Hypochlorous Acid: Effects on Two Surface Properties of Denture Materials

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Abstract
Background The chemical disinfectant is the most widely used method by the patients to maintain clean and healthy dentures, but the use of such disinfectant may affect the denture base materials. **Objectives** To assess the effect of hypochlorous acid spray disinfectant on the surface roughness and hardness of heat-cured and flexible acrylic resin denture base materials. **Materials and Methods** A study sample of forty specimens was fabricated following the ADA specification No.12, 1999. They were divided into two main groups depending on the type of the denture base materials used in this study (heat-cured PMMA and flexible resin) (20 specimens each). Then these two main groups were subdivided into two subgroups according to the type of measurement (roughness and hardness). All specimens were tested before and after disinfection. Each subgroup was evaluated before and after the application of hypochlorous acid spray as a disinfectant agent. Study data were analysed using the student T-test at a confidence level of 95% and a significant p-value of $p \leq 0.05$. **Results** The T-test indicated a highly significant difference in the hardness of heat-cured and flexible denture base materials after disinfection by hypochlorous acid ($p \leq 0.05$). However, there was no significant difference in the roughness of heat-cured and flexible denture base material after disinfection by hypochlorous acid ($p > 0.05$). **Conclusion** The hardness of heat-cured and flexible resin denture base material decreased by hypochlorous acid disinfectant, while the roughness was not affected by hypochlorous acid disinfectant.

Keywords: Disinfectant materials; denture base materials; hypochlorous acid; hardness test; roughness test.

Introduction

There are various, different kinds of removable partial dentures, but they all use normal denture teeth to replace missing natural teeth. The materials used to hold the artificial teeth and maintain the removable dental prosthesis in the mouth are the main differences between them (Wöstmann et al, 2005). Long-lasting and biologically acceptable dentures could be achieved by the use of a favourable denture base material (Khindria et al, 2009). Although polymethylmethacrylate (PMMA) acrylic resin is one of the most commonly used denture materials, it has poor mechanical qualities such as fracture resistance, transverse strength, impact strength, or fatigue resistance, in addition to being allergic to monomer (Katsumata et al, 2009). In the fabrication of removable dentures, polyamide thermoplastic resins and butadiene styrene graft PMMA copolymer resins are more widely used than PMMA based acrylic resins (de Freitas Fernandes et al, 2011; Takabayashi, 2010; Moussa et al, 2016). Nylon is a general term for a variety of thermoplastic polymers that belong to the polyamide family. Nylon polyamides were first used to make denture bases in the 1950s and are now widely used as a substitute for methylmethacrylate because of their improved aesthetic features, and heat and chemical resistance. In addition to toxicological safety for patients allergic to methacrylate monomer and metal-reinforced acrylic resin dentures. Furthermore, increased elasticity gives better comfort to patients with soft and hard tissue undercuts than PMMA dentures (Takahashi et al, 2012; Durkan et al, 2013). Although nylon resins outperform other nonmetallic denture bases in terms of mechanical qualities, there are major disadvantages such as processing difficulties, dimensional changes, staining, and high water absorption (Parvizi et al, 2004; Phoenix et al, 2004). In terms of surface roughness, the surface imperfections on denture base materials may serve as a source of infection and increase the chance of housing germs even after the cleaning of dentures. Rough surfaces facilitate bacterial and fungal cell penetration into denture base resins (Köroğlu et al, 2016). Before placing a dental prosthesis in the mouth, it is necessary to determine the surface roughness of the materials applied. Rougher surfaces can induce staining of the denture, causing discomfort for patients and promoting germ growth and biofilms. Bacteria and fungi have a higher tendency to adhere to rougher denture base materials (Abuzar et al, 2010). The hardness test is a test method for material characteristics that is used in engineering design, structural analysis, and the development of new materials. The most widely used methods for measuring hardness are Vickers, Knoop, Brinell, Shore, and Rockwell. Hardness is an essential characteristic that allows acrylic materials to withstand high forces, such as occlusal forces. This characteristic gives scratch and abrasion resistance and is related to the material arrangement, chemistry, and polymerization mechanism (Ayaz et al, 2015)The dentists and dental staff encounter several types of disease-causing microbes. Using successful decontamination methods in the dental office and laboratory can prevent cross-contamination for, dental practitioners, staff, professionals, and patients (Shihab, 2017; Inayati et al, 2021). In addition to having good antibacterial and antifungal qualities, an ideal disinfection solution should not have any detrimental effects on the mechanical properties of the denture base material such as surface roughness and hardness (Jeyapalan et al, 2015; Porwal et al, 2017; Golfeshan et al, 2020). Furthermore, it must be safe, non-corrosive, effective in a variety of forms, and reasonably priced (Salman and Saleem, 2011; Block and Rowan, 2020). Recently, hypochlorous acid (HOCl) has received a lot of attention due to its oxidation-reduction potential (ORP), PH, and residual chlorine because of its superior bactericidal and virucidal actions and fewer harmful effects on biological tissues and the environment (Fabrizio et al, 2002; Kim et al, 2000). Since hypochlorous acid has inspired a lot of interest in dentistry, it›s been suggested that it could be used to disinfect acrylic prosthetics (Jnanadev et al, 2011). The US Environmental Protection Agency recently recommended numerous disinfectants including hypochlorous acid (HOCl) to prevent COVID-19 (Nguyen et al, 2021). This study was undertaken to assess the effect of hypochlorous acid spray disinfectant on surface roughness and hardness of two denture base materials.

