Community Dental Health (2018) **35,** 228–234
Received 5 April 2018; Accepted 20 July 2018

doi:10.1922/CDH_4372Brondani07

A critical review of protocols for conventional microwave oven use for denture disinfection

Mario A Brondani[1] and Adriana R Siqueira[2]

[1]*Department of Oral Health Sciences, Division of Preventive & Community Dentistry and Prosthodontics and Dental Geriatrics, University of British Columbia, Vancouver, Canada;* [2]*Private Practice, Cavalhada Avenue, Porto Alegre, Brazil.*

Introduction: The lack of proper denture hygiene may cause denture stomatitis and be detrimental to older adults' health. The cleaning of complete dentures should be quick, efficient, and easy to perform, although it might not guarantee disinfection. The use of a microwave oven has been suggested for aiding in the disinfection of complete dentures, but lacks a gold standard protocol. ***Objectives***: To critically review the literature on protocols for complete denture disinfection using conventional microwave ovens. ***Methods***: A comprehensive literature search through PubMed Central, Cochrane Database of Systematic Reviews, and Ovid MEDLINE (R) In-Process focused on publications in English dealing with microwave therapy for denture disinfection, and on the protocols used. ***Results***: A total of 266 articles with the full-text available were found; 31 were included in this manuscript after 236 were excluded. The protocols for microwave oven use for disinfection of complete dentures varied in terms of oven potency, time used for microwaving, and solution in which the complete dentures were immersed. ***Conclusions***: There is still no standardized protocol for microwave oven use for denture disinfection. Although underutilized in residential care, daily denture hygiene seems to still be the optimal method for controlling fungal infections and denture stomatitis.

Keywords: *Microwave, disinfection, dentures, protocol, dental care for the elderly, older adults, oral hygiene*

Introduction

Oral health represents a structural and functional aspect of general health in which minimal intervention can lead to maximum benefit, particularly among those older than 65 (MacEntee *et al.*, 1997). Despite advances in health and societal living conditions, older adults may still experience comorbidities, impairment, and disabilities with impact on their wellbeing (Monahan and Wolf, 2014). For some of the older adults residing in long-term care facilities and nursing homes (Huynh *et al.*, 2017), impairment and disabilities may greatly impact the dexterity needed to perform the proper cleaning of teeth and dentures (Jokstrad *et al.*, 1996), further contributing to opportunistic oral mucosal infections, fungi proliferation, and discomfort. Although some older adults try to cope and adapt to such discomfort (Brondani, 2010), long-term care residents may hold a widespread dissatisfaction with dental care while experiencing a high prevalence of oral neglect.

Denture stomatitis, oral hygiene, and fungi in the mouth

The mouth harbors a plethora of bacteria and fungi that, in most cases, are in harmony with the host. Among these, various species of Candida fungi can be found in the mouth without causing any disturbance (Deepa *et al.*, 2014; Costerton *et al.*, 1999). However, Candida is one of the most common fungal species associated with denture stomatitis (DS), a mucosal inflammation of a multifactorial nature under the denture, associated with several local and systemic factors (Aoun and Cassia, 2016; Shi *et al*., 2016); DS can be fairly common among individuals living in nursing care facilities and remains a chronic condition in the elderly. Although an array of factors can be associated with DS, including allergic reaction to the denture material, uninterrupted denture wear, or even ill-fitting dentures (Aoun and Cassia, 2016; Shi *et al.*, 2016), poor oral and denture hygiene remain highly implicated in the development of denture stomatitis (Nicol *et al*., 2007; Webb *et al*., 1998). In particular, the *Candida albicans* species plays a significant role in the initiation and progress of DS (Barbeau *et al*., 2003). In some cases, systemic infection can occur as patients with stomatitis can have their entire digestive tract colonized by Candida, making them more prone to aspiration pneumonia, which can be fatal (Studer *et al.*, 2016; Mortenson *et al*., 2013). Unfortunately, however, Candida infection is often associated with other microorganism growth that may also aggravate some of the chronic conditions experienced by a number of older adults, drastically decreasing their quality of life (Lamont and Jenkinson, 2000). Therefore, daily denture cleaning and oral hygiene should be optimized to provide a stable oral environment. Oral care should also be able to be performed quickly and fairly easy by patients and/or their caregivers (Brondani *et al*., 2012a; Lewis *et al*., 2015). Daily hygiene of the mouth should also be financially viable, and include the cleaning of dentures with a toothbrush and liquid soap, and removal of the dentures overnight. For severe and persistent Candida infections, denture cleaning should be complemented by an antifungal and antimicrobial agent aimed at disinfection[1] (Webb *et al*., 1998). Although

[1]The term 'disinfection' (and sterilization interchangeably) was used to signify killing of microorganism on a surface after cleaning. Disinfection per se does not necessarily remove microorganisms physically from the surfaces, but can further lower the risk of spreading infection.

