

SYSTEMATIC REVIEW

The effect of overnight storage conditions on complete denture colonization by *Candida albicans* and dimensional stability: A systematic review



Tyler V. Verhaeghe, DDS, MEd,<sup>a</sup> Chris C. Wyatt, DDS, MSc/Dip Pros, FRCD(C),<sup>b</sup> and Nesrine Z. Mostafa, BDS, MSc, MSc/Dip Pros, PhD, FRCD(C)<sup>c</sup>

Denture stomatitis refers to the inflammation of the oral mucosa that supports a removable denture.<sup>1</sup> Its prevalence has been reported from 15% to 70%, and it has a higher incidence among women and the elderly.<sup>2</sup> In a random sampling of 10% of an elderly population in Denmark, individuals wearing a maxillary removable complete or partial denture were found to have denture stomatitis (65%) or healthy palatal mucosa (35%), and *Candida albicans* was present in 86.5% and 75% of the respective groups.<sup>3</sup> Another study of patients with denture stomatitis corroborated this finding, determining that 92% had *C. albicans* present.<sup>4</sup> *C. albicans* exists in a yeast and a hyphal form; the hyphal form was more frequent in the denture stomatitis group (77%) than the healthy mucosa group (47%). Furthermore, inflammatory cells with large numbers of hyphae were seen in those with denture stomatitis (65%) compared with those with healthy palatal mucosa (14%).<sup>3</sup>

ABSTRACT

**Statement of problem.** Overnight removal of complete dentures is recommended to reduce the incidence of denture stomatitis. The effect of overnight storage conditions is unclear.

**Purpose.** The purpose of this systematic review was to assess the effect of overnight storage conditions on complete denture colonization by *Candida albicans* and to explore the effect of overnight storage conditions on the dimensional stability of complete dentures.

**Material and methods.** Two electronic databases were searched through to November 2018. The terms "denture\*", "dental prosthes\*", "acrylic resin\*", "storage", "nighttime", "overnight", "wet", "dry", "water\*", and "solution" were chosen. Articles meeting the inclusion criteria were selected. For both research questions, studies that did not store the dentures overnight or for a minimum of 8 hours were excluded. For the primary research question, studies that were not randomized controlled studies or comparative studies were excluded.

**Results.** The database search strategy resulted in a total of 159 potential studies. After screening titles and abstracts and applying the inclusion and exclusion criteria, 6 studies were retrieved for a full-text assessment. Hand searching was also performed. Four studies were included in the systematic review for the primary research question. Three studies were included for the secondary research question. A meta-analysis could not be performed because of variation in study design.

**Conclusions.** Cleaning of dentures before overnight storage helps reduce *C. albicans* colonization. If the dentures are not cleaned, the use of an alkaline peroxide-based cleaning tablet should be considered. Alternately, overnight dry storage is an option for reducing *C. albicans* colonization, with clinically insignificant changes to the dimensions of the complete denture. Storing dentures in water alone may promote *C. albicans* colonization. (J Prosthet Dent 2020;124:176-82)

Although *C. albicans* has 18 different strains and may be more pathogenic than other species of the genus,<sup>1</sup> its ability to colonize the oral mucosa and complete denture may lie in its role as an opportunistic pathogen, taking advantage of continuous wearing of the complete denture, poor denture hygiene, older and thereby likely

<sup>a</sup>Graduate student, Graduate Prosthodontics, Prosthodontics, Faculty of Dentistry, University of British Columbia, Vancouver, Canada.

<sup>b</sup>Professor and Department Head, Department of Oral Health Sciences, Faculty of Dentistry, University of British Columbia, Vancouver, Canada.

<sup>c</sup>Assistant Professor, Department of Oral Health Sciences, Faculty of Dentistry, University of British Columbia, Vancouver, Canada.

