Effect of Chemical Disinfection on the Surface Roughness of Hard Denture Base Materials: A Systematic Literature Review

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Purpose: To assess the effect of chemical disinfection procedures on the surface roughness of hard denture base materials. ***Materials and Methods:*** A systematic literature review was conducted using five electronic databases (Medline, Cochrane Library, OpenGrey, Lilac, and Google Scholar) along with hand searching of the bibliographies of all located articles. ***Results:*** The review yielded 193 articles. This number was reduced to 25 by using defined inclusion and exclusion criteria. Only one in vivo study was included; all others were in vitro evaluations. For every disinfecting agent, studies were found that reported surface alteration after chemical disinfection. The current literature suggests that changes in roughness might be more often associated with sodium perborate (three out of three studies with positive correlation) and less often with chlorhexidine digluconate and glutaraldehyde (two out of seven and one out of four studies with positive correlation, respectively). Because only single studies were found for glycine-type amphoteric surfactant solution, enzyme solution, ethanol, berberine hydrochloride, chlorine, reactive oxygen species, peracetic acid, cetylpyridinium chloride, and citric acid, no conclusions can be drawn about these disinfectants. ***Conclusions:*** Physical surface alteration is only one aspect when deciding on the use of chemical disinfection procedures. More research is needed to clarify whether these procedures can be recommended to patients. *Int J Prosthodont 2014;27:215–225. doi: 10.11607/ijp.3759*

Maintaining denture wearers' oral hygiene is a challenge for modern dentistry; only a minority of patients provided with removable dental prostheses have no oral hygiene problems.[1] The presence of biofilm on dentures can have severe consequences. It has been associated with denture stomatitis and malodor,[2] aspiration pneumonia,[3] infectious endocarditis,[4] gastrointestinal infection, and chronic obstructive pulmonary disease.[5] Antimicrobial cleaning also is important for prevention of cross infection (ie, prevention of interindividual pathogen transmission from one denture to another, for example, in the laboratory).[6]

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The two major approaches used for denture cleaning are mechanical or chemical removal of plaque. Mechanical methods include brushing (using water, soap, toothpaste, or abrasives) and ultrasonic treatment.[7] Although mechanical cleaning with brushes is inexpensive and common, elderly and disabled patients might have difficulties because of poor motor coordination, poor mental function, or poor dexterity. There is, moreover, evidence that mechanical cleaning with toothpastes can result in significant wear of conventional acrylic resins.[8] Ultrasonic cleaning is less frequently used outside of dental laboratories and offices because of the high acquisition cost.[7] It is, nevertheless, currently gaining importance in the oral hygiene of institutionalized patients.[9]

Chemical methods use immersion of dentures in different cleaning solutions. This is an inexpensive, easy, and comfortable procedure, especially for patients with physical disabilities. These solutions can, moreover, reach undercuts of the denture base that are difficult to clean mechanically.[7] Chemical methods entail soaking in different oxidizing, effervescing, or chelating agents (eg, hypochlorites, peroxides, enzymes, or acids) or in detergents. Commercially available products,[10] enzyme-containing disinfectants,[11,12] sodium perborate, and chlorhexidine digluconate[13] are

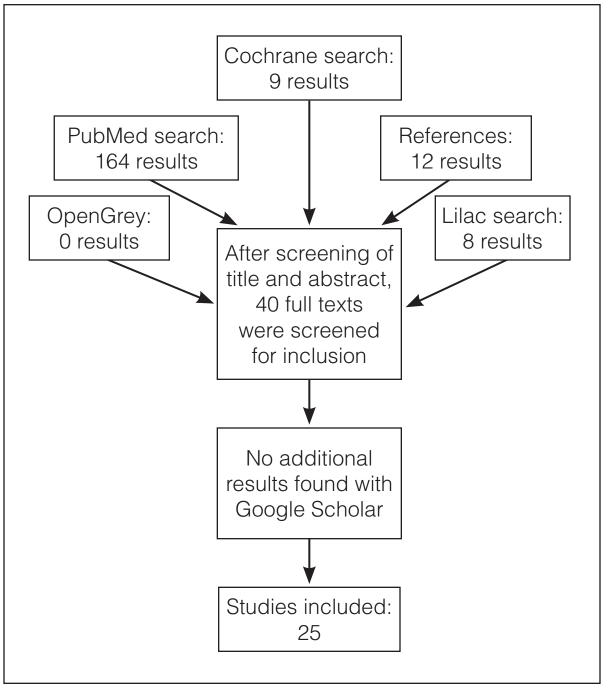

Fig 1 Search strategy.