Correspondence to: Mario A Brondani, Associate Professor, Director, Dental Public Health Graduate Program, Department of Oral Health Sciences, Division of Preventive & Community Dentistry and Prosthodontics and Dental Geriatrics, University of British Columbia JBM 116/2199 Wesbrook Mall, Vancouver, BC, V6T 1Z3. E-mail: brondani@dentistry.ubc.ca

these methods are proven to be highly effective for oral hygiene, they remain underutilized in long-term care facilities and nursing homes in particular (Yoon *et al,* 2018; Le *et al.*, 2012; Bonetti *et al*., 2015), despite oral hygiene being one of the three pillars of the oral health service delivery model for institutionalized elders (Thorne *et al*., 2001). Hence, when done inappropriately, or worse - not at all, denture care may not be sufficient to control the growth of microorganisms such as fungi (Blankenship and Mitchell, 2006). Moreover, using a toothbrush with toothpaste may scratch the surface of the dentures, further enabling the adherence of fungi and other microflora on the surface of the denture (Dovigo *et al*., 2009; Cross *et al*., 1999).

The utilization of other methods for cleaning and, if necessary, disinfecting dentures and controlling denture stomatitis have been suggested. Among these alternative methods, conventional household (kitchen type) microwave ovens have been employed for over 30 years (Brondani *et al*., 2012). The microwave oven in use today was first available commercially in 1946 in the USA and mass produced for domestic use starting in 1962 in Japan (Davis, 2016).

Microwaves are a form of high-frequency electromagnetic radiation. It is believed that microwave irradiation either leads to cell death by altering the cell structure and its membrane permeability caused by the heat generated upon the organic matter (Campanha *et al*., 2005; Campanha *et al*., 2007; Yeo *et al*., 1999), or leads to cell destruction via an interaction between the electromagnetic field produced by the microwaves and the cell molecules (Hiti *et al*., 2001; Watanabe *et al*., 2007).

Studies have shown that the use of microwaves does not induce resistance toward fungi or other microorganisms on the surface of the denture (Al-Saadi 2014; Thomas and Webb, 1995). de Campos and colleagues (2009) also argued that microwave irradiation does not alter the color or smell of dentures, although it cannot be used if the dental appliance contains metal component because of the potential for damaging the microwave magnetron.

The use of microwaves for denture fabrication has also been discussed (Consani *et al*., 2008; Pavan *et al*., 2005; Goncalves *et al*., 2006; Ribeiro *et al.*, 2008; Seo *et al*., 2007).

While microwave irradiation for disinfecting acrylic dentures was first suggested by Rohrer and Bulard in 1985, there is no agreed upon standardized protocol for microwave oven use in denture cleaning and disinfection. A review was published in 2010 on this topic (Brondani *et al*., 2012b), but given newly available information, there was a need to update such a review to now focus on the protocols used for disinfecting dentures using microwave ovens. This manuscript aims to present a comprehensive and updated critical literature review on the advantages and disadvantages of, and protocols used for, conventional microwave ovens to promote denture disinfection.

Methods

A comprehensive and updated literature search on the protocols for conventional microwave use for denture disinfection was performed, while exploring the advantages and disadvantage of microwave oven use for such an application. The search focused on studies involving the use of conventional microwave ovens on complete dentures designed for studies *in vivo* (worn by patients) and *in vitro* (complete dentures/acrylic specimens for laboratorial testing). The main focus of this manuscript was on individuals living in nursing homes because of the implication of the lack of oral hygiene towards general health. However, key words used were not limited to older adults, the elderly, or seniors so that other age groups could be included as the findings would still be applicable to older adults. The keywords [('microwave') AND ('acrylic resin' OR 'denture') AND 'protocol' AND ('candida' OR 'fungi') AND ('clean')] were used in combination with the following searching engines: PubMed Central (1970 to August 2017), Cochrane Database of Systematic Reviews (Issue from the 2nd Quarter of 2017), and Ovid MEDLINE(R) In-Process (1966 to August 2017), published in English only. Given the breadth of the keywords used, the word 'microwave' also captured *radiation* and *polymerization* of the acrylic resin, for example, while 'acrylic resin' and 'denture' were broad enough to capture *complete denture*, *denture base*, and *dental appliances* as the emphasis of this review. The publications found in each of the three search engines were limited to those containing the word 'disinfection' in the title, abstract or text given the objectives of this review. In terms of the protocols, the authors summarised their key features pertaining to the brand model and MHz of the microwave, special characteristics of the microwave, type of the solution in which the acrylic resin (e.g., complete dentures or acrylic specimens) was immersed, and amount of time used in each protocol.