## Clinical Implications

Proper denture hygiene is important before overnight storage of complete dentures, and efforts should be made toward patient education. If denture hygiene is compromised, the use of an alkaline peroxide-based cleaning tablet or dry storage can reduce the amount of *Candida albicans*, which may prevent the development of denture stomatitis. Storage of complete dentures overnight under dry conditions does not seem to affect their dimensional stability to a clinically relevant extent.

poor fitting dentures, or systemic factors such as smoking or an immunocompromised state.<sup>2</sup> A recent study to determine the risk factors for denture stomatitis using multivariate statistical analysis (rather than the previously and more commonly used univariate tests) to account for the interaction between factors found that overnight denture wearing appeared to be the main factor, followed by the age of the dentures and *Candida* infection. Type of dentures, salivary pH, and microbiological findings were not statistically significant.<sup>5</sup> However, another recent study that looked at potential risk factors associated with denture stomatitis was unable to use multivariate analysis to determine a single predictor for its severity. The authors indicated that other studies to investigate new variables should also be considered.<sup>6</sup>

An interview and clinical examination of 71 denture wearers found that wearing dentures overnight, poor denture hygiene, and denture cleanliness were all statistically significant for the prevalence of denture stomatitis. The cleaning methods used were washing (60.6%), toothbrushing with toothpaste (24%), and soaking (15.4%). The questionnaire also asked where dentures were stored when not being worn (water, moist, or table), but the findings were not reported.<sup>7</sup>

Given paucity in the literature on how dentures are stored overnight, there is uncertainty regarding what effect the overnight storage may have on factors that have been shown to contribute to the development of denture stomatitis. With the possibility for negative sequelae if denture stomatitis develops, determination of appropriate overnight storage of dentures requires further assessment. This is particularly true because studies have shown that the main reservoir for *C. albicans* is the intaglio surface of the denture.<sup>8</sup> Hence, a systematic review to evaluate the effect of overnight storage conditions on the *C. albicans* colonization of complete dentures was performed. The acrylic resin of complete dentures may experience polymerization shrinkage followed by water sorption, which may lead

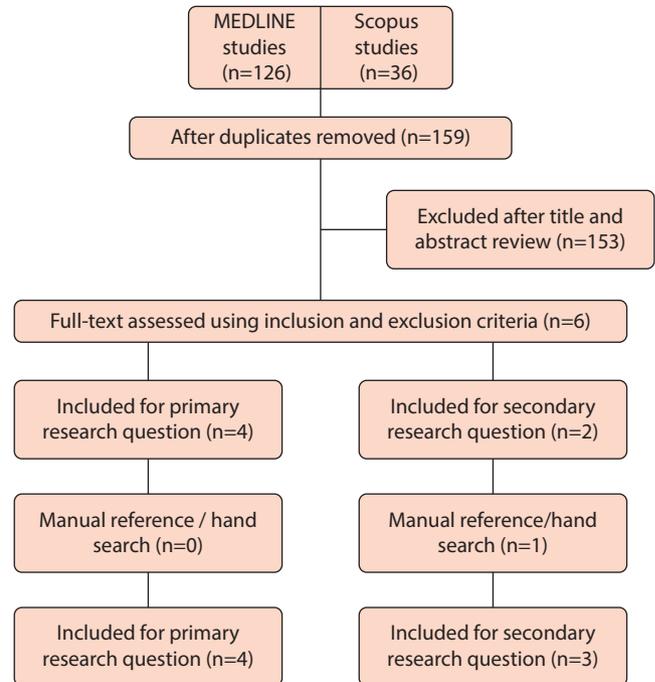


Figure 1. Study selection procedure.

to dimensional changes. As these may affect fit, particularly as time passes,<sup>9</sup> a secondary research question, the effect of the overnight storage conditions on the dimensional stability of complete dentures, was also examined.

## MATERIAL AND METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol was followed as much as possible.<sup>10</sup> Two online databases, OVID Medline (1946 to November 2018) and SCOPUS (1960 to November 2018), were systematically searched to identify randomized controlled studies or comparative studies to satisfy the patients, intervention, comparison, outcome (PICO) question, "In patients wearing complete dentures, do different overnight storage conditions affect the colonization of *C. albicans*?" The search methodology combined the use of the keywords "denture\*", "dental prosthes\*", "acrylic resin\*", "storage", "nighttime", "overnight", "wet", "dry", "water\*", and "solution" and relevant Medical Subject Headings (Mesh) terms using Boolean operators. During the initial search, included articles were limited to the English language. After removing duplicate articles, an evaluation of all titles and abstracts was performed using the inclusion and exclusion criteria. The inclusion criteria were human studies, randomized controlled studies or comparative studies that included completely edentulous patients treated with complete dentures which evaluated the effect of overnight storage conditions on the colonization of