reported to enable effective disinfection of prostheses. Sodium hypochlorite has been proved to be effective against different microbial strains, eg, *Staphylococcus aureus, Pseudomonas aeruginosa, Candida albicans, Streptococcus mutans, and Enterococcus faecalis.*[14] Even microorganisms that penetrate surfaces to a depth of 3 mm can be reached.[15]

There is no evidence about whether chemical or mechanical denture cleaning is more beneficial to oral health or patient satisfaction,[7] and some authors recommend taking advantage of both methods.[16] There are fewer microbial counts on dentures after chemical disinfection than after brushing.[17] Brushing is, however, reported to be more effective at removing adherent plaque.[18]

Little research has been undertaken to investigate the side effects of chemical disinfection procedures, eg, increased surface roughness (R_a) of denture base materials.[19] The R_a of denture materials has a substantial effect on plaque adherence and microbial colonization of prostheses because it creates niches in which microorganisms are protected against mechanical shear forces.[20] From these pits and grooves, the bacteria subsequently spread over the denture. It has been established that an increase in R_a above a threshold of 0.2 μm results in a simultaneous increase in plaque accumulation.[21] This review was, therefore, conducted to assess whether chemical disinfection is able to alter denture R_a.

Materials and Methods

Search Strategy and Study Selection

The PICO (participant, intervention, comparison, and outcome) approach[22] was used to define the topic of the present review: P = hard denture resins, I = chemical disinfection, C = immersion in distilled water, O = R_a.

A search of PubMed (Medline) and the Cochrane Library using the terms "surface roughness" [All Fields] AND ("dentures" [MeSH Terms] OR "dentures" [All Fields] OR "denture" [All Fields]) was conducted in duplicate for articles published in the dental literature. No publication year limit or language restriction was set. The bibliographies of all full-text articles retrieved by the electronic search were also evaluated. Disagreements were solved by consensus. Grey literature was searched in OpenGrey by one author using the terms "chemical AND disinfection AND denture." Furthermore, the Lilac database ("chemical AND disinfection AND surface AND roughness") and Google Scholar ("surface roughness" and "denture base acrylic" and "chemical disinfection") were screened in German, English, French, Portuguese, and Spanish.

Studies were screened on the basis of the inclusion and exclusion criteria. Inclusion criteria were clinical and preclinical (in vitro) studies, immersion in chemical disinfectants, and evaluation of R_a changes of the evaluated denture base resins. The exclusion criteria were effect of chemical disinfection on soft relining materials, color, flexural strength, surface hardness, resin teeth, and antifungal therapy on R_a. This review focused on R_a as the outcome criterion because of its clinical importance as a predominant factor affecting plaque adhesion. Because denture base resins usually account for large parts of prostheses, the emphasis was on these acrylics; other types of resin were excluded from the review.

First, titles and abstracts were screened for inclusion. The full texts of all possibly relevant articles were then checked (Fig 1). All studies meeting the inclusion criteria underwent data extraction.

Data Extraction

The studies included data on the disinfectant solution and concentration and on the type of acrylic resin tested. The presence or absence of a control group, total immersion time, and the temperature of the disinfection solution were recorded. In case of significant increases of roughness after immersion, R_a values were extracted.

Table 1 Composition of Commercially Available Denture Cleaners

Cleaner	Composition
Corega/Polident (GlaxoSmithKline)	Sodium bicarbonate, citric acid, sodium perborate monohydrate, potassium peroxymonosulfate, sodium benzoate, sodium lauryl sulfoacetate, peppermint flavor, subtilisin
Bony Plus (Bonyf)	Sodium bicarbonate, potassium hydrogen monopersulfate, citric acid, sodium carbonate, and peppermint flavor
Steradent Extra Strength (Reckitt Benckiser)	Citric acid, potassium peroxymonosulfate, sodium sulphate, sodium carbonate, sulfamic acid, malic acid, sodium dodecyl benzene sulfonate and other substances in small amounts
Efferdent (Warner-Lambert)	Ingredients not published by the company
Protefix (Queisser Pharma)	Sodium bicarbonate, potassium caroate, sodium perborate, citric acid, sodium lauryl sulphate, aroma
Valclean (Valplast)	Potassium peroxymonopersulfate, citric acid, potassium bisulphate, magnesium carbonate, potassium sulphate, peppermint extract, potassium peroxydisulphate, sucrose.

