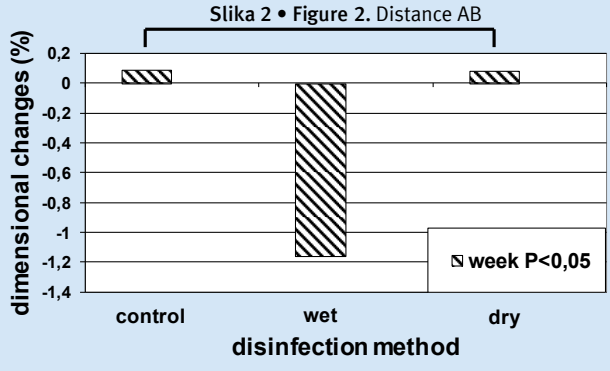
Općenito su sve proteze imale sličan obrazac dimenzijskih promjena, odnosno smanjivanja vrijednosti svih izmjerenih duljina (slike 2. do 4.). Na bazama proteza koje su bile na suhoj dezinfekciji dogodile su se manje dimenzijske promjene negoli na onima koje su prošle mokru dezinfekciju (slike 2. do 4.). Statistički značajne bile su samo vrijednosti za udaljenost AB ($p < 0,05$) (slika 2.).

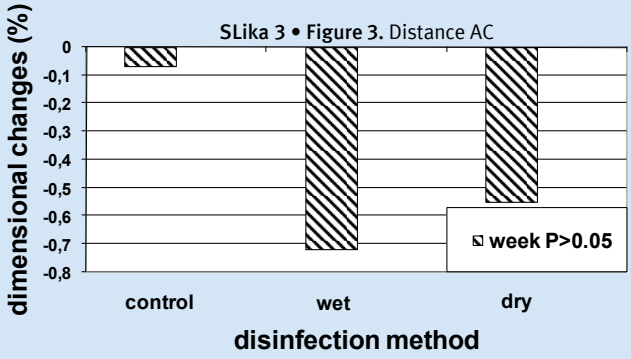
Results

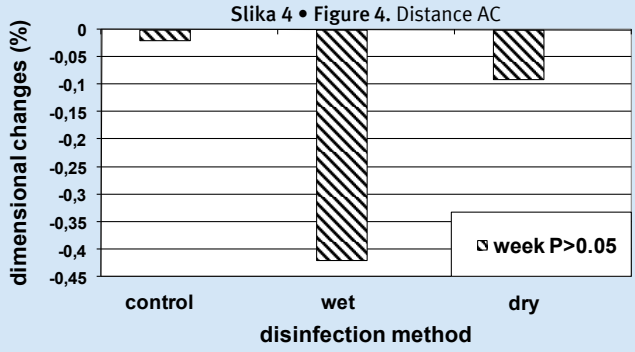
The results of this study, in bar graphs, are presented in Figures 2-4.

Generally, all microwaved dentures bases showed a similar pattern of dimensional changes, a shrinkage for all distances measured (Figures 2-4).

After seven dry disinfections, the denture bases showed smaller dimensional changes compared to those submitted to wet disinfections for all measured distances (Figures 2-4). This finding was statistically significant only for the distance AB ($p<0.05$) (Figure 2).







Denotes homogeneous subsets (P>0.05)

Slika 2. Dimenzijske promjene za udaljenost AB
Figure 2 Dimensional changes for the distance AB.
Slika 3. Dimenzijske promjene za udaljenost AC
Figure 3 Dimensional changes for the distance AC.
Slika 4. Dimenzijske promjene za udaljenost BC
Figure 4 Dimensional changes for the distance BC.

Rasprava

Najvažnije što se otkrilo ovim istraživanjem *in vitro* jest da sve baze proteza koje su bile u proceduri mikrovalne dezinfekcije, mokroj ili suhoj, pokazuju znakove skvrčavanja nakon sedam dezinfekcija. Takav je rezultat dobiven jer, kada se akrilatne proteze zagrijavaju – što je slučaj tijekom dezinfekcije u mikrovalnoj pećnici – oslobađa se unutarnji stres u materijalu koji nastaje dok se izrađuju proteze (25).

