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PREGLEDNI RAD
REVIEW

Theodoros Klironomos[1], Aspasia Katsimpali[1], Gregory Polyzois[2]

Učinak mikrovalne dezinfekcije na polimernu bazu proteze, ljepilo i zube: osnovni pregled

The Effect of Microwave Disinfection on Denture Base Polymers, Liners and Teeth: A Basic Overview

[1] Privatna ordinacija, Atena, Grčka
Dentist, Private practice, Athens, Greece
[2] Odjel za protetiku Stomatološkog fakulteta Atenskoga sveučilišta, Atena, Grčka
Professor, Department of Removable Prosthodontics, Dental School, University of Athens, Athens, Greece

Sažetak
Svrha ovoga članka bila je sažeti trenutačno znanje o učincima mikrovalne dezinfekcije na svojstva materijala za izradu proteza. Kontrola križne infekcije u dentalnoj medicini itekako je važna u svakodnevnoj kliničkoj praksi jer su u porastu razne infektivne bolesti poput hepatitisa B i C te AIDS-a (side), a metode dezinfekcije su mnogobrojne. Najraširenija u svakodnevnoj praksi jest ona kemijska, premda istraživanja upućuju na to da se tako mijenjaju fizikalna i mehanička svojstva akrilatnih smola te omogućuje rast i proliferacija određenih bakterija. A mikrovalna metoda pokazala se kao jednostavna za uporabu, jeftina je i u postupku se ne upotrebljavaju kemikalije. Pitanje koje se postavilo glasi: utječe li podvrgavanje mikrovalovima na svojstva materijala od kojih se izrađuju proteze. Mikrovalovi različito djeluju na bazu proteze, ljepilo i zube. Istraživanja su pokazala da je mikrovalna dezinfekcija sigurna alternativa za bazu proteze i podložnu masu – u usporedbi s kemijskom metodom – ako se postupak obavlja u suhom okružju, ali mogla bi uzrokovati klinički veće dimenzijske promjene kad bi se iradijacija obavljala u vlažnim uvjetima. Nema ni klinički značajnih učinaka slabljenja savojnih svojstava, zatezne čvrstoće i tvrdoće akrilatne smole proteze, ni integriteta sredstva za vezivanje i njegove čvrstoće na savijanje, poroznosti i tvrdoće. Učinci dezinfekcije mikrovalovima na čvrstoću zuba u protezi i na vezu zubi – proteza i dalje su sporni, pa još nema definitivnog zaključka.

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Adresa za dopisivanje
Theodoros Klironomos
Address: Agiou Thoma 4,
11527 Athens, Greece
tel.: +30 6978559464
e-adresa: klironomos350z@yahoo.com

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Uvod

U dentalnoj medicini vrlo je važna kontrola križne infekcije zbog pojave infektivnih bolesti poput hepatitisa B, C i AIDS-a (side) (1). Pri izradi djelomičnih proteza liječnici, ostalo osoblje i pacijenti neprestance su u opasnosti od samoinokulacije i prenošenja mikroorganizama jer terapijski zahvati u usnoj šupljini uključuju kontaminaciju predmeta krvlju i slinom, a ne može ih se jednostavno dezinficirati ili sterilizirati poput proteza, otisaka i gipsanih modela. Premda je ADA objavila smjernice za prevenciju od prenošenja infektivnih bolesti u ordinacijama dentalne medicine, mnogi su podbacili (2). U mnogim istraživanjima predlažu se različite metode kako bi se izbjegle križne infekcije u ordinacijama dentalne medicine. Tako se kemijska dezinfekcija preporučuje svaki put kad se proteza unosi ili vadi iz pacijentovih usta. Dezinfekcijske otopine kojima smo se prije koristili su klor-dioksid, natrijev hipoklorit, 4-postotni klorheksidin i glutaraldehid (3, 5). Istraživanja o učincima takve kemijske dezinfekcije potvrdila su da su se promijenila fizikalnokemijska svojstva akrilatne smole (6,7). Primjerice, proteze su dobile obojenja – nastale su smećkaste promjene na zubima i

Introduction

Cross-infection control in dentistry has become a major issue since the recent increase in some infectious diseases such as hepatitis B, C and AIDS (1) occurred. By dealing with removable prosthodontics the dentist, the dental personnel and the patients are constantly facing the risk of self-inoculation and transmission of microorganisms since the oral surgery environment usually includes a mixture of blood and saliva which contaminates a great number of instruments and items that are not easily disinfected nor sterilized such as prostheses, impressions, stone casts. Although ADA has published guidelines in order to prevent the transmission of infectious diseases in dental offices, many have failed (2). A number of studies have presented numerous methods to avoid cross infection in the dental practice.

Chemical disinfection was the recommended method to be used after the removal and before the insertion of the prosthesis in the patient's mouth. The disinfectant solutions used in the past were chlorine dioxide, sodium hypochlorite, 4% chlorhexidine and glutaraldehyde (3,5). However, studies on the effects of chemical disinfection on the physical-mechan-

na akrilatnoj bazi proteze, a pacijenti su navodili i mnoge oralno-tkivne reakcije (1, 8). Glavni nedostatak klor-dioksida jest odbojnost pacijenata prema neugodnom mirisu (9), a osim toga izbjeljuje akrilatnu bazu proteze i korozivno djeluje na protetski skelet (6, 10). Glutaraldehid i natrijev hipoklorit visoko su ili srednje citotoksični (11). Dodajmo kako se u nekim istraživanjima ističe da te otopine mogu stvoriti pogodno okružje za rast pojedinih bakterija (12). Zaključno, kemijsko natapanje proteza smatra se vremenski zahtjevnom i neodgovarajućom metodom za postupke u ordinaciji (13). Kako bi se prevladali problemi pri kemijskoj dezinfekciji, predloženi su mikrovalovi kao jeftina i brza alternativa bez kemikalija. Mikrovalovi su oblik elektromagnetske energije valnih duljina i frekvencija sličnih onima televizijskima i zrakoplovnom radaru. Važno je istaknuti da je zagrijavanje mikrovalovima energijska konverzija i znatno se razlikuje od zagrijavanja u konvencionalnoj pećnici (1). Točan mehanizam destrukcije mikrovalova još treba istražiti. U nekim istraživanjima tvrdi se da je iradijacija mikroorganizama neposredno toplinska (14), a u drugima se ističe da pritom značajnu ulogu ima netermički učinak (15, 16). Pokazano je da je mikrovalna iradijacija proteza jednaka ili učinkovitija od osmosatnog steriliziranja u 0,02-postotnoj otopini natrijeva hipoklorida (17). Budući da je glavna svrha mikrovalne dezinfekcije deaktivacija potencijalno patogenih mikroorganizama, u nekim istraživanjima istaknuto je da su proteze uronjene u vodu bile bolje dezinficirane negoli one u suhim uvjetima (18). Pojedini istraživači preporučili su dezinfekciju mikrovalovima radi prevencije ili čak terapije protetskoga astomatitisa jer je dokazano da mikrovalna iradijacija na inficiranim protezama učinkovito uništava gljivice *Candida species* (9 – 21). Zbog zagrijavanja materijala izlaganje mikrovalovima može negativno utjecati na smolu proteza, na podložnu masu ili zube. Naime, voda zakipi otprilike za minutu i pol i ostaje na toj temperaturi do kraja predviđenog vremena za dezinfekciju (14), a to može negativno utjecati na fizikalnomehanička svojstva materijala od kojega je izrađena dentalna proteza. Da bi se ublažila kumulativna distorzija zbog pretjeranog zagrijavanja tijekom iradijacije mikrovalovima, neki su predlagali kombinaciju tableta s alkalnim peroksidima i enzimima, čime bi se postigla brža dezinfekcija, no manje povećanje topline u usporedbi s korištenjem samo mikrovalova (22).