The above mentioned search engines offer a slightly different way to search and select the publications. PubMed Central, for example, offers 'limits' as to the language of publication (English, French, etc.), availability of the publication (abstract, free full text, etc.), and also offers a 'search builder' for one or more keywords. Hence, there is a high probability that the same publication appeared in more than one search engine and had to be eliminated. Although the literature was searched systematically, this manuscript does not present a systematic review, given that there was no Patient, Intervention, Comparison, and Outcome (PICO) question. Only manuscripts with the full text published in English were considered.

Results

The combined search using the keywords above on the three search engines led to 266 publications (after 34 duplicates were eliminated). These 266 publications were trimmed down to 57 that contained the word 'disinfection'. Twenty-six papers were then excluded as they were related solely to the laboratorial process of fabricating dentures using microwaves (e.g., microwave-cured acrylic resins), but not using microwaves for disinfecting dentures. The 31 remaining manuscripts were read fully by the two authors and are presented in Table 1.

From those studies that specified the microwave oven models and characteristics, 7 used 2450 Mhz models, 8 had a maximum potency of 1250 Watts, 18 had a turntable, and 27 used microwave models as presented by the manufacturer and were unmodified.

As per the use of the microwave oven on dentures, 20 studies immersed the dentures under water, 6 kept them dry, 2 used both dry and wet conditions, while 3 studies did not specify if the dentures were or not kept dry or immersed under water or any other solution. There was a substantial variation in terms of the power level and the time used to microwave the acrylic dentures (Table 1).

Table 1. Manuscripts reporting investigations of microwaves to disinfect dentures.

Study investigators	Acrylic resin*	Microorganism	Protocol			
			Microwave Oven brand	Microwave Oven characteristic	Solution immersed†	Watts/time
Sanborn *et al*., 1982	Plastic tissue culture vessels	Gram -, Gram +, Bacteria, viruses	Kenmore, 2450Mhz	Turntable	Dry	650w, 3min
Rohrer & Bulard, 1985	Denture	C.albicans Aerobe and anaerobe bacteria	Toshiba, 2450 MHz	3-dimen-tional rotating device	Dry	720w, 8 and 10 min
Najdovski *et al*., 1991	Infected waste	Vegetative Bacteria (Spores)	2 different brands, both 2450 MHz	UMD	Not specified	650w, 5min 1400w, 20min
Webb, 1996	Patients' dentures	C. albicans S. gordani	Sharp N.603, 2450MHz	UMD	Water	350w,10min
Webb *et al*., 1998	Dentures	C. albicans S. gordani	Sharp N.603, 2450MHz	UMD, Turntable	Dry	350w, 6min 650w, 2min
Baysan *et al*., 1998	Sheets of Molloplast-b	C. albicans S. aureus	Sharp (R-8270b/W/P)	UMD, Turntable	Dry	650w, 5 min
Dixon *et al*., 1999	Specimens of acrylic resin	C. albicans	Model R-2A52, Sharp, 60 Hz	UMD, Turntable	Dry, Water	15 min, high power 5 min, high power
Kansu *et al*., 1999	Specimens of acrylic resin	S. aureus E. coli C. albicans S. mutans	Vestel-Goldstar, 2450MHz	UMD, Turntable	Water Water	500w, 15 min 500w, 3 min (C.albicans only)
Banting & Hill, 2001	Patients' dentures	C. albicans	Non-specific brand 850 W	UMD	Not specified	850w, 1 min
Neppelenbroek, 2003	Specimens of acrylic resin	S. aureus P. aeruginosa C. albicans B. subtilis	Non-specific brand	UMD, Turntable	Water	650w, 6 min
Mima *et al*., 2004	Tokuso Rebase Specimen	C. albicans, S. aureus, P. aeruginosa B. subtilis	Non-specific brand	UMD, Turntable	Dry, Water	550w, 4 min
Webb *et al*., 2005	Patients' dentures	C. albicans Aerobic bacteria	Sharp N.603 M, NEC corporation	UMD, Turntable	Dry	350w, 10 min
Neppelenbroke *et al*., 2005	Patients' dentures	Different C. species	Non-specific brand	UMD, Turntable	Water	650w, 6 min
Silva *et al*., 2006	Denture	C. albicans S. aureus B. subtilis	Non-specific brand	UMD, Turntable	Water	650w, 6 min
Campanha *et al*., 2007	Denture	C. albicans	Sensor Grisp38 1250W	UMD, Turntable	Water	650w, 6 min
Mese *et al*., 2007	Specimens of acrylic resin	C. albicans	Vestel, Pekel Co., Turkey	UMD, Turntable	Dry	650w, 5 min

table 1 continued overleaf...