Results

General Outcomes

One hundred sixty-four articles were found in Medline and 9 in the Cochrane Library. The search of the bibliographies yielded 12 more articles. No additional titles were found in the OpenGrey database or in Google Scholar, whereas the Lilac database yielded 8 studies. Forty full-text articles were screened and, finally, 25 articles were included.

No randomized clinical prospective trials were identified. One was an in vivo investigation[23]; all other articles reported in vitro evaluations only. All articles were published between 1995 and 2013. The heterogeneity of the study design of the trials prevented statistical analysis of the data obtained.

The resins investigated were heat cured (boiled, microwave), cold cured, and hard relining materials. Disinfection temperatures ranged from 23°C to 50°C. Total contact times ranged from 10 minutes to 185 days 8 hours and times for the single immersion incident from 3 minutes to 7 days.

Commercial Denture Cleaners

Ten studies were conducted on six commercially available denture cleaners: Corega/ Polident (GlaxoSmithKline, London, UK), Bony Plus (Bonyf, Vaduz, Liechtenstein), Steradent (Reckitt Benckiser, Slough, UK), Efferdent (Warner-Lambert Co., Morris Plains, New Jersey, USA), Protefix (Queisser Pharma, Flensburg, Germany), and Valclean (Valplast Int Corp, New York, New York, USA). Although different active agents are combined in these products, the solutions are remarkably similar in their composition (Table 1). The effect of these denture cleaners on the R_a of different kinds of acrylic resin was evaluated by producing test specimens from heat-polymerized resins (microwaves and hot water were used as the heat sources), cold-curing resins, and autopolymerizing relining materials. The resins were in contact with the disinfectants for at least 15 minutes and up to 185 days 8 hours; time per incident ranged from 3 minutes to 60 hours and 8 minutes (Table 2). One study with Bony Plus reported a significant increase in R_a.[24] The change in R_a value was +0.13 µm, but because the initial value was not reported, it remains unclear whether R_a was above the threshold of +0.2 µm after the experiment. Decreases in R_a were observed in two other studies.[25,26]

Sodium Perborate

There are three reports on the effect of sodium perborate at a concentration of 3.8% on denture resin. Heat and cold polymerized resins, and autopolymerizing relining materials were tested (Table 3). Total contact times in the studies ranged from 20 minutes to 224 hours; time per incident ranged from 10 minutes to 24 hours. Although all three studies reported a significant increase in R_a after immersion (from +0.25 to +0.42 µm), Machado et al showed that a relining material and a heat-polymerized resin were as smooth after 224 hours total disinfection time as before disinfection.[27] Sodium perborate must, nevertheless, be suspected of roughening denture base materials because most studies report significant alteration of the surface of more than 0.2 µm.

Sodium Hypochlorite

Fourteen trials investigated changes in R_a after immersion in sodium hypochlorite at concentrations from 0.05% to 5.25% (Table 4). Different materials (heat-polymerized and cold-cured resins, and autopolymerizing relining materials) were tested with total disinfection times ranging from 10 minutes to 185 days 8 hours; time per incident ranged from 5 minutes to 7 days. Pinto et al[19] and Lira et al[26] reported reduced