**Table 1.** Summary of articles included for *Candida albicans* colonization of complete dentures under different overnight storage conditions

Author(s)	Study Design	Objective(s)	Treatment Groups			
			Stored Dry	Stored in Water	Stored in Water With Alkaline Peroxide-Based Cleansing Tablet	Stored in Water With 0.5% Sodium Hypochlorite
Stafford et al <sup>11</sup>	Comparative	Examine whether dentures stored dry showed less <i>Candida</i> colonization than when stored wet	19	10	N/A	N/A
Duyck et al <sup>12</sup>	Parallel-group randomized controlled trial	Compare role of overnight storage state on plaque growth and composition of dentures	16	18	17	N/A
Duyck et al <sup>13</sup>	Crossover randomized controlled trial	Compare role of denture cleaning methods in combination with overnight storage conditions on biofilm mass and composition of dentures	N/A	13	13	N/A
Peracini et al <sup>14</sup>	Crossover randomized clinical trial	Evaluate efficacy against <i>Candida</i> spp. by overnight soaking with 2 denture cleansers	N/A	32	32	32

cBF, control biofilm; CFUs, colony forming units; dBF, developing biofilm; mBF, mature biofilm; N/A, not applicable.

*C. albicans*, and English language studies. The exclusion criteria were any studies that did not use overnight or a minimum of 8 hours for the storage conditions. Relevant full-text articles and those for which an abstract was not available were sought and assessed. Finally, hand searching was also performed. Data collected for all selected articles were authors, study design, objectives, treatment groups, overnight storage time, preovernight storage cleaning regimen and person, follow-up, outcomes, and significant results.

A secondary PICO question, "In patients wearing complete dentures, do different overnight storage conditions have an effect on the dimensional stability of complete dentures or acrylic resin?" was also addressed. The inclusion criteria were any comparative in vivo or in vitro studies. The exclusion criteria were any studies that did not use overnight or a minimum of 8 hours for the storage conditions. Relevant full-text articles and those for which an abstract was not available were sought and assessed. Finally, hand searching was also performed. The data collection for the secondary research question included authors, study design, objectives, treatment groups, overnight storage time, specimen used, follow-up, outcomes, and significant results.

## RESULTS

The online database search resulted in a total of 162 studies (Fig. 1). After duplicates were removed, 159

studies remained. After the titles and abstracts were reviewed and the inclusion and exclusion criteria were applied, 6 full-text studies were assessed. Four studies<sup>11-14</sup> were included for the primary research question in the systematic review. The online database search was followed up by a manual search through the references of the included studies, but no additional studies were selected. For the secondary research question, 2 full-text studies, which included one of the studies from the primary research question, were assessed. A manual search through the references of the included studies as well as a hand search yielded 1 additional study, which resulted in a total of 3 included studies<sup>11,15,16</sup> for the secondary research question.

The 4 selected studies evaluating the effect of overnight storage conditions on *C. albicans* colonization included 3 randomized controlled trials and 1 comparative study, but a meta-analysis could not be performed because of variations in study design and measured outcomes (Table 1). In the selected studies, a total of 125 completely edentulous patients with complete dentures were included. Patient demographics were generally poorly described because only one<sup>14</sup> of the studies indicated the sex of the participants (7 men, 25 women), and only 1 study provided the average age (85.9 ±5.9 years).<sup>12</sup> Two studies enrolled their participants from dental school patients,<sup>11,14</sup> and 2 studies, from institutionalized patients.<sup>12,13</sup> The study treatments for overnight storage included dry storage,<sup>11,12</sup> water storage,<sup>11-14</sup> storage in

**Table 1.** (Continued) Summary of articles included for *Candida albicans* colonization of complete dentures under different overnight storage conditions