Svrha ovog članka jest dati pregled dosadašnjih znanstvenih spoznaja o učincima mikrovalne dezinfekcije na svojstva materijala korištenih za izradu dentalne proteze.

Baza proteze

Baza proteze dio je pomagala koji leži na potpornim dijelovima, a gornji dio nastavlja se na pričvršćene umjetne zube (23). Njome se nadomješta alveolarni greben i po količini i prema izgledu.

ical properties of acrylic resins came to the conclusion that these were altered (6,7). For example, dentures were presented with staining, brownish discoloration of the teeth and the acrylic denture base and patients reported a number of oral tissue reactions (1,8). The major disadvantage of chlorine dioxide is that it was rejected by the patients because of its offensive odor (9), its bleaching action over the denture resin base and its corrosive effect on the framework (6,10). In addition, glutaraldehyde and sodium hypochlorite presented high or medium cytotoxicity risk (11). Furthermore, studies have demonstrated that such solutions can provide a suitable environment for growth of certain bacteria (12). In conclusion, denture soaking chemical methods are considered to be time consuming or inappropriate for chairside procedures (13).

Therefore, in order to overcome the problems occurring with chemical disinfection, microwaves were suggested as a low-cost, quick, efficient, and chemical free alternative. Microwaves are a type of electromagnetic energy with wavelengths close in frequency to television transmissions and aircraft radar. It is very important to note that microwave heating is an energy conversion and differs greatly from heating in a conventional oven (1). The exact mechanism of destruction of the microwaves has yet to be fully understood. Some studies claim that the irradiation of the microorganisms is directly of thermal character, (14) while others claim that non thermal effects may play a significant role (15,16).

It is shown that microwaving dentures is equal to or more effective than sterilizing them in a 0.02% solution of sodium hypochlorite for 8h (17). Since the main goal of microwave disinfection is to deactivate potentially pathogenic microorganisms, some studies reported that dentures microwaved in water were more effectively disinfected than dentures irradiated in dry conditions (18). Some researchers recommend microwave disinfection in order to prevent or even treat denture stomatitis, since it was shown that microwave irradiation successfully eradicates Candida species from the infected dentures (19-21).

However, microwaving may negatively affect denture resins, liners or teeth due to the material heating after irradiation. The water starts to boil after approximately 1 minute and 30 seconds and remains at this temperature until the end of the pre-set disinfection time, (14) a phenomenon that may have negative effects on denture related materials' physical-mechanical properties. In order to moderate the cumulative distortion produced by the excessive heat, some researchers even suggested the combination of tablets containing alkaline peroxide and enzymes with microwave irradiation, thus achieving faster disinfection and less heat compared to the use of microwaves alone (22).

The aim of this paper was to overview the current scientific knowledge concerning the effect of microwave disinfection on denture related material properties.

Denture Bases

A denture base is a part of a denture which rests on the foundation area. The artificial teeth are fixed on its upper surface (23).

Također je dio proteze u koji se učvršćuju umjetni zubi te osigurava njihovo sidrenje i retenciju pomagala. Olakšava i usmjerava okluzalne sile na zube nosače ili potporna tkiva ispod protetskog sedla (23).

Dimenzijska stabilnost

Dimenzijska stabilnost proteze jest stupanj zadržavanja primarnih dimenzija dobivenih tijekom izrade. Kliničko značenje ovog parametra iznimno je važno jer utječe na prilijeganje proteze, što nagnječuje tkivo pa se događa da je pacijenti zbog toga ne prihvaćaju. Velike dimenzijske promjene mogu prouzročiti dodati pritisak na sluznicu te se ona može traumatizirati i povećati resorpciju potporne kosti.

Učinak mikrovalne dezinfekcije na dimenzijsku stabilnost akrilatne smole česta je i opširno obrađena tema u literaturi jer može utjecati na prilijeganje, retenciju i stabilnost potpunih proteza (24). Seo i suradnici (24) šest su minuta mikrovalovima jakosti 650 W dezinficirali protezu jedanput na dan tijekom tjedan dana i zaključili da ovaj postupak skraćuje njezinu bazu, ali nisu procjenjivali kliničku važnost toga nalaza. Webb i kolege (17) te Pavan i njegov tim (3) također su istaknuli da se baza zubnih proteza dimenzijski štetno mijenja ako se dezinficira mikrovalovima, a njihove vrijednosti bile su 604 W tijekom 10 minuta.

Sartori i suradnici (25) dezinficirali su proteze mikrovalovima šest minuta (690 W/u 500 mL destilirane vode) te usporedili s bazama koje su bile dezinficirane otopinom od 100 ppm aktivnoga klorida. Prema dobivenim podatcima, baze dezinficirane mikrovalovima nakon tretmana nisu *sjedale* na modele za razliku od onih uronjenih u otopinu klorida.

Goncalves i njegovi kolege dodatno su izvijestili da je iradijacija mikrovalovima (650 W/6 minuta u 200 mL vode/7 puta) rezultirala značajnim razlikama u linearnoj dimenziji baze proteze (26). Senna i suradnici uočili su veliku linearnu distorziju nakon što su proteze tijekom 36 ciklusa bile u vlažnom okružju podvrgnute trominutnoj iradijaciji mikrovalovima jakosti 900 W. Istodobno su istaknuli da šest ciklusa trominutnog mikrovalnog zračenja od 450 ili 650 W tijekom nije uzrokovalo značajne promjene (27). Wagner i Pikpo također su uočili značajne dimenzijske promjene (oko 3 posto) nakon što su proteze bile izložene u vlažnim uvjetima dva puta trominutnoj mikrovalnoj iradijaciji od 420 ili 700 W (28). Sartori i njegov tim (29) također su istraživali učinak mikrovalne dezinfekcije (dva ciklusa od 690 W/6 min.) na trodimenzionalnu stabilnost baze proteze i pokazali da ovaj postupak utječe na progresivni porast distorzije 14 dana nakon primjene.

Consani i suradnici nisu pak pronašli nikakve značajne dimenzijske promjene poslije izloženosti proteza mikrovalnoj dezinfekciji (650 W/3 min.) (30). Polyzois i njegovi kolege (7) dobili su rezultate prema kojima trominutno i petnaestominutno izlaganje mikrovalovima snagom od 50 W uzrokuje klinički nevažne dimenzijske promjene na protezama (< 0,03 %).