Material and Methods

The rectangular shape of the plastic pattern was made by cutting a flexible nylon sheet by disc into the appropriate shape and dimensions (65×10×3mm) length, width, and thickness respectively following the ADA specification No.12, 1999 (MSaied, 2011; Alwaeli and Alsegar, 2021). A total of 40 specimens were fabricated 20 of heat-cured acrylic resin (Spofa dental, Czech Republic) and another 20 specimens of thermoplastic flexible resin. Then each group was subdivided into two subgroups according to the test method. The conventional moulding technique was followed to fabricate the heat-cured acrylic specimens. The mixing of powder/liquid ratio of (22g/10ml) heat-cured according to the manufacturer guidelines. The curing water bath was used at 74°C for 90min. Then the temperature was increased to 100°C for 30min. Once processed, the flask was left to cool at room temperature for 30 min, after that, cooled under tap water for 15min before deflasking. The flask was open and the specimens were removed from the stone mould. All the specimens were finished and polished. After completing the finishing and polishing of the specimens, all the specimens were kept in distilled water at 37°C for 48 h before the testing. A total of 20 specimens were prepared in this manner. While the flexible resin specimens were prepared using injection moulding technology. Four rectangular plastic designs were placed in an injection moulding flask and sprued with modelling wax in such a way that the pattern was attached to the sprues (6-8mm in diameter for the major sprues, 2-4mm in diameter for the minor sprues) and fixed to specific regions so that each mould space could be filled with polyamide denture base material (Rizgar, 2009). Then the upper part of the metal flask is placed over the lower part and filled with stone. Once the stone was set, the flask was opened and the plastic patterns were removed to get the mould space. The flask was screwed into its specially designed clamp and positioned on the bench press. The polyimide cartridge (Valplast cartridge, Lichen Dental, China) was placed in the cylindrical sleeve and heated according to the manufacturer›s instructions (280°C-290°C), and the heating cylinder was ready for injection. The material was injected into the flask using an injection device, and the grip of the injection device was pressed at a pressure of 5 bar Figure (1). The pressure was released after 5min and the flask was ejected from the injection unit device to allow it to cool at room temperature. After that, the flask was opened Figure (2). After completing the finishing and polishing of the specimens, all the specimens were kept in distilled water at 37°C for 48h before the testing procedure (Jyothi et al, 2012). Each denture base material has been divided into two groups according to the testing method before and after application of disinfectant spray, for the PMMA, Group A: (n=10) including PMMA specimens for roughness test; and Group B: (n=10) including PMMA specimens for the hardness test. On the other hand, the flexible resin groups include Group C: (n=10) including flexible resin specimens for the roughness test, and Group D: (n=10) including flexible resin specimens for the hardness test.