Table 2 Commercially Available Denture Cleaners*

Study	Cleaner	Acrylic resin	Contact time per incident (total contact time)	Temperature (°C)
Harrison et al[38]	Steradent Extra Strength	Meliodent (boiled) (Heraeus Kulzer)	1 × 60 h 8 min (60 h 8 min)	50
Rodrigues Garcia et al[62]	Polident	Onda-cryl (microwaved) (Clássico Odontological Goods)	3 × 5 min (15 min); 45 × 5 min (3 h 45 min); 90 × 5 min (7 h 30 min)	37
da Silva et al[13]	Corega	Jet (cold-cured, chemically activated) (Clássico Odontological Goods)	10 × 10 min (100 min)	Room temperature
Hashiguchi et al[25]	Polident	1. GC Acron (heat-cured) (GC America) 2. Tokuyama Rebase 2 normal (self-cured) (Tokuyama Dental)	10 × 15 min (2 h 30 min); 30 × 15 min (7 h 30 min); 60 × 15 min (15 h)	50
Peracini et al[24]	1. Corega 2. Bony Plus	Lucitone 550 (heat-polymerized) (Dentsply)	1. 30 × 5 min (2 h 30 min) 2. 30 × 3 min (1 h 30 min)	40
Felipucci et al[33]	1. Corega 2. Polident	Boiled (QC-20; Dentsply)	1. 180 × 3 min (15 h) 2. 180 × 5 min (9 h)	45
Lira et al[26]	Efferdent	1. Auto (Classico; Classico Dental Products) 2. Microwave (Ondacryl, Clássico Odontological Goods) 3. Boiled (QC-20; Dentsply)	720 × 20 min (240 h)	Room temperature
Davi et al[34]	1. Corega 2. Polident	Lucitone 550 (heat polymerized) (Dentsply)	1. 180 × 5 min (9 h) 2. 180 × 3 min (15 h)	40
Durkan et al[60]	1. Corega 2. Protefix 3. Valclean	1. Rodex (heat-polymerized) (Denture material Povere) 2. Paladent (heat-polymerized) (Heraeus Kulzer)	20 × 15 min (300 min)	50
Paranhos et al[28]	Corega	Lucitone 550 (heat-polymerized) (Dentsply)	556 × 8 h (185 d 8 h)	30

*Active agents are specified in Table 1.

Table 3 Sodium Perborate

Study	Disinfectant (%)	Acrylic resin	Contact time per incident (total contact time)	Temperature (°C)
da Silva et al[13]	3.8	Jet (cold-cured, chemically activated)	10 × 10 min (100 min)	Room temperature
Machado et al[61]	3.8	1. Lucitone 550 (heat polymerizing) 2. Kooliner (hard reliner) (GC America) 3. DuraLiner II (hard reliner) (Reliance Dental)	2 × 10 min (20 min) and 7 × 24 h (168 h)	50
Machado et al[27]	3.8	1. Lucitone 550 (heat polymerizing) 2. Three hard chairside reline resins: ▪ Tokuyama Rebase II-TR New Truliner-NT (The Bosworth Co) ▪ Ufi Gel hard-UH (Voko)	28 × 8 h (224 h)	50

R_a for hard denture base materials. Three other studies reported increased roughness: Odagiri et al with a change of +0.66 µm,[6] Paranhos et al with +0.195 µm (after 185 days 8 hours of immersion),[28] and Carvalho et al with +0.26 µm.[29] The other studies did not reveal any significant differences in surface properties after sodium hypochlorite immersion.

Chlorhexidine Digluconate

Seven studies investigated R_a after immersion in 0.12%, 2%, or 4% chlorhexidine digluconate (Table 5). Different resins were used (heat-polymerized, cold-cured resins, and autopolymerizing relining materials). Total disinfection times ranged from 10 minutes to 7 days; time per incident ranged from 5 minutes to 7 days. Although a slight increase in roughness was observed for one relining material in one study (+0.24 µm),[30] the authors concluded that, in general, chlorhexidine digluconate had no adverse effect on R_a. Pinto et al reported reduced R_a for a hard relining material.[19] The other studies found no significant differences.

Control	Results
Tap water	No difference between R_a for control and immersion in cleaner
Tap water	R_a after prolonged immersion not significantly different
No treatment	No significant differences
Tap water	1. Heat-cured: control and chemical immersion, no significant difference 2. Self-cured: test group less rough than control
Distilled water	1. Corega: R_a no different from use of distilled water 2. Bony plus: R_a significantly increased (+0.13 μm)
Distilled water	No significant difference from control
Distilled water	R_a decreased before and after thermocycling for Efferdent compared with control
Deionized water	No significant difference from control
Distilled water	No significant increases in roughness after immersion
Distilled water	No significant difference between R_a for control and immersion disinfectant

Control	Results
No treatment	R_a increased significantly (+0.31 μm)
Distilled water	Increase in roughness after 2 cycles and after 7 d of immersion (+0.24 to +0.26 μm)
Water	Lucitone 550, Tokuyama Rebase: no significant differences New Truliner-NT, Ufi Gel hard-UH: R_a significantly increased (+0.25 to +0.42 μm)

Glutaraldehyde

Four studies investigated R_a changes after disinfection with 2% glutaraldehyde. Different acrylic resins were used (heat polymerized, cold-cured resins, and autopolymerizing relining materials). Total disinfection times ranged from 10 minutes to 7 days; time per incident ranged from 10 minutes to 7 days (Table 6). Pinto et al reported reduced R_a for a hard relining material.[19] The other investigations found no evidence that 2% glutaraldehyde had any deleterious effects on the R_a of denture base resins.