Roher i Bulard (31) ustanovili su da izlaganje proteza mikrovalnoj dezinfekciji – kako u vlažnim tako i u suhim

It is used to replace the missing alveolar ridge both in bulk and appearance. Furthermore, it is the part of a denture where the prosthetic teeth are attached and provide bracing and retention for the denture. It facilitates the transfer of occlusal forces to the abutment teeth and when the denture is tissue supported to the foundation area (23).

Dimensional stability

The dimensional stability of a denture is the degree to which the material used for its fabrication retains its primary dimensions. The clinical significance of this parameter is very crucial, as it affects the fit of a denture, making it intolerable to the tissue and as a result to the patient. Great dimensional changes can also add an extra pressure to the mucosa which might traumatize the underlying bone and increase its resorption.

Microwave disinfection's effects on the dimensional stability of acrylic resins is widely examined in the literature since it could influence the fit, retention and stability of complete dentures (24).

Seo et al. (24) submitted denture bases to microwave disinfection at 650 W for 6 min (once per day for 7 days) and concluded that this procedure led to denture bases' shrinkage, but the clinical relevance of these findings was not assessed. Webb et al. (17) and Pavan et al. (3) also demonstrated that denture bases are likely to undergo damaging dimensional alternations when disinfected by microwave irradiation. The irradiation parameters were 604 W for 10 minutes.

Sartori et al., (25) submitted denture bases to microwave disinfection (690W for 6 min in 500 mL of distilled water) and compared them to bases that had previously been chemically disinfected with a 100 ppm active chloride solution. They stated that bases disinfected with microwaves after a period of time did not fit to their casts, unlike bases immersed in chloride solutions. In addition, Goncalves et al., reported that microwave irradiation (650 W for 6 min in 200 mL of water for 7 times) revealed significant differences in the linear dimension of denture bases (26). Senna et al. observed significant linear distortion when the dentures were submitted to 36 cycles of microwave irradiation at 900 W for 3 min in wet environment. Nevertheless, they reported that 6 cycles of microwave irradiation at 450 or 630 W for 3 min caused no significant alternations (27). Wagner and Pikpo also observed important dimensional changes of approximately 3% when dentures were exposed twice to either 420 or 700 W of microwave irradiation in wet environment for 3 min (28). Sartori et al., (29) also investigated the effect of microwave disinfection (two cycles at 690 W for 6 min) on the tridimensional stability of denture bases and showed that this procedure generated a progressive increase in distortion after 14 days as a result.

On the contrary to the aforementioned, Consani et al. found no significant dimensional changes when they submitted dentures to microwave disinfection (650 W/3 min) (30). Polyzois et al. (7) reported that 3 and 15 min of microwave exposure at 500 W could cause dimensional changes of no clinical importance (<0.03%) on the dentures. Rohler and

uvjetima – snagom od 720 W, tijekom 16 minuta ne uzrokuje dimenzijske promjene. Webb i suradnici (17) zaključili su isto, ali samo ako su proteze slabije ozračene (331 W/6 min.). Burns i njegov tim (32) istaknuli su da su uzorci napravljeni od različitih akrilatnih smola ostali dimenzijski stabilni nakon petnaestominutne mikrovalne iradijacije jakosti 650 W. Fleck i kolege istraživali su učinak dvaju protokola o dezinfekciji (690 W/6 min. i 345 W/6 min.) na dimenzijsku stabilnost akrilatne smole baze proteze. Postupak je u objema skupinama za dezinfekcijski protokol uključivao po tri minute tijekom sedam dana. Pronašli su da je prvi protokol narušio dimenzijsku stabilnost baze proteze, ali da 345 W tijekom šest minuta nije na njih imalo značajan utjecaj (33).

Polychronestakis i suradnici zračili su proteze svakodnevno tjedan dana u suhim i vlažnim uvjetima i to po šest minuta snagom od 650 W te zaključili da, ako je dezinfekcija obavljena u suhim uvjetima, dimenzijske promjene nisu klinički značajne (34).

Ti suprotni nalazi mogu biti rezultat razlika u trajanju dezinfekcije i snage mikrovalne pećnice, te u vrsti korištenih materijala i metoda za mjerenje distorzije (25). Primjerice, materijali za proteze različito se ponašaju ako je iradijacija obavljena u vlažnim ili suhim uvjetima. Uranjanje u vodu prihvaćeno je jer se pretpostavljalo da se tako povećava učinkovitost dezinfekcije (19). No voda zakipi već za 90 sekundi (19), što može povećati temperaturu akrilatne smole iznad njezine točke staklastog prijelaza i učiniti je savitljivijom (35). Tako se može olakšati završavanje baza proteze i uzrokovati oslobađanje napetosti unutar materijala tijekom proizvodnje (36, 37). Nadalje, viša temperatura vode može pojačati raspršivanje zaostale rezidualne molekule monomera (38, 39) na aktivna područja polimernog lanca (40), a posljedica je da daljnja polimerizacija skvrčava bazu zubne proteze.

Basso i suradnici istraživali su učinak mikrovalne dezinfekcije na okluzalne vertikalne dimenzijske promjene potpunih proteza. Maksilarne potpune proteze tri su minute zračili mikrovalovima jakosti 650 W. Nakon što su uzorci bili ozračeni jedanput na tjedan tijekom mjesec dana (4 tjedna), nije bila uočena nikakva značajna promjena. No kada su uzorke zračili mikrovalovima četiri puta tjedno tijekom mjesec dana (4 tjedna), ustanovili su nedopustivu distorziju. Smatraju da su u tom slučaju – ako se proteza više puta izlaže mikrovalnom zračenju (nekoliko ciklusa) – promjene u okluzalnoj vertikalnoj dimenziji uzrokovane otpuštanjem napetosti stvorene još tijekom proizvodnje (41).

Čvrstoća na savijanje

Čvrstoća na savijanje ili savojna čvrstoća jest istodobno mjerenje zatezne i smične veze te tlačne čvrstoće (42). To je opterećenje koje se događa na protezi pri žvakanju. Klinički smanjena čvrstoća može rezultirati pucanjem proteze.

Bulard (31) asserted that both wet and dry dentures' exposal to microwave disinfection at 720 W for 16 minutes, showed no dimensional changes. Webb et al. (17) came to the same conclusion but only when dentures were irradiated with reduced exposures (331 W for 6 min).

Burns et al. (32) showed that specimens made from three different acrylic resins had no alternations on their dimensional stability after 15 min at 650 W of microwave irradiation. Fleck et al. investigated the effect of two microwave disinfection protocols (690 W / 6 min) and (345 W / 6 min) on the dimensional stability of acrylic resin denture bases. The procedure for both disinfection protocol groups was performed 3 times with a 7-day interval. They found that the first protocol had detrimental effects on the dimensional stability of denture bases, but they also suggested that 345 W for 6 min had no significant effects on them (33). Polychronakis et al. irradiated dentures daily for a week in both dry and wet conditions for 6 minutes at 650 W and concluded that the dimensional changes observed when the disinfection took place in dry conditions were of no clinical significance (34).