...table 1 continued

Sanitá *et al*., 2007	Denture	Different C species from HIV patients	Non-specific brand	UMD, Turntable	Water	650w, 3 min
Mima *et al*., 2008	Specimens of acrylic resin	C. albicans P. aeruoginosa S. aureus B. subtilis	Sensor Grisp38 1250W	N/A	Water	650w, 3 min 650w, 2 min (C. albicans only)
Silva *et al*., 2008	Denture	Different C species	Non-specific brand	N/A	Water	650w, 3 min
Kim *et al*., 2008	Simulated denture	C. albicans	M.M209E, LG, South Korea	N/A	Not specified	Power not mentioned, 4 min
Buergers *et al*., 2008	Soft denture relining circular specimens	C. albicans	KOG-6Do7. Germany Daewoo Butzbach, 800w, 2450 Mhz	UMD	Water	800w, 6 min
Neppelenbroek, 2008	Patients' dentures	Different C species	Sensor Grisp38 1250W	UMD	Water	650w, 6 min
Vergani *et al*., 2008	Patients' dentures	Different C species and other microorganisms	Non-specific brand	UMWatts/ time D	Water	650w, 3 min
Dovigo *et al*., 2009	Denture	S. aureus P. aeruginosa B. subtilis	Sensor Grisp38 1250W	UMD, Turntable	Water	650w, 3 and 5 min
Sanitá *et al*., 2009	Denture	Different C species from HIV patients	Sensor Grisp38 1250W	UMD, Turntable	Water	650w, 3 min
Ribeiro et *et al*., 2009	Patient's dentures	Different C species S. mutans and other non-identified microorganisms	Sensor Grisp38 1250W	UMD, Turntable	Water	650w, 2 and 3 min
Machado *et al*., 2011	Specimens of acrylic resin	Different C. species	Non-specific brand	UMD	Water	650w, 6 min
Senna *et al*., 2012	Denture + specimens of acrylic resin	C. albicans	Continental AW-42	UMD	Water	450, 630 and 900 W at 1, 2 or 3 min each
Vasconcelos *et al*., 2013	Specimens of acrylic resin	N/A	Eletrolux	UMD, Turntable	Water	1300 W at a potency of 50%, 3 min
Silva M *et al*., 2013	Denture	Different C. species	Non-specific brand	UMD	Water	650w, 3 min
Senna *et al*., 2013	Denture + specimens of acrylic resin	C. albicans	Continental AW-42	UMD, Turntable	Water	450w, 3 min

* Included patients' dentures, flasks of acrylic resin, and dentures fabricated just for a study.

γ Any modification made on the microwave that was not specified by the manufacture. UMD – Unmodified domestic oven. N/A – Not Available

g Solution in which the dentures were immersed in when placed into the microwave oven. When non-immersed, it was assumed to be placed dry.

Discussion

Contrary to recommendations from dental and allied professionals, many individuals wearing dentures (either partial or complete) do not remove the appliances at night, and as a result, denture-bearing tissues do not get a chance to rest or receive the benefits associated with the properties of the antibacterial agents naturally present in saliva. Hence, Candida and other fungal species rapidly thrive on the surfaces of dental appliances that are not cleaned properly or that are in constant, and almost permanent, contact with the moist oral mucosa (Perezous *et al*., 2005). Microwaving the dentures may then emerge as an alternative method for disinfection when compared to soaking dentures in sodium hypochlorite (Sanita *et al*., 2009) or chlorhexidine (Oliveira *et al*., 2008). However, there is no agreed upon, or standardized, protocol for the use of microwave ovens for complete denture disinfection.

Exploring the protocols

Table 1 shows the 31 studies identified by our literature search, and exemplifies the lack of standardization, or of an acceptable protocol that could be used as a gold standard for denture disinfection. As the risk of re-infection of the oral mucosa and denture surface is significantly reduced with the use of a microwave oven, albeit not eliminated, studies used potencies ranging from 350W to 1400W, and with exposure times varying from 1 to 20 minutes. A 650W potency was used in 21 studies, while 450W potency was used in 4 studies. Lack of standardization also occurred in terms of the solution used to immerse the dentures in during the microwave irradiation, with 71% of the studies immersing the denture under water while 25% kept them dry, with or without a water container close by; 4% of the studies did not specify if any solution was used. Microwaves lead water molecules, which are polar, to align with a magnetic field that oscillates and constantly changes orientation, causing the water molecules to spin and generate heat; water also provides additional mass in the microwave oven that will absorb the radiation in 'competition' with the denture. Some studies (Burns *et al*., 1990; Rosentritt *et al*., 2008) have reported that microwaves do not appear to cause detrimental dimensional and structural changes in the denture acrylic, while other studies claim the opposite (Fleck *et al.*, 2007; Pavan *et al.*, 2005).