Other Disinfectants

Information about nine more denture cleaners was found. Lima et al reported on Ortoform (F&A Pharmaceutical), a commercially available enzyme solution.[23] No information was given about the specific enzymes contained in the product. Microwave-cured resin was tested for 4 × 10 minutes. There were no data on temperature. The difference from the control group (no treatment) was not statistically significant.

Hashiguchi and colleagues evaluated 1.0% to 4.5% glycine-type amphoteric surfactant solutions and their effect on the R_a of heat-cured and self-cured resin after 10 ×, 30 ×, and 60 × 15 minutes (the method entailed ultrasonic cleaning). The R_a of heat-cured resin cleaned in 4.5% disinfectant was significantly higher than in the control group.[25] Nevertheless, values remained below 0.08 μm after immersion, which is clearly below the threshold of the 0.2 μm that was reported to lead to increased plaque accumulation.

Sartori et al produced a 0.01% chlorine solution (500 mL distilled water and one effervescent chlorine disinfectant tablet from Aquatabs, Medentech). They investigated microwave polymerized resin after 2 × 24 hour immersion time (37°C). Roughness was not significantly different, irrespective of whether mechanical or chemical polishing was used.[31]

The effect of reactive oxygen species on R_a was studied by Odagiri et al.[6] A cold-cured resin was disinfected for 30 minutes. Roughness was not significantly different from that of a control specimen.

The effect of 2% peracetic acid on denture resin was investigated by Fernandes et al.[32] Specimens of different heat-cured resins were immersed for 2 × 30 minutes. Disinfection did not cause damage to the acrylic resin surfaces.

Felipucci et al described the effect of cetylpyridinium chloride and citric acid on heat-cured acrylic resin after 1,800 minutes (180 × 10 minutes) and 2,700 minutes (180 × 15 minutes) (45°C).[33] There were no significant differences from a control group that was immersed in distilled water. Davi et al reported on the same disinfectants after the same time span at 40°C.[34] No significant difference from a control group that was immersed in deionized water was found for citric acid and cetylpyridinium chloride.

Different concentrations of ethanol were tested as a denture disinfectant by Regis et al.[35] After immersion of specimens made of microwave-cured resin for 30 days (37°C), no significant differences were described in comparison with a specimen immersed in water.

In a study on a trial cleaner composed of berberine hydrochloride, trisodium citrate, sodium lauryl

Table 4 Sodium Hypochlorite

Study	Disinfectant (%)	Acrylic resin	Contact time per incident (total contact time)	Temperature (°C)
Ma et al[37]	5.25	1. Dentsply reline material 2. HyFlo fluid resin (Hygenic) 3. Perm resin (Hygenic) 4. Lucitone 199 (Dentsply) 5. Triad VLC reline resin (Dentsply)	10 min (10 min), 30 min (30 min), 24 h (24 h), 7 d (7 d)	Not given
Azevedo et al[39]	1	Two standard hard chairside reliners: ▪ Kooliner ▪ Duraliner II One heat-treated chairside reliner: Duraliner II +10 min in water at 55°C)	1. 10 min (10 min) 2. 7 d (7 d)	23
Lima et al[23]	0.5	Ondacryl (microwave)	4 × 10 min (40 min)	Not given
da Silva et al[13]	1	Jet (cold cured, chemically activated)	10 × 10 min (100 min)	Room
Paranhos et al[63]	1. 0.5 2. 1 3. 5.25 + sodium polymetaphosphate	Ondacryl (microwave)	180 × 20 min (60 h)	23
Pinto et al[19]	1. 1 2. 2 3. 5.25	Hard chairside reliners: ▪ Jet ▪ Kooliner ▪ Tokuyama rebase	1. 30 × 10 min (5 h) 2. 30 × 5 min (2 h 30 min) 3. 30 × 5 min (2 h 30 min)	Not given
Davi et al[64]	1. 0.5 2. 1 3. 0.12 with sodium polymetaphosphate	Ondacryl (microwave)	60 × 24 h (60 d)	Not given
Felipucci et al[33]	0.05	Boiled (QC-20)	180 × 10 min (30 h)	45
Lira et al[26]	0.5	1. Auto (Classico) 2. Microwave (Ondacryl) 3. Boiled (QC-20)	720 × 20 min (240 h)	Room temperature
Odagiri et al[6]	5	ProBase Cold (Ivovlar)	1 × 30 min (30 min)	Room temperature
Davi et al[34]	0.05	Lucitone 550 (heat-polymerized)	180 × 10 min (30 h)	40
Carvalho et al[29]	1	Auto (Classico)	60 min (60 min)	37
Fernandes et al[32]	1	1. Lucitone 550 2. QC-20 3. Vipi-Wave (Vipi)	2 × 30 min (60 min)	Not given
Paranhos et al[28]	0.5	Lucitone 550 (heat polymerized)	556 × 8 h (185 d 8 h)	23