The controversy in the aforementioned results may be attributed to the difference in the disinfection time, power of the microwave oven, type of the materials and methods used to measure distortion (25). For example, denture resin materials have different behavior if irradiation takes place in dry or wet conditions. The immersion in water was adopted because it was believed that it increases the effectiveness of the disinfection (19). However, the water starts to boil after 90 seconds of irradiation (19), which could lead to an increase in temperature beyond the acrylic resin's glass transition temperature and thus it would become more flexible (35). This may facilitate the warping of denture bases, caused by the release of stresses stored within the material during fabrication (36,37). Furthermore, it is highly possible that the higher temperature of the water may enhance the dispersion of the remaining residual monomer molecules (38,39) to the active sites of the polymer chain (40). Consequently, further polymerization may lead to shrinkage of the denture bases.

Basso et al. investigated the effects of microwave disinfection on the occlusal vertical dimension changes of complete dentures. The researchers submitted maxillary compete dentures to microwave irradiation at 650 W for 3 min. When the specimen was irradiated once a week for 4 weeks, no significant differences were observed in the occlusal vertical dimension. Nevertheless, the specimens submitted to microwave disinfection 4 times a week for 4 weeks underwent unacceptable distortion. They suggested that when dentures are exposed to many cycles of microwave irradiation, the differences in occlusal vertical dimension are caused by the release of the inherent stress established during fabrication (41).

Flexural strength

Flexural strength is the simultaneous measurement of tensile, shear bond and compressive strengths (42). It describes the loading that occurs on the denture during mastication. Clinically, diminished flexural strength could lead to dentures more prone to fracturing.

Polyzois i suradnici (7) smatraju da promjene u savojnoj čvrstoći baze proteze nisu klinički značajne nakon mikrovalne dezinfekcije (500 W/15 min.) u suhim uvjetima. Consani i njegov tim (43, 44) upozorili su na metodu mikrovalne dezinfekcije (5 ciklusa/650 W/3 min. u vodi) koja ne rezultira značajnom razlikom u čvrstoći na savijanje između dezinficiranih i nedezinficiranih uzoraka. Ribeiro i kolege u svojem istraživanju (650W/1–5 min./2 ciklusa/proteza uronjena u vodu) zaključili su isto (45). Konchada i suradnici također nisu pronašli promjene u savojnoj čvrstoći nakon što su sa 650 W pet minuta zračili proteze uronjene u vodu (42). Sanna i kolege nisu zabilježili veće razlike u savojnoj čvrstoći nakon šest ciklusa trominutne iradijacije mikrovalovima jakosti 450 W ili 630 W, iako se modul elastičnosti smanjio nakon 36 ciklusa (27).

Hamoud i Ahmed istaknuli su, pak, da su i pet i petnaest minuta dezinfekcije mikrovalovima pri jakosti od 750 W – kako u suhim uvjetima, tako i u slučaju proteza uronjenih u vodu – smanjili čvrstoću na savijanje akrilatne baze proteze, pa su zaključili da se ta metoda ne može primjenjivati za ta pomagala (1).

Čvrstoća

Udarna čvrstoća mjera je energije primanja materijala kada iznenada frakturira (42). Proteze s visokom udarnom čvrstoćom otpornije su na pucanje. Zato se ističe da postupak dezinfekcije ne bi smio smanjivati vrijednosti udarne čvrstoće.

Seo i suradnici dokazali su da udarna čvrstoća baze proteze dezinficirane mikrovalovima (650 W/6 min.) svakodnevno tjedan dana, nije pokazivala nikakve razlike u usporedbi s kontrolnom skupinom (46). Konchada i njegov tim također su zaključili da petominutna dezinfekcija mikrovalovima jakosti 650 W nije utjecala na udarnu čvrstoću proteze (42). Senna i kolege izvijestili su da se tijekom 36 ciklusa trominutne mikrovalne iradijacije (630 W ili 900 W) nije dogodila značajna promjena u udarnoj čvrstoći proteze (27).

Suprotno tome, Hamouda i Ahmed tvrde da je mikrovalna dezinfekcija, suha ili uronjena u vodu, (750W/5 ili 15 min.), uz ostala svojstva, odlučujuća za udarnu čvrstoću (1).

Tvrdoća

Tvrdoća je neposredno povezana s cjelovitošću materijala i njegovom otpornošću na raspadanje zbog termičkih, kemijskih i mehaničkih utjecaja (27). U kliničkim uvjetima tvrdoća je otpornost proteze na abraziju tijekom vremena. Postupak dezinfekcije koji smanjuje njezinu tvrdoću klinički je neprihvatljiv jer je čini podložnom trošenju.

Ribeiro i suradnici opisali su dezinfekcijski protokol koji ne uništava tvrdoću proteze (650 W/1/5 min./2 min./uronjena u vodu) (45). Dixon i njegov tim uočili su povećanje tvrdoće, ali smatraju da to nije klinički važno (47). Polyzois i kolege istaknuli su da tvrdoća baze proteze ostaje nepromijenjena nakon mikrovalne dezinfekcije (500 W/3 i 15 min.) u suhim uvjetima (7). Sartori sa svojim suradnicima također smatra da mikrovalna dezinfekcija klinički ne utječe na tvrdoću u usporedbi s tradicionalnom kemijskom dezinfekci-

Polyzois et al. (7) suggested that the changes in flexural strength after microwave disinfection (500 W / 3 or 15 min) of denture base resins in the dry state were of no clinical importance. Consani et al. (43,44) indicated that the method of microwave disinfection (5 cycles at 650 W for 3 min in water) had no important discrepancies in the flexural strength between disinfected and non-disinfected specimens. Ribeiro et al. in their research (650 W / 1-5 min / 2 cycles / immersed in water) came to the same conclusion (45). Konchada et al. also found no alternations in flexural strength when they irradiated dentures at 650 W for 5 min, while immersed in water (42). Senna et al. observed no significant changes in flexural strength after 6 cycles of microwave irradiation at 450 or 630 W for 3 min, even though the elastic modulus decreased after 36 irradiation cycles (27).

On the other hand, Hamouda and Ahmed demonstrated that both 5 and 15 minutes of microwave disinfection at 750 W, either in dry conditions, or immersed in water produced a reduction of the flexural properties of denture base acrylic resins and concluded that this method is not acceptable for dentures (1).

Impact strength

Impact strength is a measure of energy received by the material when it experiences sudden fracture (42). A denture with high impact strength is more resilient to fracturing. Thus it is highly favored for a disinfection procedure not to diminish dentures' impact strength values.