Sterilization and disinfection of the denture acrylic is believed to happen as the water uniformly transfers heat throughout the surfaces of the denture, either immersed in water (Dixon *et al.*, 1999) or placed close to a container with water (Hamouda and Ahmed, 2010). Pelczar and colleagues (1993) have also suggested the use of sodium hypochlorite to facilitate sterilization of acrylic *in vitro*, but the impact of using such substances in the dentures that will be worn by patients remains unknown.

Microwaves are also believed to eliminate the growth of yeast, which may further prevent the recurrence of denture stomatitis (Thomas and Webb, 1995; Burns *et al*., 1990), although these results have not yet been fully confirmed. The effect of microwaves in disinfecting the denture's acrylic surface seems to be irrefutable, yet the time required to adequately do so remains arbitrary, as shown in Table 1 and as reported in various studies (Keskin and Kansu, 1999; Webb *et al.*, 1998; Polyzios *et al.*, 1995).

The lack of a gold standard protocol for microwave use for denture disinfection may also reflect the complexity and dynamism of the oral biofilm at individual levels; a protocol that may work in one case, may not be as effective in another but more experimental research, either conducted in laboratories or in the field, is needed. None of the studies seemed to unravel the frequency to which microwave irradiation can be used to disinfect complete dentures, the extent to which denture stomatitis can be controlled and prevented, and the impact of microwave radiation on the mucosal oral biofilm over time. More importantly, it remains unclear as to whether or not microwaves alone would replace regular denture hygiene, or if they would work as an adjunct to it after the denture has been properly cleaned. In fact, daily hygiene remains ideal for denture cleaning in any circumstance, but there seems to exist no discussion as to whether or not the former replaces the later procedure. What is well known is the appalling lack of oral hygiene of older adults living in long-term care facilities (MacEntee *et al.*, 1999), despite efforts to educate both staff and residents (Brondani *et al*., 2012). Nonetheless, we would like to encourage educational institutions around the world to critically consider the use of microwave to disinfecting complete dentures when teaching oral and denture hygiene.

Conclusions

This updated comprehensive literature search on the use of conventional microwave therapy for denture disinfection showed that there is still no established protocol; a firm protocol working as a gold standard might be difficult to attain given the variety of factors influencing the effectiveness of microwave use on denture disinfection and sterilization. Although underutilized in residential care, daily denture hygiene seems to still be the optimal method for controlling fungal infections and denture stomatitis.

Acknowledgements

The authors would like to acknowledge Drs Eduardo Dickie and Jessye Giordani for their thought-provoking comments on the initial drafts of this manuscript. The authors are thankful to Ms. Angela Tether for her editorial work. The authors declare no conflict of interest.

References

Al-Saadi, M.H. (2014): Effectiveness of Chemical and Microwave Disinfection on Denture Biofilm Fungi and the Influence of Disinfection on Denture Base Adaptation. *Journal of the Indian Prosthodontic Society* **14**: 24-30.

Aoun, G., and Cassia, A. (2016): Evaluation of denture-related factors predisposing to denture stomatitis in a Lebanese population. *Materia Sociomedica* **28**, 392–396.

Banting, D.W., and Hill, S.A. (2001): Microwave disinfection of dentures for the treatment of oral candidiasis. *Special Care in Dentistry* **21**, 4-8.

Barbeau, J., Seguin, J., Goulet, J.P., de Koninck, L., Avon, S.L., Lalonde, B., Rompré, P., and Deslauriers, N. (2003): Reassesing the presence of candida albicans in denture related stomatitis. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics* **95**, 51-59.

Baysan, A., Whiley, R., and Wright, P.S. (1998): Use of microwave energy to disinfect a long-term soft lining material contaminated with Candida albicans or Staphylococcus aureus. *Journal of Prosthetic Dentistry* **79**, 454-458

Blankenship, J.R., and Mitchell, A.P. (2006): How to build a biofilm: a fungal perspective. *Current Opinions in Microbiology* **9**,/588-594.

Bonetti, D., Hampson, V., Queen, K., Kirk, D., Clarkson, J., and Young, L. (2015): Improving oral hygiene for patients. *Nursing Standard* **29**, 44-50.

Brondani, M.A. (2010): The voice of the elderly in accepting alternative perspectives on oral health. *Community Dental Health* **27**, 139–144.

Brondani, M.A, Chen, A., Chiu, A., Gooch, S., Ko, K., Lee, K., Maskan, A., and Steed, B. (2012a): Undergraduate geriatric education through community service learning. *Gerodontology* **29**, e1222-1229.

Brondani, M.A., Samim, F., and Feng, H. (2012b): A conventional microwave oven for denture cleaning: a critical review. *Gerodontology* **29**, e6-15.

