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Comparative Study of Hardness for Hard Chairside Relining and Denture Base Materials on Repeated Disinfection Procedures: An in Vitro Study

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ABSTRACT

Aim: There is hypothesis that disinfection procedures may decrease the hardness of reline and acrylic denture base resins. The aim of this in vitro study was therefore to investigate the effect of chemical and microwave disinfection procedures on hardness values of commonly used hard chairside reline (Ufi Gel hard, Kooliner) and denture base acrylic resins (Lucitone 199).

Materials and Method: Powder (polymer) and liquid (monomer) were mixed according to manufacturers' instructions to prepare 20 specimens from each material. Specimens were divided into 2 control and 2 test groups. Hardness measurements (VHN-Vicker's hardness number) were made after polymerization and water immersion (Control groups), and after chemical and microwave disinfection (Test groups). Measurements of hardness were analyzed using One-way analyses of variance (ANOVA) and Tukey's Honestly Significant Difference (HSD) test (α=.05).

Results: Chemical disinfection method significantly increased (p=.001) hardness values of Lucitone 199 (from 19.00 VHN to 21.02 VHN) and Kooliner (from 13.02 VHN to 14.02 VHN), whereas increased hardness values for Ufi Gel hard (from 17.00 VHN to 17.16 VHN) were statistically insignificant (p=.642). Microwave disinfection method also significantly increased (p=.001) the hardness values of Lucitone 199 (from 19.00 VHN to 26.00 VHN), Ufi Gel hard (17.00 VHN to 21.00 VHN) and kooliner (13.02 VHN to 14.08 VHN).

Conclusions: Both chemical and microwave disinfection methods increase the hardness of reline and acrylic denture base resins, contradicting previously published studies. Microwave disinfection method is more appropriate compare to chemical disinfection method.

Keywords: Cross contamination, Cross-linking agent, Oral microbial flora, Residual monomer.

INTRODUCTION

Dental prostheses used by patients are exposed to normal oral microbial flora that includes bacteria, viruses, and fungi. Dental personnel adjusting or repairing these prostheses may therefore be at risk of contracting infections from prostheses that have not been properly disinfected[1]. Cross contamination from patients to dental laboratory and vice versa can also occur

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through contaminated dentures. Therefore, to prevent cross-contamination infection control procedures such as the chemical disinfection or microwave irradiation are performed. The hardness of a material is an important property, since it indicates the ease of finishing of a material as well as its resistant to in-service scratching during cleaning procedures. Measurements of surface hardness of denture base resin indicate to what extent the forces applied during mastication can be resisted. It has been observed that some disinfectant procedures may have a softening effect on acrylic resins, reducing the surface hardness [2,3]. Therefore, this study was conducted to investigate the effect of chemical disinfection and microwave irradiation on the hardness of two hard chairside reline resins and one heat-polymerizing denture base acrylic resin.

MATERIALS & METHODS

Materials

The materials used in this study along with their type, manufacturer and batch No. are presented in **Table 1**. These materials were selected to evaluate the influence of the disinfection methods on the hardness of reline resins having different compositions. The Lucitone 199 was selected to represent the conventional polymethyl methacrylate heat-polymerizing acrylic resins, which are commonly used for the fabrication of denture bases.

Methods

Test specimens were produced in moulds prepared by the investment of wax patterns in Dental plaster within the flask. Sixty square patterns of 12×12×3mm dimension were made of a Modelling wax [4]. Materials were mixed, packed polymerized according to manufacturer's instructions (Table 2).

After polymerization, the specimens were visually inspected, and were required to have a smooth surface without voids or porosity; otherwise, they were discarded. Immediately after polymerization, any flash and excess were removed by polishing using progressively finer grades (600-1200) of silicon carbide paper (3M of Brazil; São Paulo, Brazil), to obtain a smooth, flat surface. The square shape (12×12×3mm) of the specimens was chosen to ensure that the hardness measurements were made at the same locations on the specimen surface [4]. Twenty specimens were produced for each material and divided into 2 controls and 2 experimental groups of 5 specimens each (Table 3).

Control group ND contained 5 specimens from each material which were not disinfected and the hardness were measured after polymerization for the hard reline resins, whereas for the heat-polymerized denture base acrylic resin, measurements were made after the specimens had been conditioned in distilled water at 37°C for 48 hours. These values were used as controls, as the patients will be wearing the relined denture bases soon after polymerization, without any effect of water sorption and disinfection [5].