Seo et al. demonstrated that the impact strength of denture bases disinfected with microwaves (650 W / 6 min) daily for a period of seven days showed no differences compared to the control group (46). Konchada et al. also concluded that microwave disinfection at 650 W for 5 min did not affect dentures' impact strength (42). Senna et al. reported that 36 cycles of microwave irradiation at 630 or 900 W for 3 min caused no significant changes to dentures' impact strength (27).

Conversely, Hamouda and Ahmed claimed that either immersed or non-immersed in water, microwave disinfection (750 W / 5 or 15 min) is detrimental for their impact strength - along with other properties (1).

Hardness

Hardness is directly connected with the integrity of a material and its resilience to decay by thermal, chemical or mechanical action (27). In clinical situations, hardness represents dentures' resilience to abrasion over time. A disinfection procedure which decreases dentures' hardness is unacceptable for clinical use because it makes them prone to wear.

Ribeiro et al. showed that the disinfection control protocol (650 W / 1-5 min / 2 cycles / immersed in water) had no detrimental effects on dentures' hardness (45). Dixon et al. noticed an increase in hardness, but they considered this increment of no clinical significance (47). Polyzois et al. demonstrated that the hardness of a denture base resin remained unaffected during microwave disinfection (500 W / 3 and 15 min) in the dry state (7). Sartori et al. also found that microwave disinfection had no effect of clinical significance on

jom, ali se smanjila nakon 14 dana (29). Ipak su zaključili da je uranjanje u kloridnu otopinu sigurnije negoli mikrovalni protokol (690 W/6 minuta), kad je riječ o površinskoj tvrdoći proteze (29). Konchada i kolege kažu da petominutno zračenje mikrovalovima jakosti 650 W u vlažnim uvjetima nije promijenilo tvrdoću dezinficiranih proteza (42).

Consani i njegov tim izvijestili su da je mikrovalna dezinfekcija [650 W/3 min./1 ciklus/vlažni uvjeti (43) i 650 W/3min./5 ciklusa/vlažni uvjeti] (44) snizila tvrdoću testiranih proteza.

A Senna i suradnici uočili su da je mikrovalna dezinfekcija povećala tvrdoću proteza nakon 36 ciklusa trominutnog zračenja jakosti 630 ili 900 W (27).

their hardness compared to the traditional disinfection procedure, but decreased after 14 days (29). Still, they concluded that the traditional immersion in chloride solution is a safer procedure than the conventional microwave protocol (690 W for 6 min) with regard to surface hardness of dentures (29). Konchada et al. reported that microwave irradiation at 650 W for 5 min in wet conditions did not change the hardness of the dentures disinfected (42).

Consani et al. reported that microwave disinfection (650 W / 3 min / 1 cycle / in wet conditions) (43) and (650 W / 3 min / 5 cycles / in wet conditions) (44) decreased the hardness of the denture resin tested.

On the other hand, Senna et al. demonstrated that in fact microwave disinfection increases the dentures hardness after 36 irradiation cycles at 630 or 900 W / 3 min (27).

Tvrde i otporne mase za podlaganje

Snaga veze

Gubitak adhezije između baze proteze i podložne mase uobičajeni je klinički neuspjeh koji se proučavao u dosadašnjim istraživanjima (48,51), a u njima se proučavalo sprječavanje ljuštenja podložne mase, promjena boje i zadržavanje bakterija (52). Istaknimo da kvalitetna veza povećava savojnu snagu podložne mase (50). Braden je pokazao da temperatura vode znatno utječe na njezino prodiranje u akrilatnu smolu (51). Zbog stvorene topline tijekom mikrovalne dezinfekcije može nastati povećano upijanje vode, što može smanjiti snagu veze između baze proteze i podložne mase (48) jer apsorbirana voda djeluje kao plastifikator (53).

Machado i suradnici istaknuli su da sedam šestominutnih ciklusa dezinfekcije mikrovalovima jakosti 650 W, ako su pritom proteze uronjene u vodu, ne razara snagu veze dva stvrdnjavajuća materijala u ordinaciji (54) i dviju otpornih podložnih masa (55).

Čvrstoća na savijanje

Smanjivanje savojne čvrstoće podložne mase tijekom mikrovalne dezinfekcije može materijal učiniti krhkim, podložnim pukotinama i lomu. Rezidualni monomer iz smolastih podložnih masa i proteze može, zbog učinka plastifikacije koji smanjuje sile među lancima, utjecati na savojnu čvrstoću (56). U vezi s tom tezom ističe se da mikrovalno zračenje može povećati stupanj konverzije autopolimerizirajućih smola i tako pojačati njihovu savojnu čvrstoću. Suprotno tome, mikrovalna dezinfekcija u vlažnim uvjetima može smanjiti čvrstoću na savijanje podložne mase jer se radi plastificiranja u strukturu apsorbiraju molekule vode (53, 56). Slijedom toga rezidualni monomer može iscuriti dok je proteza u vodi i potaknuti manji učinak plastifikacije nego što to čine molekule vode, a to je fenomen koji rezultira smanjenjem čvrstoće na savijanje.

Ribeiro i suradnici ustanovili su da dva ciklusa mikrovalne dezinfekcije (650 W) – minutno i petominutno – na četiri različite tvrde podložne mase nisu štetno utjecali na savojnu čvrstoću (45). Vergani i njegov tim (57) proučavali su čvrstoću na savijanje četiriju protetskih podložnih masa koje su zračili mikrovalovima tri, četiri i pet minuta snagom od

Hard and Resilient Denture Liners

Bond strength

Loss of adhesion between denture bases and liners is a common clinical failure examined in previous studies (48-51). A strong bond is necessary in order to prevent abruption of the liner, staining and retention of bacteria (52). In addition, the quality of the bonding increases the flexural strength of the liner (50). Braden has shown that the temperature of the water has an important effect on the diffusion of water into acrylic resins (51). As a result, the heat generated by microwave disinfection might cause an increase in the water sorption rate which will decrease the bond between the denture base and the liner (48) since the absorbed water acts as a plasticizer (53).

Machado et al. reported that seven cycles of microwave disinfection at 650 W for 6 min while immersed in water had no detrimental effects on the bond strength values of two hard chair-side (54) and two resilient liners (55).

Flexural Strength

The reduction of liners' flexural strength during microwave disinfection could make the material more brittle and thus more prone to crack propagation and fracture. The residual monomer of denture liners' resin might adversely affect their flexural strength by a plasticizing effect which diminishes interchain forces (56). In this context, microwave irradiation may escalate the degree of conversion of auto-polymerized resins, thus enhancing their flexural strength. On the other hand, microwave disinfection in wet conditions could lead to the reduction of liners' flexural strength which might be related to the plasticizing effect of absorbed water molecules (53,56). According to that, the residual monomer that might leach out while immersed in water, has a lesser plasticizing effect than the received water molecules, a phenomenon that leads to diminished flexural strength.