Buergers, R., Rosentritt, M., Schneider-Brachert, W., Behr, M., Handel, G., and Hahnel, S. (2008): Efficacy of denture disinfection methods in controlling Candida albicans colonization in vitro. *Acta Odontologica Scandinavica* **66**, 174-180.

Burns, D.R., Kazanoglu, A., Moon, P.C., and Gunsolley, J.C. (1990): Dimensional stability of acrylic resin materials after microwave sterilization. *International Journal of Prosthodontics* **3**, 489-493.

Campanha, N.H., Pavarina, A.C., Brunetti, I.L., Vergani, C.E., Machado, A.L., and Spolidorio, D.M. (2007): Candida albicans inactivation and cell membrane integrity damage by microwave irradiation. *Mycoses* **50**, 140-147.

Campanha, N.H., Pavarina, A.C., Vergani, C.E., and Machado, A.L. (2005): Effect of microwave sterilization and water storage on the Vickers hardness of acrylic resin denture teeth. *Journal of Prosthetic Dentistry* **93**, 483-487.

Costerton, J.W., Stewart, P.S., and Greenberg, E.P. (1999): Bacterial biofilms: a common cause of persistent infections. *Science* **284**, 1318–1322.

Cross, L.J., Riggio, M.P., and Bagg, J. (1999): Genetic typing of Candida albicans strains isolated from the oral cavity of patients with denture stomatitis before and after itraconazole therapy. *Microbial Ecology in Health and Disease* **11**, 35–40.

Davis, A. (2016): A history of the microwave oven. The Institute. http://theinstitute.ieee.org/tech-history/technology-history/a-history-of-the-microwave-oven

Deepa. A.G., Nair, B.J., Sivakumar, T.T., and Joseph, A.P. (2014): Uncommon opportunistic fungal infections of oral cavity: A review. *Journal of Oral Maxillofacial Pathology* **18**, 235–243.

Dixon, D.L., Breeding, L.C., and Faler, T.A. (1999): Microwave disinfection of denture base materials colonized with Candida albicans. *Journal of Prosthetic Dentistry* **81**, 207-214.

Dovigo, L.N., Pavarina, A.C., Ribeiro, D.G., de Oliveira, J.A., Vergani, C.E., and Machado, A.L. (2009): Microwave disinfection of complete dentures contaminated in vitro with selected bacteria. *Journal of Prosthodontics* **18**, 611-617.

Fleck, G., Ferneda, F., da Silva, D.F., Mota, E.G., and Shinkai, R.S. (2007): Effect of two microwave disinfection protocols on adaptation of poly (methyl methacrylate) denture bases. *Minerva Stomatologica* **56**, 121-127.

Goncalves, A.R., Machado, A.L., Giampaolo, E.T., Pavarina, A.C., and Vergani, C.E. (2006): Linear dimensional changes of denture base and hard chair-side reline resins after disinfection. *Journal of Applied Polymer Sciences* **102**, 1821-1826.

Hamouda, M., Ahmed, S.A. (2010): Effect of microwave disinfection on mechanical properties of denture base acrylic resin. *Journal of the Mechanical Behavior of Materials* **3**, 480-7.

Hiti, K., Walochnik, J., Faschinger, C., Haller-Schober, E.M.,and Aspöck, H. (2001): Microwave treatment of contact lens cases contaminated with acanthamoeba. *Cornea* **20**, 467-470.

Huynh, J., Donnelly, L.R., and Brondani, M.A. (2017): Exploring dental student participation in interdisciplinary care team conferences in long-term care. *Gerodontology* **34**, 249–256.

Jokstrad, A., Ambjornsen, E., and Eide, K.E. (1996): Oral health in institutionalised elderly people in 1993 compared with 1980. *Acta Odontol Scandinavica* **54**, 303-308.

Kansu, G., Keskin, Y., and Misirligil, A. (1999): The effect of microwave energy on sterilization of acrylic resin base material. *Türk Klinik Hek Biologic* **5**, 19-25.

Keskin, Y., and Kansu, G. (1999): Effects of sterilization methods on dimensional stability of different types of polymerized base resins. *Türk Klinik Journal of Dental Sciences* **5**, 92-98.

Kim, J.E. (2008): Effects of denture disinfection methods on survival of Candida albicans. (abstract) http://iadr.confex.com/iadr/2008Toronto/techprogram/abstract_102847.htm

Lamont, R.J., and Jenkinson, H.F. (2000): Adhesion as an ecological determinant in the oral cavity. In, *Oral Bacterial Ecology: The Molecular Basis*; eds. Kuramitsu, H. K. and Ellen, R. P. pp. 131–168. Wymondham, UK: Horizon Scientific Press.