Overnight Storage Time	Preovernight Storage Cleaning Regimen and Person	Follow-up	Outcomes	Significant Results
8 h	Unknown; patient	None	Prevalence and density of <i>C. albicans</i>	Mean density of <i>C. albicans</i> CFU after dry storage reduced from 161.7 ±142.8 to 12.5 ±13.4 and increased from 179.3 ±171.4 to 320.8 ±101.4 after water storage <i>C. albicans</i> prevalence reduced from 100% to 58% after dry storage and remained at 100% after water storage
Overnight (not defined in hours)	Brushing with soap only right before storage, not during day; researcher	7 d (for developing biofilm) and 14 d (for mature biofilm)	Incidence and count (log10) of <i>C. albicans</i> in cBF, dBF, and mBF	<i>C. albicans</i> incidence lowest in tablet group, especially compared with water group, in both dBF and mBF, but not statistically significant ( $P=.06$ ) <i>C. albicans</i> count significantly lower in tablet group compared with water group for both dBF and mBF (-69.3 ±3.8% and -75.9 ±3.2%, with $P<.05$ and $P<.01$ , respectively) <i>C. albicans</i> count equal for dBF and mBF in tablet group
Overnight (not defined in hours)	Brushing with denture brush and water or ultrasonic cleaning in water for 15 min only before storage, not during day; researcher	5 consecutive days (2-d washout period)	Count (log10) of <i>C. albicans</i>	Amount of <i>C. albicans</i> not significantly affected
Overnight (>8 h)	Brushing with denture brush and liquid neutral soap for 2 min, 3 times per day; patient	7 d (3 alternate periods)	CFU counts (log10-CFU+1) of <i>Candida</i> spp. Prevalence of <i>Candida</i> spp. before and after solution use	Significant reduction of <i>Candida</i> spp. counts after using either solution noted (Fr=69.29, $P<.001$ ) <i>C. albicans</i> most prevalent species

water with an alkaline peroxide-based cleansing tablet,<sup>12-14</sup> or storage in water with 0.5% sodium hypochlorite.<sup>14</sup> Overnight storage time was either defined as 8 or more hours<sup>11,14</sup> or was only identified as overnight.<sup>12,13</sup> The preovernight storage cleaning regimen was not described in 1 study,<sup>11</sup> was brushing with soap only immediately before storage,<sup>12</sup> was either brushing with a denture brush and water or ultrasonic cleaning in water for 15 minutes only immediately before storage,<sup>13</sup> or was brushing with a denture brush and soap for 2 minutes 3 times per day.<sup>14</sup> The person following the treatment regimen was either the patient<sup>11,14</sup> or the researcher.<sup>12,13</sup> Follow-up ranged from none<sup>11</sup> to up to 14 days.<sup>14</sup>

Stafford et al<sup>11</sup> reported that the mean density of *C. albicans* colony-forming units (CFUs) decreased from 161.7 ±142.8 to 12.5 ±13.4 when dry storage conditions were used and increased from 179.3 ±171.4 to 320.8 ±101.4 when water storage conditions were used. The prevalence of *C. albicans* reduced from 100% to 58% under dry storage conditions but remained at 100% with water storage conditions. Only descriptive statistics were used.

Duyck et al<sup>12</sup> reported that the incidence of *C. albicans* was lowest in the alkaline peroxide tablet storage, especially compared with the water storage group in both developing and mature biofilm, although it was not statistically significant ( $P=.06$ ). The *C. albicans* count was statistically significantly lower in the tablet group

compared with the water storage group for both developing biofilm ( $P<.05$ ) and mature biofilm ( $P<.01$ ). In the tablet storage group, the *C. albicans* count was equal for the developing and mature biofilms. Duyck et al<sup>13</sup> reported that the amount of *C. albicans* was not significantly different between overnight water storage and alkaline peroxide tablet storage. Peracini et al<sup>14</sup> reported a statistically significant reduction of *Candida* spp. counts after using either alkaline peroxide tablets or 0.5% sodium hypochlorite solutions (Fr=69.29,  $P<.001$ ) and that the most prevalent *Candida* species was *C. albicans*.