Ribeiro et al. suggested that two cycles of microwave disinfection (650 W) on four different hard liners after different exposure times (1-5 min) had no detrimental effects on their flexural strength (45). Vergani et al. (57) examined the flexural strength of four hard denture liners that were irradiated for 3, 4 and 5 minutes at 500, 550 and 650W respec-

500, 550 i 650 W, te su zaključili da se ona za pojedine podložne mase može optimizirati pravilnom kombinacijom snage i vremena te postpolimerizacijskim mikrovalnim ozračivanjem. To sve može poboljšati trajnost podloženih proteza.

Pavarina i suradnici (86) istaknuli su da šestominutna mikrovalna dezinfekcija snagom od 650 W (2 – 7 ciklusa) povećava savojnu čvrstoću pet testiranih materijala za podlaganje proteza u ordinaciji. Patil i kolege također su istraživali učinak mikrovalne dezinfekcije na dvama otpornim materijalima za podlaganje i zaključili da petominutno zračenje s 650 W povećava njihovu čvrstoću na savijanje (58).

Poroznost

Idealna površina podložne mase trebala bi biti glatka. No poroznost je često glavni klinički nedostatak koji potiče promjenu boje, nakupljanje mikroorganizama i stvaranje kamenca (59, 60). Čak i nakon što je podložena proteza očišćena, moguće je da su ostali mnogobrojni mikroorganizmi (61). Nakon mikrovalne dezinfekcije može nastati poroznost zbog isparavanja zaostaloga monomera pri visokim temperaturama kojima se materijal izlaže (62).

Novais i suradnici ispitivali su poroznost nakon mikrovalne dezinfekcije (650 W/6 minuta/7 ciklusa) pet podložnih masa, no dobili su različite rezultate jer su neke mase dobile na poroznosti, nekima se smanjila, a kod jedne je ostala stabilna (62).

Dimenzijska stabilnost

Podložne mase obično se upotrebljavaju da bi se poboljšalo kliničko prilijeganje potpunih proteza (18). Tijekom mikrovalne dezinfekcije te su mase izložene vrlo visokim temperaturama, čak i višima od staklaste transformacije polimera, što rezultira distorzijom (18).

Visoka temperatura dodatno utječe na slobodni monomer i potiče daljnju polimerizaciju, pa tako i dimenzijske promjene (63).

Seo i suradnici istražili su dimenzijsku stabilnost četiriju podložnih masa nakon mikrovalne dezinfekcije (650 W/6 minuta/7 ciklusa) i ustanovili da taj postupak uzrokuje povećano skvrčavanje testiranih uzoraka (24).

Basso i njegov tim (18) procjenjivali su učinak mikrovalne dezinfekcije (650 W/3 min./1 – 5 ciklusa) na autopolimerizirajuće podložne mase, a njihova opažanja su različita. Pojedine podložne mase su se skupljale, a kod nekih nisu uočene promjene. Goncalves i kolege također su proučavali dimenzijsku stabilnost četiriju autopolimerizirajućih podložnih masa nakon mikrovalne dezinfekcije (650 W/6 min./2 ili 7 ciklusa) i zaključili da su se dvije skvrčile, a dvije su ostale stabilne (26).

Tvrdoća

Tvrdoćom se smatra vrlo važno fizikalno svojstvo podložnih masa koje se upotrebljavaju u djelomičnim protezama. Ako tvrdoća s vremenom raste, podložne mase gube elastičnost, što rezultira stvaranjem pretjeranih okluzalnih sila na noseću sluznicu, bol, iritaciju mekih tkiva i resorpciju kosti te *plesanje* proteze.

Dixon i suradnici istaknuli su da mikrovalna dezinfekcija stvara granični i klinički nevažan učinak na tvrdoću dviju

tively and concluded that the flexural strength of certain liners could possibly be optimized by the proper power/time combination with microwave post-polymerization irradiation, thus resulting in the improvement of the longevity of the relined dentures.

Pavarina et al. (6) demonstrated that microwave disinfection at 650 W for 6 min (2-7 cycles) increased the flexural strength of five hard chair-side reline materials. Patil et al. also investigated the effects of microwave disinfection on two resilient liners and concluded that 650 W for 5 min increased their flexural strength (58).

Porosity

The ideal surface of the liners should be smooth. However, porosity is a common clinical flaw that often occurs and leads to staining, calculus deposition and accumulation of microorganisms (59,60). Even after the relined denture has been cleaned, there is a great chance that numerous microorganisms remain (61). Porosity through microwave disinfection may occur from the vaporization of the unreacted monomer due to the high temperatures that these materials are exposed (62).

Novais et al. examined the occurrence of porosity after microwave disinfection (650 W / 6 min / 7 cycles) in five hard liners and came to mixed results, since some liners experienced an increase in their porosity, others presented a decrease and one material remained stable (62).

Dimensional stability

Denture liners are commonly used in order to improve the clinical fit of complete dentures (18). However, during microwave disinfection liners are exposed to very high temperatures even beyond the glass transition of the polymers, resulting in their distortion (18). In addition, the high temperature affects the free monomer and promotes further polymerization and thereby extra dimensional changes (63).

Seo et al. examined the dimensional stability of four hard liners after microwave disinfection (650 W / 6 min / 7 cycles) and suggested that the procedure produced increased shrinkage on the specimens tested (24).

Basso et al. (18) evaluated the effect of microwave disinfection (650 W / 3 min / 1-5 cycles) on hard chair-side reline resins and came to mixed observations. Some of the liners presented shrinkage, but in others no wrapping was observed. Goncalves et al. also examined the dimensional stability of four hard chair-side liners after microwave disinfection (650 W / 6 min / 2 or 7 cycles) and concluded that two of them shrank and the other two remained stable (26).

Hardness

Hardness is considered a very important physical property of the liners used in removable prosthodontics. When hardness increases by time, liners lose their elasticity, an implication that leads to excessive occlusal forces to the underline mucosa, pain, soft tissue irritation and subsequently to bone resorption and denture misfit.

Dixon et al. showed that microwave disinfection produced marginal and not clinically significant effects on the

masa za podlaganje, ako su zračene u vlažnim uvjetima (47). Ribeiro i njegov tim također su istraživali učinak mikrovalnog zračenja (650 W/1 – 5 min./2 ciklusa) na tvrdoću četiriju masa za podlaganje nakon različitog trajanja izlaganja i zaključili da nema znatnijih razlika u odnosu prema kontrolnoj grupi (45).

Machado i kolege podvrgnuli su mikrovalnoj dezinfekciji dvije mase za podlaganje (650 W/6 min./7 ciklusa) dok su uzorci bili uronjeni u 200 mL vode i tvrde da se tvrdoća masa za podlaganje nije značajno promijenila (55). Pavan i suradnici također su istaknuli da dva ciklusa mikrovalne dezinfekcije (500 W/3 min.) nisu utjecala na vrijednosti tvrdoće dugotrajnih masa za podlaganje koje su ispitivali (64).