Le, P., Dempster, L., Limeback, H., and Locker, D. (2012): Improving residents' oral health through staff education in nursing homes. *Special Care in Dentistry* **32**, 242-250.

Lewis, A., Wallace, J., Deutsch, A., King, P. (2015). Improving the oral health of frail and functionally dependent elderly. *Aust Dent J* 2015 **60**(1), 95-105.

MacEntee, M.I., Hole, R., and Stolar, E. (1997): The significance of the mouth in old age. *Social Science and Medicine***45**, 1449-1458.

MacEntee, M.I., Thorne, S., and Kazanjian, A. (1999): Conflicting priorities: oral health in long-term care. *Special Care in Dentistry* **19**, 164–72.

Machado, A.L., Giampaolo, E.T., Vergani, C.E., Souza, J.F., and Jorge, J.H. (2011): Changes in roughness of denture base and reline materials by chemical disinfection or microwave irradiation: surface roughness of denture base and reline materials. *Journal of Applied Oral Sciences* **19**, 521-528.

Mese, A., and Mese, S. (2007): Effect of microwave energy on fungal growth of resilient denture liner material. *Biotechnology* **21**, 91-93.

Mima, E.G., Pavarina, A.C., Neppelenbroek, K.H., Vergani, C.E., Spolidorio, D.M., and Machado, A.L. (2008): Effect of different exposure times on microwave irradiation on the disinfection of a hard chairside reline resin. *Journal of Prosthodontics* **17**, 312-317.

Monahan, D.J., Wolf, D.A. (2014): the continuum of disability over the lifespan: the convergence of aging with disability and aging into disability. *Disability and Health Journal* **7**, S1-3.

Najdovski. L., Dragas, A.Z., and Kotnik, V. (1991): The killing activity of microwaves on some non-sporogenic and sporogenic medically important bacterial strains. *Journal of Hospital Infection* **19**, 239-247.

Neppelenbroek, K.H., Pavarina, A.C., Palomari Spolodorio, D.M., Sgavioli Massucato, E.M., Spolidorio, L.C., and Vergani, C.E. (2008): Effectiveness of microwave disinfection of complete dentures on the treatment of Candida-related denture stomatitis. *Journal of Oral Rehabilitation* **35**, 836-846.

Neppelenbroek, K.H., Pavarina, A.C., Palomari Spolidorio, D.M., Vergani, C.E., Mima, E.G., and Machado, A.L. (2003): Effectiveness of microwave sterilization on three hard chairside reline resins. *International Journal of Prosthodontics* **16**, 616–620.

Nicol, R., Sweeney, M.P., McHugh, S., and Bagg, L. (2005): Effectiveness of health care worker training on the oral health of elderly residents of nursing homes. *Community Dentistry and Oral Epidemiology* **33**, 115–124.

Oliveira, M.E.G., Pavarina, A.C., Neppelenbroek, K.H. Vergani, C.E., Spolidorio, D.M., and Machado, A.L. (2008): Effect of different exposure times of microwave irradiation on the disinfection of a hard chairside reline resin. *Journal of Prosthodontics* **17**, 312–317.

Pavan, S., Arioli, F.l.J.N., Dos Santos, P.H., and Mollo, F.A. (2005): Effect of microwave treatments on dimensional accuracy of maxillary acrylic resin denture base. *Brazilian Dental Journal* **16**, 119-123

Pelczar, Jr. M.J., Chan, E.C., and Krieg, N.R. (1993): Control of microorganisms: principles and physical agents. In, *Microbiology: Concepts and Applications,* vol. 1, 2nd edn; eds. Pelczar, Jr. M.J., Chan, E.C., and Krieg, N.R. pp. 200-220 . New York, NY: McGraw-Hill.

Perezous, L.F., Flaitz, C.M., Goldschmidt, M.E., Engelmeier, R.L. (2005): Colonization of Candida species in denture wearers with emphasis on HIV infection: a literature review. *Journal of Prosthetic Dentistry* **93**, 288-93.

Polyzios, G.L., Zissis, A.J., and Yannikakis, S.A. (1995): The effect of glutaraldehyde and microwave disinfection on some properties of acrylic denture resin. *International Journal of Prosthodontics* **8**, 150-154.

Ribeiro, D.J., Pavarina, A.C., Dovigo, L.N., Palomari Spolidorio, D.M., Giampaolo, E.T., and Vergani, C.E. (2009): Denture disinfection by microwave irradiation: A randomized clinical study. *Journal of Dentistry* **37**, 666-672.

Rohrer, M.D., and Bulard, R.A. (1985): Microwave sterilization. *Journal of the American Dental Association* **110**, 194-198.

Rosentritt, M., Schneider-Brachert, W., Behr, M., Handel, G., and Hahnel, S. (2008): Efficacy of denture disinfection methods in controlling Candida albicans Buergers colonization in vitro. *Acta Odontologica Scandinavica* **66**, 174–180.