In Control group WI the specimens were stored in distilled water into a 200 ml beaker at 37±2°C for 48 hours, and hardness values were measured. This minimum volume of water was calculated by measuring the volume that would completely cover a maxillary complete denture in a standard pressure vessel. This time was chosen as being representative of the first recall appointment for adjustments after relining [5].

Disinfection Procedures

The specimens from Test group CD were chemically disinfected by immersion in full strength Cidex (2% alkaline glutaraldehyde) for 10 minutes at room temperature. The specimens from Test group MW were disinfected by an unmodified domestic microwave oven (Intellowave, LG India). The specimens were placed in a 200 ml beaker of sterile distilled water. This beaker was placed on the rotation plate (2D turntable) in a microwave oven and irradiated at 650 W for 6 minutes [6,7]. The specimens were disinfected twice for two days to simulate the disinfection which occurs, first, when contaminated dentures are taken from the patient, and then again before the dentures are returned to the patient [5]. Between two disinfection cycles the specimens were stored in distilled water at room temperature.

Hardness measurements

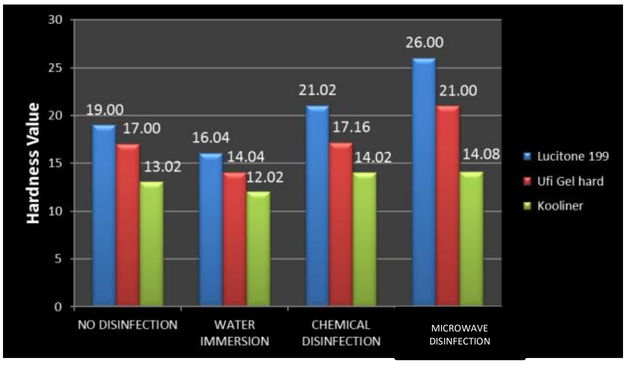

Fig 1: Comparison of mean hardness values (VHN) for different materials, evaluated after various disinfection methods.

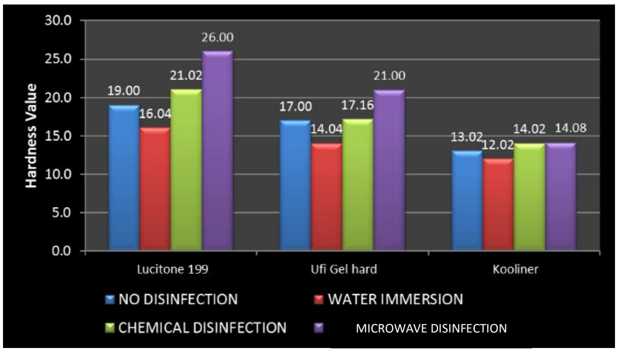

Fig 2: Comparison of mean hardness values VHN after disinfection procedures for different materials.

Microhardness measurements were obtained with a Vicker's hardness tester (LM 300 AT, LECO). The test involves the use of a diamond indenter point in the shape of a square-based pyramid. For all specimens, a 25-g load and a 30-second time period were used. The diagonals of the pyramid impressed on the specimen by the Vicker's indenter were measured and noted. Microhardness tester automatically displayed digital hardness value on the screen using the lengths of the diagonals of the indentation. Eight indentations were made at different points on each specimen, and the mean Vicker's hardness number (VHN) was then calculated for that specimen.

All readings obtained were subjected to statistical analysis to finalize the result. The statistical software SPSS PC+ was used for data analysis. Mean, standard deviation and standard error were estimated from the sample for each study group. One-way analyses of variance (ANOVA) were conducted on the hardness and surface roughness data, followed by Tukey's Honestly Significant Difference (HSD) test for post hoc comparisons (α=.05). All statistical analysis was performed at a confidence level of 95%. In the present study, $p \leq 0.05$ was considered as the level of significance.

RESULTS

The results of the analysis of variance of hardness data revealed that materials, disinfection methods and their interactions were significant (P<.001).

Both chemical and microwave disinfection methods significantly increased (P=.001) the hardness of all three types of materials except for Ufi Gel hard where increase in hardness by chemical disinfection was not significant (P=.642) (Table 4) (Figure 1).