Zubi za proteze

Zubi za proteze izrađeni su od keramike ili češće od polimera. Polimerni zubi klasificirani su prema svojem sastavu i načinu polimerizacije u konvencionalne akrilatne zube i IPN zube (međupenetrirajuće polimerne mreže). Konvencionalni akrilatni zubi homogeni su u konfiguraciji i sastavljeni od polimerne mreže jedne vrste smole, a IPN zubi su, pak, kemijski sastavljeni od dviju mehanički isprepletenih polimernih mrežica. Naime, dvije mrežice križno su povezane pa njihova polimerizacija stvara čvrstu kemijsku vezu (23).

Retencija polimernih zuba na bazi proteze uglavnom se postiže mikromehaničkim povezivanjem polimera proteze i polimerne mrežice zuba za proteze (23).

Tvrdoća

Tvrdoća je jedno od temeljnih fizikalnih svojstava smolastih zuba za proteze opisanih u literaturi. Koristi se u procjeni otpornosti zuba za proteze na trošenje kako bi se održale postavljena vertikalna dimenzija i žvačna funkcija (65 – 68).

Campanha i suradnici istaknuli su da se tvrdoća akrilatnih zuba za proteze ne mijenja značajno ako se koristimo šestominutnom mikrovalnom dezinfekcijom (3 ciklusa) jakosti 650 W u vlažnim uvjetima i to 90 dana (67).

Vasconelos i kolege izvijestili su, pak, da tri ciklusa trominutne dezinfekcije mikrovalovima jakosti 300 W znatno smanjuju tvrdoću zuba za proteze u usporedbi s tradicionalnom dezinfekcijskom tekućinom – glutaraldehidom i hipokloridom (69). Campanha i njegov tim (70) tvrde također da sedam ciklusa mikrovalnih zračenja (650 W/6 min.) smanjuje tvrdoću svih testiranih akrilatnih zuba.

Snaga veze

Neočekivano ispadanje zuba iz proteze velik je problem koji može kompromitirati njezinu cjelovitost i kliničku uporabljivost. Pojava pukotina, kontaminacija zuba zaostalim voskom i preopterećenje bili su razlozi koji su se navodili pri ispadanju zuba (71, 72). Da bi se razmotrilo zračenje mikrovalovima kao pouzdana alternativna metoda za dezinfekciju proteza, prijeko je potrebno da ono ne utječe na zube i snagu veze, što bi posljedično rezultiralo ispadanjem zuba nakon nekoliko ciklusa dezinfekcije. U literaturi je ovaj mogući učihardness of two resilient liners when the irradiation took place in wet conditions (47). Ribeiro et al. also investigated the effect of microwave irradiation (650 W / 1-5 min / 2 cycles) on the hardness of four hard liners after different exposure times, and found no significant discrepancies compared to the control group (45). Machado et al. submitted two resilient liners to microwave disinfection (650 W / 6 min / 7 cycles) while the specimens were immersed in 200 mL of water and reported that the hardness of the liners was not adversely affected by microwave irradiation (55). Pavan et al. also suggested that two cycles of microwave disinfection (500 W / 3 min) did not affect the hardness values on the long-term resilient denture liners that were examined (64).

Denture teeth

Denture teeth are made of either porcelain or more prevalently by polymers. Polymer teeth are classified based on their composition and system of polymerization to conventional acrylic resin teeth and IPN (Interpenetrating Polymer Network) teeth. Conventional acrylic resin teeth have a homogeneity in their configuration and a polymer network of one resin type. On the other hand, IPN teeth chemically consist of two polymer networks mechanically tangled together. These networks are highly cross-linked and their polymerization creates strong chemical bonds (23).

The polymer teeth retention to the denture base is mainly achieved by micromechanical interlocking between the denture's polymer and the polymer network of the prosthetic teeth (23).

Hardness

Hardness is one of the most essential physical properties of resin denture teeth examined in the literature. It is used for the assessment of prosthetic teeth wear resistance as they operate to maintain the originally established vertical dimension and masticatory activity (65-68).

Campanha et al. showed that the hardness of acrylic resin denture teeth presented no significant changes if microwave disinfection (3 cycles) is used at 650 W for 6 min in a wet environment for 90 days (67).

However, Vasconelos et al. reported that 3 cycles of microwave disinfection at 1300 W for 3 min significantly decreased denture teeth hardness, compared to the traditional glutaraldehyde and hypochloride disinfecting solutions (69). Campanha et al. (70) also suggested that seven cycles of microwave irradiation (650 W / 6 min) decreased the hardness of all acrylic resin teeth tested.

Bond strength

The unexpected detachment of teeth from dentures is a very important issue that compromises integrity and clinical service ability of complete dentures. Crack propagation, residual wax contamination of teeth and excessive stress were to blame for teeth debonding in the past (71,72). In order to consider microwave irradiation as a reliable alternative for denture disinfection, it is crucial that it does not adversely affect the teeth/denture bond strength, consequently leading to teeth debonding after several disinfection cycles. Thus, the

nak slabljenja veze zub – proteza potanko istražen jer klinički neobično važan.

Campanha i njegov tim istražili su učinak mikrovalnog zračenja (650 W/3 min.) na vezu između zuba i protetske baze te zaključili da taj postupak može značajno smanjiti vrijednosti snage veze, bez obzira na postavke kojima se koristimo (73). Tretirane akrilatne uzorke zuba uronili su u vodu i podvrgnuli različitim tehnikama mikrovalnog zračenja (650 W/3 min.) te ih usporedili s kontrolnom grupom. Ozračenim zubima bila je smanjena vrijednost veze zub – akrilatna baza proteze (74). Premda su u nedavnom istraživanju Campanha i suradnici odbacili negativne učinke mikrovalne dezinfekcije (650 W/3 min) na snagu veze zubi – baza, ističu da pet ciklusa zračenja ne samo da ne oslabljuje snagu veze nego je čak povećava (75).

Iz ovog pregleda može se zaključiti da još ima nedorečenosti i neodgovorenih pitanja. Primjerice, nema protokola za korištenje mikrovalnog zračenja koji će osigurati dezinfekciju proteza, a da ne nastaju klinički značajne promjene fizikalnomehaničkih svojstava. Snaga zračenja i korištenog vremena izgleda da su nasumce odabrani pa je njihov raspon velik – od 350 do 1400 W te od minute do dvadeset minuta (76). Tako ostaju nepoznanice idealna učestalost te srednjoročni i dugoročni učinci povremene mikrovalne dezinfekcije. Potrebna su daljnja istraživanja kako bi se proučio učinak mikrovalnog zračenja na materijale za izradu proteza u srednjoročnom i dugoročnom razdoblju te se istodobno mora prihvatiti siguran dezinfekcijski protokol, a moraju se istražiti i fizikalnomehanička svojstva, primjerice stabilnost boje, visokoelastična svojstva, zaostali monomer i dr.

Rasprava

Kemijski dezinficijensi bili su dosad glavna sredstva u prevenciji križne kontaminacije No njihova uporaba uzrokovala je mnogobrojne teškoće, poput obojenja proteze i neželjene reakcije intraoralnih tkiva (8). U literaturi su navedeni i drugi problemi, kao što su neugodan miris nakon korištenja natrijeva klorida, smećkasta boja proteza i jezika (1), promjene u svojstvima akrilatne smole (7) i prodiranje određenih komponenti dezinficijensa u materijal (67).