The 3 selected studies that evaluated dimensional stability were comparative in vitro studies. A meta-analysis was not possible because of variations in study methodology and measured outcomes (Table 2). A total of 81 specimens consisting of either denture bases representing a mandibular denture,<sup>11</sup> maxillary denture,<sup>15</sup> or acrylic resin disks<sup>16</sup> were used. The study treatments for overnight storage were either stored dry for 8 hours and then in water,<sup>11</sup> stored dry for 8 hours and then in artificial saliva for 16 hours,<sup>15</sup> or stored in distilled water for 8 hours and then in artificial saliva for 16 hours.<sup>16</sup> Follow-up time ranged from 2 instances (time between was unknown) up to 30 days. The outcomes of dimensional change were measured by using optical equipment or optical equipment with a software program. Using descriptive statistics, Stafford et al<sup>11</sup> noted an overall mean contraction of 0.0267 mm (0.05%) with a range of 0.002 to 0.055 mm (0.005% to 0.1%), which was deemed

**Table 2.** Summary of articles included for dimensional stability of complete dentures under different overnight storage conditions

Author(s)	Study Design	Objective(s)	Treatment Groups			Overnight Storage Time (h)	Specimen Used	Follow-up	Outcomes	Significant Results
			Stored Dry/Water	Stored Dry/Art. Saliva 16 h	Stored in Distilled Water/Art. Saliva 16 h					
Stafford et al <sup>11</sup>	Comparative (in vitro)	Examine change of dimension of dentures with overnight drying	5	N/A	N/A	8	Denture bases fabricated from silicone mold separate of brass master die to represent mandibular denture	Repeated on 2 separate instances (time between unknown)	Nikon optical comparator at 10x to measure: anteroposterior dimension, posterior dimension	Overall mean contraction of 0.0267 mm (0.05%) with range 0.003-0.055 mm (0.005%-0.1%) No clinical significance
Abd Shukor et al <sup>15</sup>	Comparative (in vitro)	Determine and compare dimensional changes of maxillary dentures after simulated overnight drying	36 (4 groups of 9)	N/A	N/A	8	Maxillary dentures made from 4 different types of resin	4 cycles over 5 consecutive days	Measurements using video camera connected to computer to measure: interpremolar width, intermolar width, right and left anteroposterior dimension between premolars and molars	Largest dimensional changes observed after dentures fully hydrated then air-dried for first 8 h Statistical significance of dimensional change reduced during cyclic drying Largest changes in cross-arch rather than anteroposterior dimensions Statistically significant changes seen across different types of resin but so small as to be clinically irrelevant
Garcia Lda et al <sup>16</sup>	Comparative (in vitro)	Evaluate effect of AAA on dimensional stability of different types of acrylic resin submitted to different storage protocols	N/A	20 (10 thermal, 10 chemical)	20 (10 thermal, 10 chemical)	8	Acrylic resin (thermal and chemical activation) disks of 15x0.5 mm	30 d	Photographs and software program to measure: major and minor axes of pattern on disks	Acrylic resin disks stored in water had largest distance between major and minor axes statistically different from control groups ( $P<.05$ ) Dry storage showed least dimensional change

AAA, artificial accelerated aging; N/A, not applicable.

to be clinically insignificant. Abd Shukor et al<sup>15</sup> observed that the largest dimensional change was after the fully hydrated dentures were dried for the first 8 hours; however, during the cyclic drying, the statistical significance of the dimensional changes was reduced. The largest changes were noted in the cross-arch dimension rather than the anteroposterior dimension, and while dimensional changes were noted across the different types of resin, they were so small as to be clinically irrelevant. Finally, the study by Garcia Lda et al<sup>16</sup> reported that acrylic resin stored overnight in distilled water had the greatest dimensional change from the control groups (stored dry exclusively), which was statistically significant ( $P<.05$ ), and that groups with 8 hours of dry storage showed the least amount of dimensional change.