For all the three types of materials evaluated, specimens subjected to microwave disinfection showed significant higher hardness values than those which were chemically disinfected and the differences were statistically significant (p=.001) except for Kooliner where the increase in hardness was statistically insignificant (p=0.929) (Table 4) (Figure 2).

For all experimental conditions, the mean hardness values of the reline materials were significantly lower (p=.001) than those of Lucitone 199 denture base resin. All Ufi Gel hard reline resin specimens were significantly harder (p=.001) than those made with Kooliner (Table 4). For all the three types of materials specimens subjected to water immersion showed significant lower (p=.001) hardness values compared to other three groups and specimens subjected to microwave disinfection showed significant higher (p=.001) hardness values compared with other groups except for group CD where the difference was not significant (p=.929) (Table 4).

DISCUSSION

The hypothesis that both disinfection methods could cause adverse effects on the hardness of the denture base and reline materials was rejected. The hardness of the Lucitone 199, Ufi Gel hard and Kooliner was increased after repeated disinfection, regardless of the method used.

Table 1. Materials used in the study.

Material	Type	Manufacturer	Batch No.
Lucitone 199	Heat cure denture base resin	Dentsply International York, PA	P: 101101 L: 100915
Ufi Gel hard	Hard chairside denture liner	Voco, Germany	P: 946459 L: 929004
Kooliner	Hard chairside denture liner	GC America Inc. Alsip, U.S.A	P: 910211 L: 910201
Cidex	Disinfectant, Alkaline Glutaraldehyde 2%	Johnson & Johnson Ltd. India	B0148

Table 2. Composition and Manipulation of materials used.

Material	Powder/Liquid ratio	Composition		Polymerization Cycle
		Powder	Liquid	
Lucitone 199	21g / 10ml	PMMA	MMA/ EGDMA	90 min at 72ºC and 30 min in boiling water
Ufi Gel hard	30g / 10ml	HEMA	BMA	9.5 min at room temperature
Kooliner	15g / 6ml	PEMA	IBMA	10 min at room temperature

PMMA, polymethyl methacrylate; MMA, methyl methacrylate; EGDMA, ethylene glycol dimethacrylate; HEMA, hydroxyethyl methacrylate; BMA, butyl methacrylate; PEMA, polyethyl methacrylate; IBMA, isobutyl methacrylate

Table 3. Specimen group.

Group	Disinfection Method
Control ND	Not disinfected
Control WI	Water immersion.
Experimental CD	Chemical Disinfection
Experimental MW	Microwave Disinfection

Table 4: Mean (SD) hardness values (VHN) of materials evaluated.

Material	Disinfection Method			
	No Disinfection	Water Immersion	Chemical Disinfection	Microwave Disinfection
	ND	WI	CD	MW
Lucitone 199	$19.00(0.16)^{aA}$	$16.04(0.09)^{bA}$	$21.02(0.08)^{cA}$	$26.00(0.19)^{dA}$
Ufi Gel hard	$17.00(0.32)^{aB}$	$14.04(0.15)^{bB}$	$17.16(0.18)^{aB}$	$21.00(0.16)^{cB}$
Kooliner	$13.02(0.08)^{aC}$	$12.02(0.25)^{bC}$	$14.02(0.15)^{cC}$	$14.08(0.08)^{cC}$

Horizontally, means with same superscript lowercase letters are not statistically significant (*P* >.05). Vertically, means with same superscript uppercase letters are not statistically significant (*P* >.05).

For chemical disinfection with Cidex, this is in accordance with other studies which showed a gradual increase in surface hardness of some denture base resin after chemical disinfection procedures [2,8]. One possible explanation for the increase in hardness may be that the amount of unreacted monomer in the specimens was reduced due to leaching during the disinfection procedures. Another mechanism related to monomer reduction involves further polymerization of the residual monomer due to active radicals remaining in the polymerized acrylic resin. Residual monomer is known to have a plasticizing effect which reduces the polymer interchain forces so that deformation occurs more easily under load during hardness tests. According to Asad et al [2] this could be accounted for by the slow absorption of disinfecting solution into the resin that resulted in some structural change in the polymer.