Naši rezultati pokazali su da se u bazama proteza nakon mokre dezinfekcije događaju najveće linearne promjene u posteriornom dijelu proteze u usporedbi s onima koje su suho dezinficirane. Jedno od mogućih objašnjenja jest da voda kada zakipi (voda u mikrovalnoj pećnici počne ključati nakon 90 sekundi) podiže temperaturu proteze, što uzrokuje konverziju zaostatnog monomera (34) u polimer (25).

Na bazama proteza koje su bile mokro mikrovalno dezinficirane dogodile su se linearne promjene do -1,16 posto. Taj rezultat u skladu je s istraživanjem Sartorija i suradnika (24) koji su otkrili da ponovljena mokra dezinfekcija negativno utječe na adaptaciju baze proteze na njihov originalni gipsani odljev. Fleck i njegovi kolege (26) istaknuli su da ponovljena mokra dezinfekcija negativno utječe na adaptaciju baza proteza na gipsani model. Nadalje, naši su rezultati u skladu s rezultatima Seoa i suradnika (32) koji su otkrili skupljanje od 2,36 posto nakon tjedan dana svakodnevne dezinfekcije. Wagner i njegovi kolege (31) ustanovili su skupljanje od 1,92 posto između bukalnih nabora nakon dviju trominutnih dezinfekcija sa 700 W. A Consani i suradnici (35) izjavili su nakon istraživanja mokre dezinfekcije da takva vrsta dezinfekcije ne uzrokuje dimenzijske promjene pri adaptaciji proteze na gipsani model.

Discussion

The main finding of this *in vitro* study was that all denture bases submitted to microwaving disinfection, either wet or dry, exhibited shrinkage after seven disinfections. This may be due to the fact that when acrylic denture bases are heated, as occurs during microwaving, internal stresses incorporated during the processing are released (25).

Our results revealed that denture bases which had undergone wet disinfections showed greater linear changes, compared to those occurring during dry disinfections at the posterior region of the denture bases. This can be explained by the fact that the boiling water (water starts to boil after 90 sec of irradiation) raises the temperature of the denture base, which in turn causes the residual monomer (34) conversion into polymer (25).

Denture bases which had undergone wet microwave disinfection presented linear changes up to -1.16%. This finding is in agreement with the study by Sartori et al. (24) claiming that repeated wet microwave irradiation negatively affects the internal adaptation of denture bases to their casts. Fleck et al. (26) showed that repeated wet disinfection had harmful effects on denture bases' adaptation to the casts. Furthermore, our results are comparable with those of Seo et al. (32) who reported shrinkage of 2.36% after daily disinfections for seven days. Wagner et al. (31) revealed a decrease of 1.92% at the distance between buccal flanges after two disinfections at 700 W for 3 minutes. On the other hand, Consani et al. (35) reported that repeated wet microwave disinfections did not adversely affect the denture base adaptation.

Our finding that dry disinfection caused minor shrinkage is in agreement with the report of Polyzois et al. (13) stat-

Naši rezultati, da suha dezinfekcija uzrokuje minimalno skupljanje, u skladu su s rezultatima Polyzoisa i suradnika (13) koji su ustanovili da se pravokutni akrilatni uzorci zanemarivo skupljaju nakon dezinfekcije (-0,005 do 0,009 %). Također potvrđuje rezultate Burnsa i njegovih kolega (36) – oni su otkrili minimalno skupljanje od 0,03 posto u cilindričnom uzorku nakon petnaestominutne dezinfekcije na jakosti od 650 W. Naši rezultati potvrđuju rezultate Pavana i suradnika (10) koji su priopćili da nakon trominutne dezinfekcije na jakosti od 500 W, akrilatna baza nije značajno promijenila oblik i mogla je biti pripasana na gipsani model. Unatoč tim rezultatima, istaknuli su da desetominutna mikrovalna dezinfekcija na jakosti od 604 W znatno mijenja oblik baze proteze i utječe na podešavanje proteze na gipsani model.