## DISCUSSION

In 2011, the American College of Prosthodontists published guidelines for maintaining complete dentures based on evidence from the literature.<sup>17</sup> One of these guidelines was that to prevent warping, dentures should

be stored in water, both after cleaning and if not to be replaced immediately in the mouth. Another guideline was not to wear dentures continuously to minimize the potential for denture stomatitis. However, literature was not cited for the first guideline. Given that a significant relationship exists between *Candida* spp. counts and overnight denture wear,<sup>18</sup> the second guideline is well advised considering the role of *C. albicans* in the etiology of denture stomatitis. It stands to reason that if dentures are stored extraorally overnight to reduce the colonization of *C. albicans* intraorally, the storage conditions should reduce the colonization of *C. albicans* on the denture itself and prevent recolonization of the oral mucosa when reinserted. However, ideal storage conditions of dentures are lacking, and this finding was reiterated by one of the studies included in this systematic review.<sup>12</sup> As such, the effects of different overnight storage conditions on the colonization of complete dentures by *C. albicans* and, as a secondary research question, the effects of the storage conditions on the dimensional stability require appropriate assessment.

The systematic search on *C. albicans* colonization resulted in only 4 studies<sup>11-14</sup> for the primary research

question. While 3 of them were randomized controlled trials (RCTs), level of evidence II according to the National Health and Medical Research Council (NHMRC) guidelines, a comparative study<sup>11</sup> with concurrent controls (split mouth design) at the level of evidence III-2 was also included<sup>19</sup> because of the paucity of studies and because it examined the dry storage condition. Power analysis to determine an acceptable sample size was performed in the study by Duyck et al<sup>13</sup> but was not described in the other studies.

With the exception of the comparative study where participants were intentionally assigned without randomization and therefore had a high risk of bias,<sup>11</sup> participants chosen for the remaining studies had a low risk of bias with regard to random sequence generation and a mostly low risk of bias with regard to allocation concealment as patients were assigned through randomization. Allocation concealment was not completely possible in 1 study<sup>14</sup> as one of the treatments used sodium hypochlorite, the odor of which would be detectable to the participants, and another treatment used an effervescent tablet, which would be noticeable. Still, as a crossover RCT, all participants would have experienced this treatment at one point. Blinding of participants in the comparative study was considered unclear to biased because the preovernight storage cleaning regimen was unknown and under the control of the participant, assumingly without instruction. Blinding of participants was low in 2 studies<sup>12,13</sup> because the preovernight storage cleaning regimen and overnight storage were performed by the researcher and not the participant. Again, blinding of 1 study<sup>14</sup> that placed dentures into sodium hypochlorite and used effervescent tablets made the risk of blinding high. Considering these latter studies as being of low quality would not, however, be appropriate.

Blinding of researchers in 3 of the studies<sup>11,12,14</sup> appeared to have a low risk of bias, but 1 of the studies<sup>13</sup> had an unclear risk of bias as it stated 2 researchers performed the preovernight storage cleaning of the dentures and the overnight storage treatment but did not clarify if one was responsible for each of the tasks or if they shared the tasks. Blinding of outcome assessors would be expected to have a low risk of bias as the outcome measures of prevalence, density, incidence, or count of *Candida* spp. or *C. albicans* are objective measures. Duyck et al<sup>13</sup> noted that a different researcher did the microbial sampling and not those who had performed the treatments. They reported a partial loss of data from 1 participant due to an unexpected need for medication, which would have affected the outcome measures but was appropriately accounted for. Peracini et al<sup>14</sup> also fully described the details of the loss of 7 participants from the 39 who had been enrolled.

Only 3 studies were included for the secondary research question on dimensional stability, which

would be considered as level of evidence III-2<sup>11,16</sup> and III-3 according to the NHMRC guidelines.<sup>15</sup> Power analysis was not reported in any of these studies. With regard to dimensional stability, water sorption from final processing to the point of full saturation would result in an expansion of between 0.02% and 0.35%, where 0.5% would change a posterior cross-arch dimension of 50 mm by only 0.25 mm.<sup>11</sup> Conversely, in terms of shrinkage of acrylic resin, posterior cross-arch changes of 0.5 mm, which equates to approximately 1%, does not significantly affect fit or comfort.<sup>11</sup> Understanding the magnitude of these changes, particularly in light of the short period of overnight storage time of 8 hours and given that the diffusion coefficient of acrylic resin is low, gives perspective regarding the results of 2 studies, concluding that dry overnight storage of removable dentures would have no clinical significance.<sup>11,15</sup> The other study<sup>16</sup> found that dry storage showed the least dimensional change because the control groups to which comparisons were made were dry (24 hours for 30 days) and thus not representative of the overall storage conditions of dentures, which are generally in a moist environment in the patient's mouth for approximately 16 hours. As such, interpretation of these results, particularly in comparison with the other 2 studies in which the specimens were stored in wet conditions for the other 16 hours, warrants caution.