Suprotno tome, mikrovalna dezinfekcija je jednostavna, brza i jednostavna. Pritom se ne stvaraju smećkaste promjene ni na protezi ni na oralnome tkivu, a nema ni neugodan miris. Dezinficira učinkovito i nema rok trajanja. Ipak, tako se ne mogu dezinficirati proteze s metalnim dijelovima, a o njezinoj svakodnevnoj uporabi još se treba raspravljati (76).

Uzmu li se u obzir navedeni podatci iz literature, može se zaključiti da je mikrovalna dezinfekcija dobra kad je riječ o alternativi za proteze i podložne mase ako se obavlja u suhim uvjetima najduže tijekom tri dezinfekcijska ciklusa. Nadalje, za postizanje najbolje dezinfekcije i minimalnih neželjenih učinaka na dentalne materijale, optimalni parametri su trominutno zračenje jakosti 650 W.

possible weakening effects of microwave disinfection on the teeth/denture bond strength is examined thoroughly in the literature as it is an issue of great clinical significance.

Campanha et al. investigated the effect of microwave irradiation (650 W / 3 min) on the bond between teeth and denture bases and concluded that this procedure might lead to important decrease of the bond strength values, regardless of the ridge laps treatments which may have been used (73). They also submitted acrylic specimens treated with different techniques to microwave irradiation (650 W / 3 min) while immersed in water and compared to the control group; and the irradiated specimens presented decreased teeth/resin bond strength values (74). However, in their latest study, Campanha et al. disputed the negative effects of microwave disinfection (650 W / 3 min) on the teeth/base bond strength, suggesting that 5 irradiation cycles not only do not decrease, but also increase the bond values (75).

From this overview it could be concluded that there are still reservations and lasting questions remaining unanswered. For instance, there is no established protocol for the use of microwave irradiation that ensures dentures' disinfection by causing no implications of clinical significance on their physical-mechanical properties. Also, the exposure time and power used, seems to have been randomly selected. There is a wide range of parameters used, from 350 to 1400 W and from 1 to 20 min (76). Furthermore, the optimal irradiation frequency and the mid- and long-term effects of periodical microwave disinfection on dentures remain unknown. Thus, more studies should be conducted investigating the effects caused by microwave irradiation on denture related materials in the mid- and long-term, providing a reliable disinfection protocol and examining more physical-mechanical properties, e.g. color stability, viscoelastic properties, residual monomer, etc.

Discussion

Chemical disinfectants were the main method for preventing cross-contamination in the past. Although, their usage produced significant disadvantages such as denture staining and intra-oral tissue reactions (8). Other problems presented in the literature were a characteristic offensive odor after the use of sodium chloride, brownish discoloration of dentures and tongue (1), alterations of acrylic resins properties (7) and penetration of certain chemical disinfectants' components in the material after the disinfection procedure (67).

On the other hand, microwave disinfection is a simple, quick and easy to use alternative. It does not produce brownish discoloration on dentures and oral tissues, nor has an unpleasant odor. It also disinfects dentures effectively and does not have an expiration date. Nevertheless, it cannot disinfect dentures with metal parts and its daily use is still debatable (76).

Considering the data from the aforementioned literature, it can be concluded that microwave irradiation is a recommended alternative for the disinfection of dentures and liners if the procedure is carried out in dry conditions for a max-

Zaključci

- Mikrovalna dezinfekcija (650 W/3 min./3 ciklusa), u usporedbi s kemijskom metodom, sigurna je alternativa za dezinfekciju baza proteze, podložne mase i zuba ako se postupak obavlja u suhim uvjetima. Ako se to čini u vlažnom okružju, može uzrokovati klinički značajne dimenzijske promjene. Više od tri ciklusa na ovim postavkama mogu nepovoljno utjecati na fizikalnomehanička svojstva akrilatne baze proteze, podložne mase ili zuba.
- Iradijacija mikrovalovima (650 W/3 min.), čini se, ne uzrokuje klinički znatne promjene kad je riječ o savitljivosti, zateznoj čvrstoći i tvrdoći akrilatne baze proteze te o vezi, savojnoj snazi, poroznosti i tvrdoći veznog dijela korištenih zubnih podložnih masa.
- Učinak mikrovalne dezinfekcije na tvrdoću zuba u protezi i na snagu veze zub – baza proteze još je kontroverzan, pa nema konačnog zaključka.

imum of 3 disinfection cycles. Furthermore, the optimum disinfection parameters in order to achieve best disinfection results with minimum adverse influence onto dental materials' physical-mechanical properties are 650 W for 3 minutes.

Conclusions

- Microwave disinfection (650 W / 3 min / 3 cycles) is a safe alternative for the disinfection of denture bases and liners compared to the chemical one when the procedure is carried out in dry conditions, but could possibly cause dimensional changes of clinical significance when the irradiation takes place in wet environment. More than 3 cycles of microwave disinfection in these settings could adversely affect the physical-mechanical properties of denture base resins, liners or teeth.
- Microwave irradiation (650 W / 3 min) seems to have no detrimental effects of clinical importance on the flexural properties, impact strength and hardness of denture resins and the bond, flexural strength, porosity and hardness of denture liners.
- The effects of microwave disinfection on the hardness of denture teeth and teeth/denture bond strength are still controversial and no safe conclusions can be drawn.

Abstract
The aim of this paper was to overview the current scientific knowledge concerning the effect of microwave disinfection on denture related material properties. Cross-infection control in dentistry is a significant issue in everyday clinical practice due to the recent increase in some infectious diseases such as hepatitis B, C and AIDS and therefore numerous methods of disinfection have been used. The most widespread method of disinfection used in everyday practice is chemical, however, studies have suggested that chemical disinfectants alter the physical and mechanical properties of the acrylic resins and enable the growth and proliferation of certain bacteria. Therefore, microwaves were introduced as an easy to use-and-access, low cost, chemical free alternative. The question that arose was if and in what way the microwave irradiation affected the denture related material properties. Microwaving affects the denture resin bases, liners and teeth in different ways. The results showed that microwave disinfection could be a safe alternative for the disinfection of denture bases and liners compared to the chemical one, when the procedure is carried out in dry conditions, but could possibly cause dimensional changes of clinical significance on them when the irradiation takes place in wet environment. It also seems to have no detrimental effects of clinical importance on the flexural properties, impact strength and hardness of denture resins and the bond, flexural strength, porosity and hardness of denture liners. The effects of microwave disinfection on the hardness of denture teeth and teeth/denture bond strength are still controversial and no safe conclusions can be drawn.

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Address for correspondence
Theodoros Klironomos
Address: Agiou Thoma 4,
11527 Athens, Greece
Tel.: +30 6978559464
klironomos350z@yahoo.com

Key words
Microwaves; Disinfection; Cross Infection; Acrylic Resins; Resins, Synthetic; Physical Phenomena

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