For the microwave disinfection method, the residual monomer content can be reduced by 2 temperature-dependent mechanisms: further polymerization reaction at the sites of active radicals and diffusion of the unreacted molecules out of the resin. During microwave disinfection, water in which the materials were placed reached the boiling temperature and this provided uniform heating of the specimens [9]. Microwaves cause the water molecules to vibrate 2 to 3 billion times a second, thus producing friction that results in the heating of the water [6,10]. Therefore, it is likely that the heating of the acrylic resins during the disinfection procedures may have enhanced the further polymerization and residual monomer release processes [11]. As a result, the hardness of all three types of materials was increased. Faltermeier et al [12] also observed that heat, used as a secondary polymerization method, significantly increased the hardness of polymethyl methacrylate autopolymerizing acrylic resins.

For all the three types of materials, specimens submitted to water immersion show the lowest hardness values compare to other three groups. A possible explanation for the decreased hardness resulting from immersion in water might be due to the water's plasticizing effect [13-15]. Water, as small molecules, may act as a plasticizer following diffusion into the polymer, thus progressively relaxing the polymer chains and subsequently lowering the hardness of the acrylic resin [14,15]. Pavarina et al [16] and Campanha et al [6] concluded that water molecules may interfere with entanglement of polymer chains and thereby change the physical characteristics of the resultant polymer [14]. According to Anusavice [15], this permits the relaxation of stresses incurred during polymerization.

Lucitone 199 was consistently harder than the reline materials for all experimental conditions. Differences in composition of the materials evaluated may have been partly responsible for these findings. The manufacturers purport that the liquids of Kooliner and Ufi Gel hard materials contain the monomers isobutyl methacrylate and butyl methacrylate, respectively. They also purport that the powder of both materials is composed of polyethyl methacrylate (PEMA). According to Ping Chaing et al [17] reline resins are mechanically weaker than polymethyl methacrylate, and this was supported by the results of the present study. The results could also be attributed to the fact that, for the Lucitone 199 denture base acrylic resin, the polymerization is initiated by heat, while for the reline resins Kooliner and Ufi Gel hard, the initiator is an amine-peroxide that induces free radical polymerization upon mixing at room temperature. The activation mode of polymerization significantly influences the degree of conversion of monomer to polymer. Hardness is sensitive to the residual monomer content, which was found to be lower in Lucitone 199. The higher hardness value of Lucitone 199 could also be due to higher amount of cross-linking agent (EGDMA, ethylene glycol dimethacrylate) present in Lucitone 199 than that in Ufi Gel hard and Kooliner. Cross-linking agent reduces the denture base's solubility to organic solvents, and it reduces the tendency of the denture base to craze (form pre-cracks) under stress [14].

Between Ufi Gel hard and Kooliner, lower hardness values were observed for Kooliner specimens in all groups. This could be related to this material's powder-to-liquid ratio, since it has been demonstrated that the lower this ratio, the higher the content of residual monomer remaining in the polymerized resin [15]. Other reason could be that the liquid of Kooliner doesn't contain cross-linking agent EGDMA [14].

For all the three types of material evaluated, specimens submitted to microwave disinfection shows higher hardness values than those which were chemically disinfected. According to Polyzois et al [8] it might be due to the lack of water plasticizing effect on microwave irradiated specimens.

CONCLUSION

This study evaluated the effect of an infection control protocol and microwave irradiation on the hardness of denture base acrylic resin (Lucitone 199) and hard chairside reline resins (Ufi Gel hard and Kooliner).

1) This comparative in vitro study revealed that hardness of Lucitone 199, Ufi Gel hard and Kooliner were significantly increased by both chemical and microwave disinfection procedures.

2) For all the three types of materials evaluated, specimens subjected to microwave disinfection show significant higher hardness values than those which were chemically disinfected.

3) Specimens subjected to water immersion show lowest hardness values and specimens subjected to microwave disinfection show highest hardness values amongst all groups of study.

4) Specimens of Ufi Gel hard show higher hardness values than specimens of Kooliner.

Although the chemical disinfection of denture is a convenient and inexpensive method it has some drawbacks. It can affect the mechanical and physical properties of denture base and relining materials. It is likely that certain components of the disinfectant solutions may penetrate the material and may be unintentionally introduced into the oral cavity. The use of disinfectants has been considered to be time consuming and inappropriate. In addition, if the denture is heavily contaminated, it may not be completely disinfected by immersion alone.

The results of this in vitro study favour the microwave disinfection method because it improves hardness of materials. It can also disinfect interior of materials when bacteria penetrate into the acrylic resin. Moreover it is easy to use and less time consuming compared to chemical disinfection.

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CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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