With regard to *C. albicans* colonization of removable dentures where the preovernight storage cleaning regimen was unknown and under the patient's control, a reduction in mean density and prevalence was noted with dry storage compared with water storage where an increase in mean density was observed and prevalence was unchanged.<sup>11</sup> When a preovernight storage cleaning regimen of brushing with soap was performed by a researcher, the *C. albicans* incidence was lowest in the water with an alkaline peroxide-based cleaning tablet, followed by dry storage and then water storage, whereby the *C. albicans* count was statistically significantly lower between the tablet and water group in either developing ( $P < .05$ ) or mature ( $P < .01$ ) biofilm.<sup>12</sup> When a preovernight storage cleaning regimen of either brushing with water or ultrasonic cleaning with water for 15 minutes was performed by a researcher, the amount of *C. albicans* was not significantly affected whether an alkaline peroxide-based cleaning tablet was used or not.<sup>13</sup> Finally, when a preovernight storage cleaning regimen of brushing with a denture brush and soap for 2 minutes a day, 3 times per day, by the patient was performed, a significant reduction ( $F = 69.29$ ,  $P < .001$ ) of *Candida* spp. count was observed when either water with an alkaline peroxide-based cleaning tablet or water mixed with 0.5% sodium hypochlorite was used. However, the latter should not be recommended because of its detrimental

effects on the acrylic resin with long-term exposure.<sup>14</sup> Changes in dimensional stability, particularly with regard to overnight storage in dry conditions, were concluded not to be clinically significant,<sup>11,15</sup> and in a cyclical drying environment, statistically significant changes to dimensional stability were even reduced.<sup>15</sup>

These findings suggest the importance of the pre-overnight storage cleaning regimen to first reduce the *C. albicans* colonization. Efforts to improve patient education on denture hygiene should thus be considered. If the cleaning regimen is compromised, such as in the frail elderly or in an institutional environment where oral hygiene may have low priority, overnight storage in water with an alkaline peroxide-based cleaning tablet should be advocated. If this tablet is not available, consideration should be given to storing the dentures dry. Changes in the dimensional stability of dentures stored dry for 8 hours do not appear to be of any clinical significance. Storing the dentures dry is a better alternative than storing them in water, particularly if they have not been properly cleaned beforehand, possibly increasing *C. albicans* colonization. Nevertheless, given the limited number of randomized controlled trials in this systematic review, the current evidence requires that more studies be carried out. Given the low sample numbers, consideration should be given to power analysis and standardization of study designs to permit a meta-analysis. Finally, in determining risk factors for denture stomatitis using multivariate statistical analysis, consideration should be given to the overnight storage conditions of removable dentures.

## CONCLUSIONS

Based on the findings of this systematic review, the following conclusions were drawn:

1. Preovernight storage cleaning regimen is of significant importance in reducing *C. albicans* colonization of complete dentures.
2. If the standard of this regimen is compromised, the use of an alkaline peroxide-based cleaning tablet should be recommended.
3. If a tablet is not available, overnight dry storage is a viable option with clinically insignificant changes to the dimensional stability of the complete denture.
4. If the preovernight storage cleaning regimen is compromised, storing the complete denture in water alone is not recommended and may promote *C. albicans* colonization.