sulphate, sodium phosphate, and sodium bicarbonate, Nakamoto et al evaluated the effect on heat-cured resin after 24 weeks of immersion (37°C).[36] There was no significant difference, compared with a control group immersed in distilled water.

Assessment of the Quality of the Included Studies

In the investigations by Lima et al,[23] Pinto et al,[19] Ma et al,[37] and Fernandes et al,[32] no information was given about the temperatures of the immersion solutions.

Control	Results
No control	Five denture resins were unaffected after immersion in 4 of 5 disinfectants (multicide was stopped) for up to 7 d. R_a below +0.2 µm for all
Water	Roughness of the materials was not affected even after 7 d
No treatment	The difference in roughness from the control was not statistically significant
No treatment	No significant difference
Distilled water	No statistically significant differences between surface roughness
Deionized water	Jet: R_a increase with every disinfectant and even water (+0.02 to 0.05 µm) Kooliner: decrease, except for 1% sodium hypochlorite (+0.02 µm) Rebase: no significant differences with the disinfectant solutions, but a significant difference with deionized water (+0.03 µm)
Distilled water	No statistically significant differences between surface roughness in comparison with distilled water
Distilled water	No statistically significant differences between surface roughness in comparison with control
Distilled water	R_a decreased before and after thermocycling compared with control
Double-distilled water	R_a significantly increased in comparison with control (+0.66 µm)
Deionized water	No significant difference from control
Distilled water	Significant increase of roughness in comparison with control (+0.26 µm)
No treatment	Cleaner did not cause damage to the acrylic resin surfaces
Distilled water	Significant difference between R_a for control and immersion disinfectant (+0.195 µm)

There were no negative controls (specimens that were not subjected to immersion) in the studies by da Silva et al,[13] Ma et al,[37] and Fernandes et al.[32]

In studies by Azevedo et al,[39] Regis et al[35] and Machado et al[27] (controls stored in water), description of the control group was imprecise as to the kind of water used.

Discussion

Molecular mechanisms have been proposed for alteration of denture base surfaces by immersion in disinfecting agents, including the following.

(1) Soluble materials such as initiators, plasticizers (eg, di-n-butyl phthalate), and free monomer are present in acrylic resins.[40] Release of these substances might depend on the ionic concentration of disinfectant solutions.[27] Elution of these components might result in alteration of the physical properties of polymers, which might increase chipping of particles.[25]

(2) Acrylic, a polar material, effectively absorbs water and aqueous disinfectant solutions. Water molecules interfere with the entanglement of polymer chains, changing the physical characteristics of the polymer.[41] Absorption of water initially causes softening of the polymeric resin, as a result of swelling of the network, reducing the frictional forces between the polymer chains (relaxation of stress).[42] Repeated absorption-desorption cycles may eventually cause irreversible damage to the material, with formation of microcracks, as a result of hydrolytic degradation of the polymer, scission of ester linkages, and gradual deterioration of the infrastructure of the polymer over time.[19,42] Absorption of water might be accelerated by increased disinfection temperature.[43]

Increase of R_a is an important issue because it has been described as the predominant factor affecting plaque adhesion.[44] However, the presence of macromolecules (mucins, bovine serum albumin, or salivary pellicle) was found to modulate microbial colonization of surfaces with different roughness.[45] Furthermore, the presence of dietary carbohydrates,[46] the surface free energy,[44] the wettability,[47] the hydrophobicity,[48] and electrostatic interactions[49] also influence the adhesion of microorganisms to polymer-based materials.