Sanborn, M.R., Wan, S.K., and Bulard, R. (1982): Microwave sterlization of plastic tissue culture vessels for reuse. *Applied Environmental Microbiology* **44**, 960-964.

Sanitá, P.V., Pião, J., and Vergani, C.E. (2007) : Microwave sterilization of dentures contaminated with candida albicans isolated from HIV infected patient. http://iadr.confex.com/iadr/brazil07/preliminaryprogram/abstract_112282.htm

Sanitá, P.V., Vergani, C.E., Giampaolo, E.T., Pavarina, A.C., and Machado, A.L. (2009): Growth of Candida species on complete dentures: effect of microwave disinfection. *Mycoses* **52**, 154-160.

Senna, P.M., da Silva, W.J., and Cury, A.A. (2012): Denture disinfection by microwave energy: influence of Candida albicans biofilm. *Gerodontology* **29**, e186-191.

Senna, P.M., Sotto-Maior, B.S., Silva, W.J., and Del Bel Cury, A.A. (2013): Adding denture cleanser to microwave disinfection regimen to reduce the irradiation time and the exposure of dentures to high temperatures. *Gerodontology* **30**, 26-31.

Shi, B., Wu, T., McLean, J., Edlund, A., Young, Y., He, X., Lv, H., Zhou, X., Shi, W., Li, H., and Lux, R. (2016): The Denture-Associated Oral Microbiome in Health and Stomatitis. *mSphere* **1**, e215-2116.

Silva, M., Consani, R., Sardi, J., Mesquita, M., Macêdo, A., and Takahashi, J. (2013): Microwave irradiation as an alternative method for disinfection of denture base acrylic resins. *Minerva Stomatologica* **62**, 23-29.

Silva, M.M., Vergani, C.E., and Mima, E.G.O. (2008): Effect of microwave disinfection in the treatment of denture stomatitis. http://iadr.confex.com/iadr/2008Toronto/techprogram/abstract_103625.htm

Silva, M.M., Vergani, C.E., Giampaolo, E.T., Neppelenbroek, K.H., Spolidorio, D.M., and Machado, A.L. (2006): Effectiveness of microwave irradiation on the disinfection of complete dentures. *International Journal of Prosthodontics* **19**, 288-293.

Studer, P., Räber, G., Ott, D., Candinas, D., and Schnüriger, B. (2016): Risk factors for fatal outcome in surgical patients with postoperative aspiration pneumonia. *International Journal of Surgery* **27**, 21-25.

Thomas, C.J., and Webb, B.C. (1995): Microwaving of acrylic resin dentures. *European Journal of Prosthodontics and Restorative Dentistry* **3**, 179–182.

Thorne, S., Kazanjian, A., and MacEntee, M.I. (2001): Oral health in long-term care: the implications of organizational culture. *Journal of Aging Studies* **15**, 271-283.

Vasconcelos, L.R., Consani, R.L., Mesquita, M.F., and Sinhoreti, M.A. (2013): Effect of chemical and microwave disinfection on the surface microhardness of acrylic resin denture teeth. *Journal of Prosthodontics* **22**, 298-303.

Vergani, C.E., Giampaolo, E.T., and Pavarina, A.C. (2008): Efficacy of denture microwave disinfection in treating denture stomatitis. http://iadr.confex.com/iadr/2008Toronto/techprogram/abstract_109028.htm

Yeo, C.B., Watson, I.A., Stewart-Tull, D.E., and Koh, V.H. (1999): Heat transfer analysis of *Staphylococcus aureus* on stainless steel with microwave radiation. *Journal of Applied Microbiology* **87**, 396-401.

Yoon, M.N., Ickert, C., Slaughter, S.E., Lengyel, C., Carrier, N., and Keller, H. (2018): Oral health status of long-term care residents in Canada: Results of a national cross-sectional study. *Gerodontology* doi: 10.1111/ger.12356. [Epub ahead of print]

Watanabe, K., Kakita, Y., Kashige, N., Miake, F., and Tsukiji, T. (2007): Effect of ionic strength on the inactivation of micro-organisms by microwave irradiation. *Letters in Applied Microbiology* **31**, 52-56.

Webb, B.C. (1996): Laboratory and clinical studies on the treatment of candida-associated denture stomatitis with sodium hypochlorite or microwave irradiation. Thesis, University of Sydney. http://hdl.handle.net/2123/4466

Webb, B.C., Thomas, C.J., Willcox, M.D.P., Harty, D.W., and Knox, K.W. (1998): Candida-associated denture stomatitis. Aetiology and management: A review part 3.Treatment of oral candidiasis. *Australian Dental Journal* **43**, 244-249.