## REFERENCES

1. Arendorf TM, Walker DM. Denture stomatitis: a review. *J Oral Rehabil* 1987;14:217-27.
2. Gendreau L, Loewy ZG. Epidemiology and etiology of denture stomatitis. *J Prosthodont* 2011;20:251-60.
3. Budtz-Jørgensen E, Stenderup A, Grabowski M. An epidemiologic study of yeasts in elderly denture wearers. *Community Dent Oral Epidemiol* 1975;3:115-9.
4. Marin-Mazuelos E, Aller AI, Romero MJ, Rodriguez Armijo A, Gutierrez MJ, Bernal S, et al. Response to fluconazole and itraconazole of *Candida* spp. in denture stomatitis. *Mycoses* 1997;40:283-9.
5. Čanković M, Bokor-Bratić M, Marinovski J, Stojanović D. Prevalence and possible predictors of the occurrence of denture stomatitis in patients older than 60 years. *Vojnosanit Pregl* 2017;74:311-6.
6. Perić M, Živković R, Milić Lemić A, Radunović M, Milčić B, Arsić Arsenjević V. The severity of denture stomatitis as related to risk factors and different *Candida* spp. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2018;126:41-7.
7. Sadig W. The denture hygiene, denture stomatitis and role of dental hygienist. *Int J Dent Hyg* 2010;8:227-31.
8. Coulthwaite L, Verran J. Potential pathogenic aspects of denture plaque. *Br J Biomed Sci* 2007;64:180-9.
9. Miessi AC, Goiato MC, dos Santos DM, Dekon SF, Okida RC. Influence of storage period and effect of different brands of acrylic resin on the dimensional accuracy of the maxillary denture base. *Braz Dent J* 2008;19:204-8.
10. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JPA, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ* 2009;339:b2700.
11. Stafford GD, Arendorf T, Huggett R. The effect of overnight drying and water immersion on *candida* colonization and properties of complete dentures. *J Dent* 1986;14:52-6.
12. Duyck J, Vandamme K, Muller P, Teughels W. Overnight storage of removable dentures in alkaline peroxide-based tablets affects biofilm mass and composition. *J Dent* 2013;41:1281-9.
13. Duyck J, Vandamme K, Krausch-Hofmann S, Boon L, De Keersmaecker K, Jalon E, et al. Impact of denture cleaning method and overnight storage condition on denture biofilm mass and composition: A cross-over randomized clinical trial. *PLoS One* 2016;11:e0145837.
14. Peracini A, Andrade IM, Oliveira VC, Macedo AP, Silva-Lovato CH, Pagnano VO, et al. Antimicrobial action and long-term effect of overnight denture cleansers. *Am J Dent* 2017;30:101-8.
15. Abd Shukor SS, Juszczyk AS, Clark RKF, Radford DR. The effect of cyclic drying on dimensional changes of acrylic resin maxillary complete dentures. *J Oral Rehabil* 2006;33:654-9.
16. Garcia Lda F, Roselino Lde M, Mundim FM, Pires-de-Souza Fde C, Consani S. Influence of artificial accelerated aging on dimensional stability of acrylic resins submitted to different storage protocols. *J Prosthodont* 2010;19:432-7.
17. Felton D, Cooper L, Duquon I, Minsley G, Guckes A, Haug S, et al. Evidence-based guidelines for the care and maintenance of complete dentures: a publication of the American College of Prosthodontists. *J Prosthodont* 2011;20:S1-12.
18. Compagnoni MA, Souza RF, Marra J, Pero AC, Barbosa DB. Relationship between *Candida* and nocturnal denture wear: quantitative study. *J Oral Rehabil* 2007;34:600-5.
19. Australian Government, NHMRC. How to use the evidence: assessment and application of scientific evidence. Available at: [http://nhmrc.gov.au/\\_files\\_nhmrc/file/publications/synopses/cp69.pdf](http://nhmrc.gov.au/_files_nhmrc/file/publications/synopses/cp69.pdf). Accessed December 1, 2018.

### Corresponding author:

Dr Tyler V. Verhaeghe  
 UBC Faculty of Dentistry  
 2151 Wesbrook Mall  
 Vancouver, BC V6T 1Z3  
 CANADA  
 Email: [tyler.verhaeghe@alumni.ubc.ca](mailto:tyler.verhaeghe@alumni.ubc.ca)

Copyright © 2019 by the Editorial Council for *The Journal of Prosthetic Dentistry*.  
<https://doi.org/10.1016/j.prosdent.2019.07.014>