Decreases in R_a after immersion are not suspected of creating plaque retention niches but are a sign of alteration of the structure of the resins. In total, a decrease in roughness was noticed in three studies. However, it must be emphasized that the two trials that discovered decreases in roughness after immersion in commercially available denture cleaners used prolonged immersion times that differed from the times recommended by the manufacturers.[25,26]

One methodologic strength of this review was that all included articles reported on one well-defined outcome criterion: mean R_a measured by means of mechanical profilometry. Mechanical profilometry records the arithmetic mean of peak-to-valley distances throughout a sampling distance when a stylus is moved along a surface. It is frequently used for assessment of R_a in dental research[50,51] and has a sensitivity of approximately 0.01 µm.[52]

Table 5 Chlorhexidine Digluconate (CHX)

Study	Disinfectant (%)	Acrylic resin	Contact time per incident (total contact time)	Temperature (°C)
Azevedo et al[39]	4	Two standard hard chairside reliners: ▪ Kooliner ▪ Duraliner II One heat-treated chairside reliner: Duraliner II + 10 min in water at 55°C	1. 10 min (10 min) 2. 7 d (7 d)	23
da Silva et al[13]	2	Jet (cold cured, chemically activated)	10 × 10 min (100 min)	Room
Pinto et al[19]	4	Hard chairside reliners: ▪ Jet ▪ Kooliner ▪ Tokuyama rebase	1. 30 × 10 min (5 h) 2. 30 × 5 min (2 h 30 min) 3. 30 × 5 min (2 h 30 min)	Not given
Felipucci et al[33]	0.12	Boiled (QC-20)	180 × 10 min (30 h)	45
Davi et al[34]	0.12	Lucitone 550 (heat polymerized)	180 × 10 min (30 h)	40
Carvalho et al[29]	2	Auto (Classico)	60 min (60 min)	37
Machado et al[30]	4	1. Lucitone 550 (heat polymerizing) 2. Three hard chairside reline resins: ▪ Tokuyama Rebase II-TR ▪ New Truliner-NT ▪ Ufi Gel hard-UH	2 × 10 min (20 min) and 7 × 10 min (70 min)	23

Table 6 Glutaraldehyde

Study	Disinfectant (%)	Acrylic resin	Contact time per incident (total contact time)	Temperature (°C)
Ma et al[37]	2	1 Dentsply reline material 2. HyFlo fluid resin 3. Perm resin 4. Lucitone 199 5. Triad VLC reline resin	10 min (10 min), 30 min (30 min), 24 h (24 h), 7 days (7 d)	Not given
da Silva et al[13]	2	Jet (cold cured, chemically activated))	10 × 10 min (100 min)	Room
Pinto et al[19]	2	Hard chairside reliners: ▪ Jet ▪ Kooliner ▪ Tokuyama rebase	30 × 10 min (5 h)	Not given
Carvalho et al[29]	2	Auto (Classico)	60 min (60 min)	37

The methodology of this review excluded studies on surface alteration of soft relining materials because the different compositions (different amounts of plasticizers) resulted in different physical properties. Other possible physical changes (eg, color, flexural strength, surface hardness) must, moreover, be reviewed in further research because the focus of this review was on R_a with its possible consequence of increased accumulation of plaque. The effect on metals (eg, corrosion as reported by Felipucci et al[33]) was also beyond the scope of this evaluation. Despite an extensive literature search, it is unlikely that all relevant publications were identified.

Based on a summarization of the current literature, chemical disinfectants can be categorized according to the probability of causing changes in roughness. Sodium perborate is likely to roughen the surface because all trials found significant increases in roughness (3 of 3 studies). Commercial denture cleaners (4 of 10 studies reported alterations in roughness: 2 increased, 2 decreased) must be rated as possibly causing alteration. Changes in surface are unlikely for chlorhexidine digluconate (2 of 7 studies reported alterations in roughness: 1 increased, 1 decreased), sodium hypochlorite (5 of 14 studies reported alteration of roughness: 1 increased, 2 decreased), and glutaraldehyde