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Application of disinfection spray
The hypochlorous acid spray (Movity, Turkey) was applied to the specimens with 10 puffs for 10sec for each specimen at a distance of 30cm away from the surface of the specimen (Block and Rowan, 2020). The specimen was kept for 10min then rinsed and wiped to be ready for the mechanical testing procedure (Park et al, 2007).For the surface roughness test, the specimens of the groups (A and C) were subjected to a roughness test before and after disinfection using a profilometer device (surface roughness tester TR220 Portable TIME Group Inc, China) Figure (3). The specimen is placed horizontally and fixed on a uniform platform according to the apparatus instructions, the sharp stylus of this apparatus was moved across the surface of the specimen and measured all imperfections with the needle, which identifies the surface. For more accuracy, three measurements were done for each specimen before and after disinfection and a mean is calculated, and micrometres were used to express the results. For the surface hardness test, the specimens of the group (B and D) were subjected to a hardness test using Shore D hardness tester (durometer hardness tester-TH 210, time group Inc. Italy) Figure (4) which is it is appropriate for resin materials. This equipment is made up of a blunt-pointed indenter with a diameter of 0.8mm that tapers to a 1.6 mm diameter cylinder. The indenter is connected to a digital scale with a 0-100 unit graduation. The digital scale reading was used to take measurements. Each specimen was indented three times before and after disinfection, and the mean was taken.

Figure (1): The injection procedure.

Figure (2): The flask after injection.

Figure (3): Profilometer device.

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Figure (4): Shore D hardness tester.

Statistical methods

Surface hardness and roughness results were analyzed. The t-test and descriptive statistics were applied to calculate the mean, standard deviation, maximum, and minimum values.

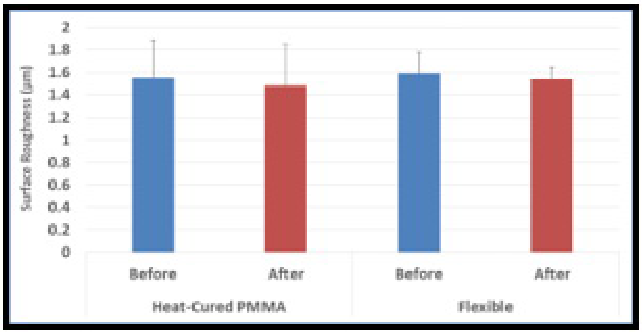

Figure (5): Bar-chart for the surface roughness of heat-cured acrylic and flexible resin before and after disinfection.

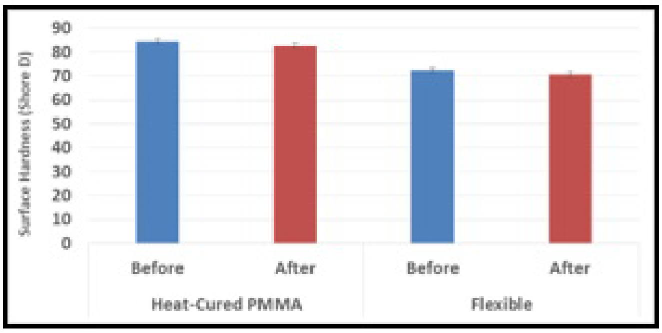

Figure (6): Bar-chart for the surface hardness of heat-cured acrylic and flexible resin before and after disinfection.

Results

Roughness test for heat cure acrylic resin and flexible acrylic resin denture base materials

Table (1) showed the independent T-test which confirmed that there are non-significant differences in the roughness of both heat-cured and flexible denture base materials before and after the application of disinfection spray (P>0.05). The results indicated that the highest mean value of roughness of both heat-cured acrylic resin and flexible acrylic resin was obtained before disinfection while the lowest mean value was obtained after the application of disinfection spray as in Figure (5).