U svakodnevnoj praksi prihvatljivo je da materijal za bazu proteze podnese linearne promjene od jedan posto tijekom njezine izrade i korištenja. Referentna točka odnosi se na područje prvih molara. Ove smjernice dao je Woelfer sa suradnicima. (37) prije 50 godina.

Uzimajući u obzir navedene rezultate različitih istraživača da suha dezinfekcija uzrokuje skupljanje manje od jedan posto, možemo zaključiti da, ako se proteza mora često dezinficirati, to je bolje učiniti u suhim uvjetima u mikrovalnoj pećnici jer tako nećemo utjecati na dimenzijsku stabilnost baze i izbjeći ćemo kliničke probleme zbog skupljanja baze proteze.

Zaključci

Unatoč ograničenjima u ovom laboratorijskom istraživanju možemo zaključiti sljedeće:

Dezinfekcija s pomoću mikrovalne energije može uzrokovati dimenzijske promjene (skupljanje) totalnih proteza.

Baze totalnih proteza uronjenih u vodu dimenzijski su se znatnije promijenile tijekom mikrovalnog zračenja od onih suho dezinficiranih.

Baze proteza koje su dezinficirane u suhim uvjetima pokazale su komparabilnu dimenzijsku stabilnost s kontrolnom skupinom.

Mikrovalna dezinfekcija trebala bi se obavljati u suhim uvjetima zato što se pritom ne događaju značajne dimenzijske promjene.

Sukob interesa

Ne postoji.

ing that acrylic rectangular specimens which underwent dry disinfection showed negligible dimensional changes (-0.005 to 0.009%). Also, it confirms the report of Burns et al. (36) who revealed a minor shrinkage up to 0.03% in cylindrical specimens after a 15-minute at 650 W microwave disinfection. Furthermore, the finding corroborates the study of Pavan et al. (10) that microwave irradiation at 500 W for 3 min did not affect the adaptation of maxillary acrylic denture bases. However, microwaving of denture bases at 604 W for 10 min adversely affects their fit to the stone casts.

In everyday practice, a denture base material is considered to be acceptable when the linear changes across first molars occurring during processing and use are under the limit of 1%, as it was suggested by Woelfer et al. (37) about 50 years ago.

Concerning the above mentioned reports and our findings that dry disinfection caused shrinkage less than 1%, we may conclude that when there is a need for dentures to be repeatedly disinfected, a dry microwaving disinfection is preferable since it does not affect the dimensional stability of denture bases to a degree which would cause clinical problems.

Conclusions

Under the limitations of this laboratory study, the following conclusions can be drawn:

Disinfection using microwave energy may cause dimensional changes (shrinkage) of complete dentures.

Denture bases immersed in water during microwave irradiation exhibited greater dimensional changes compared to those which were not immersed in water.

Denture bases submitted to repeating disinfection, without being immersed in water, showed dimensional stability comparable to the untreated denture bases.

Microwaving disinfection is preferable to be carried out in dry environment because the dimensional changes occurred seem to be of no clinical significance.

Conflict of interest

Non declare.

Abstract

Objective. The aim of this study was to evaluate the effect of repeated microwave disinfections on the dimensional stability of acrylic dentures. **Materials and Methods.** Three groups of dentures made of a heat polymerized acrylic resin were tested. I: dentures kept in water (control group). II: dentures microwaved daily while being immersed into water (wet disinfection). III: dentures microwaved daily without being immersed into water (dry disinfection). Measurements were taken across three reference points, on two occasions: after curing and immersion in water for 24 hours, and one week later. Data obtained were analyzed using one-way analysis of variance (ANOVA) and Scheffe's multiple range test. **Results.**The results showed that the microwave disinfection provokes dimensional changes of the same pattern (shrinkage). The dentures which underwent wet disinfection exhibited the greatest shrinkage ($p<0.05$). **Conclusions.** Disinfection using microwave energy may cause dimensional changes (shrinkage) of complete dentures. The microwave "dry disinfection" method can be safely applied in everyday practice since the dimensional changes which occurred seem to be of no clinical significance.

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Key words
Complete Dentures, Acrylic Resins; Disinfection; Microwaves; Dimensional Measurement Accuracy

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