Control	Results
Water	Roughness of the materials was not affected
No treatment	No significant difference
Deionized water	Jet: R_a increase (+0.03 μm) but also in water (+0.04 μm) Kooliner: decrease Rebase: no significant differences with the disinfectant solutions, but a significant difference with deionized water (+0.03 μm)
Distilled water	No statistically significant differences in surface roughness in comparison with control
Deionized water	No significant difference from control
Distilled water	No significant difference from control
Distilled water	Increase in roughness after the first cycle for NT (0.24 μm) In general, no adverse effect on surface roughness

Control	Results
No control	Five denture resins were unaffected after immersion in 4 of 5 cleaners (multicide was stopped) for up to 7 days. R_a below +0.2 μm for all
No treatment	No significant difference
Deionized water	Jet: R_a increase (+0.03 μm) but also in water (+0.04 μm) Kooliner: decrease Rebase: no significant differences with the disinfectant solutions, but a significant difference with deionized water (+0.03 μm)
Distilled water	No significant difference from control

(1 of 4 studies reported a decrease in roughness). No conclusions could be drawn for any of the other disinfectants because only single studies were available.

This review revealed the heterogeneity of the trials on chemical disinfection procedures with regard to the immersion protocol (time of immersion and concentration of the solution), solution temperature, and investigated resin types. Total immersion times used in the included trials ranged from 10 minutes to 185 days 8 hours to evaluate the short-term and long-term effects of immersion. Time per incident varied from 3 minutes to 7 days. No studies could be found that evaluated the effect of different immersion times and different concentrations on antimicrobial effect. There is currently no consensus about a protocol for immersion disinfectants. Additionally, there are a multitude of disinfectant products with a variety of different concentrations. This heterogeneity might have biased the results of this review and prevented statistical analysis.

The temperature of the water used with denture cleaners might have a detrimental effect on the color and R_a of lining materials.[53] The physical properties (eg, hardness) of hard denture base resins have been reported to change substantially when hot water at 100°C is used with a commercial denture cleaner. This did not occur with warm water at 40°C and the same effervescent tablet. This phenomenon was explained on the basis of increased absorption of water at higher temperatures.[54] High temperatures have the additional effect of thermal expansion of the resins, which is suspected of causing molecular fracture and degradation of the resin matrix and might result in absorption of more water.[54] Temperatures from 71°C to 90°C are, moreover, reported to cause distortion of methacrylate-based denture resins because of the release of internal stresses introduced during processing and curing.[55] There are currently no studies reporting the efficacy of chemical denture disinfectants at different temperatures, which means that the ideal temperature for different agents is unknown. Because temperature has an effect on the physical properties of acrylic resins, however, it is evident that conveying information about this aspect is an important component of study quality. Such data were missing from four articles.

The type of acrylic resin was repeatedly reported to be an important factor affecting surface alteration after chemical disinfection[26] because component elution might directly affect R_a. The amount of elution from autopolymerized resins is greater than that from microwave and heat-polymerized resins.[56] Monomer-to-polymer conversion is higher for heat-polymerized materials, and residual monomer content is lower.[57] Autopolymerizing resins can be improved by adding crosslinking agents with long lateral chains or several reactive centers to achieve more complete polymerization and lower levels of residual monomer.[58] In this context, Viljanen et al reported that the addition of acetoxyethyl methacrylate enhanced the copolymerization of methyl methacrylate.[59] Of the 25 studies included in this review, 8 reported a significant increase in roughness (sodium perborate was used as a disinfectant in 3 of these studies).[6,13,24,27–30,60,61] In 6 of these 8 studies, surface alteration was observed for autopolymerizing resin. This suggests that use of autopolymerizing resins might be a risk factor for increased R_a after chemical disinfection. Three more trials reported a significant decrease in R_a.[19,25,26] In all of these studies, surface alteration was, again, observed for self-curing resins.

This study investigated the effect of chemical disinfection procedures on denture base resin roughness. It is evident that none of the results can be interpreted as clinical recommendations because factors such as antimicrobial activity, plaque removal power, cost, and other side effects (eg, hardness or flexural strength) are important in clinical practice. These have not been considered in this work. An important yet unclear aspect is whether mechanical cleaning is neglected by patients when chemical, and more comfortable, procedures are used. New methods for denture disinfection, eg, use of reactive oxygen species, are interesting options for further improvement of denture hygiene without affecting physical properties.

Conclusions

There is a lack of reliable scientific information on the effect of chemical disinfection procedures on dentures. Realistic randomized clinical trials must be conducted to enable clinicians to give evidence-based recommendations to patients about denture aftercare and oral hygiene.

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