Table (1): The independent T-test for the surface roughness of two denture base materials before and after disinfection

Denture Base Material	State	t	P-Value	Sig.
Heat-cured acrylic resin	Before	4.232	.002	P<0.01 (S)
	After			
Flexible resin	Before	3.755	.005	P<0.01 (S)
	After			

Hardness test for heat cure acrylic resin and flexible acrylic resin denture base materials

Table (2) showed the independent T-test which confirmed that there are highly significant differences in the hardness of both heat-cured and flexible dentures before and after the application of disinfection spray (P<0.01). The results indicated that the highest mean value of hardness of both heat cure acrylic resin and flexible acrylic resin was obtained before disinfection while the lowest mean value was obtained after the application of disinfection spray as in Figure (6).

Table (2): The independent T-test for the surface hardness of two denture base materials before and after disinfection.

Denture Base Material	State	t	P-Value	Sig.
Heat-cured acrylic resin	Before	1.164	0.275	P>0.05 (NS)
	After			
Flexible resin	Before	1.110	0.296	P>0.05 (NS)
	After			

Discussion

During adjustment, repair, or relining procedures, direct contact with the dentures can expose the practitioners and technicians to infection. Bacteria, viruses, and fungus may be detected on these dentures (Inayati et al, 2021). Denture disinfection has been advocated as a necessary practice for reducing cross-contamination and keeping good health. Several agents, classified as mechanical and chemical, are recommended for denture disinfection. The ideal disinfection treatment should be effective with no negative effect on the quality of the materials used in denture bases (Porwal et al, 2017). Hypochlorous acid (HOCL) as the disinfectant spray has an excellent ability to kill some germs and viruses with fewer undesirable effects on biological tissues and the environment due to its oxidation-reduction potential (ORP), pH and residual chlorine. Because of its desirable properties, the HOCL can be used to disinfect the denture bases. Its use has been studied in medical, dental, animal husbandry, horticulture, restaurants, and other settings where microbial growth is known to cause health risks (Jnanadev et al, 2011). In this study, two denture base materials of heat-cured and flexible acrylic resins were investigated concerning their roughness and hardness before and after disinfection with HOCL. In the present study, the application of HOCL disinfecting spray on the surface of heat-cured and flexible acrylic resin specimens showed a non-significant increase in the surface roughness. This result may be in agreement with other studies, which indicated non-significant changes in the roughness of the denture resin materials after using some disinfection agents (Salman and Saleem, 2011, Jeyapalan et al, 2015). This means the absence of the effect of disinfectant on the surface geometry of the two denture materials which may be related to the strong surface character of heat-cured and flexible denture base materials due to their crosslinking structure (Durkan et al, 2013). On the other hand, the surface hardness of the heat-cured and flexible acrylic resins after the application of HOCL spray showed a highly significant decrease in surface hardness. This finding is consistent with some prior studies, which found that using different disinfectant materials could decrease the hardness of different denture base materials (Jyothi et al, 2012; Durkan et al, 2013; Alwaeli and Alsegar, 2021). This reduction in the surface hardness of the specimens of heat-cured and flexible denture base material after disinfection by HOCL spray may be related to the acidity of HOCL which may be responsible for the greater softening of acrylic resin. Acid solutions weaken polymer molecule bonds, which makes them softer and more easily degraded (Golfeshan et al, 2020). Another explanation of the results is that disinfection may serve as a plasticizer, allowing for the relaxing of stresses created during processing and, as a result, a reduction in surface hardness occurs (Moussa et al, 2016).

Conclusion

Within the present study limitations, the application of hypochlorous acid disinfectant spray did not affect the surface roughness of the heat-cured and flexible resin denture base materials. It otherwise might decrease the surface hardness of such denture base materials.

Conflict of interest

We are the authors (Fatima Kadhim Ghadeer, Maha Kareem Jabbar, and Najwah Yousuf Hameed) state that the manuscript for this paper is original, and it has not been published previously (or part of an MSc. dissertation or PhD thesis) and is not under consideration for publication elsewhere, and that the final version has been seen and approved by all authors.

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