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An Invitro-study to Evaluate Effect of Microwave Sterilization and Water Storage on the Vickers Hardness of Acrylic Resin Denture Teeth

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Statement of Problem

Acrylic resin denture teeth soften upon immersion in water, and the heating generated during microwave sterilization may enhance this process.

Purpose:

Two brands of acrylic resin denture teeth were investigated with respect to the effect of microwave sterilization and water immersion on Vickers hardness (VHN).

Materials and Methods:

80 specimens were made for each brand and divided into 4 groups(n=20) :

Group I - Control Group

Group II - Microwave sterilization Group

Group III - 90-day Water immersion Group

Group IV - 90 day Water immersion + Microwave sterilization Group

8 VHN measurements were obtained for each specimen with Vickers hardness tester, and statistically analysed by Student's Unpaired "T" test.

Results:

2 cycles of microwave sterilization did not affect the hardness of both brands of acrylic resin denture teeth when the specimens were not previously immersed in water, in contrast, 2 cycles of microwave sterilization increased the VHN values of both brands of acrylic resin denture teeth when the specimens were previously immersed in water.

However, after 90-days of water immersion the hardness of OT [oradent] specimens were decreased with the exception of PT [perirock] specimens.

Conclusions:

For specimens immersed in water for 90 days, 2 cycles of microwave sterilization increased the hardness of both brands of acrylic resin denture teeth.

Keywords: Acrylic resin denture teeth, Vickers hardness number, Microwave sterilization, Water immersion.

Introduction

Infection control is a topic of intense interest within the dental proffession.. [1] The recent increase in the incidence of communicable diseases such as HepatitisB and Acquired immuno-deficiency syndrome (AIDS) has lead to a significant change in attitude towards the importance of cross-infection control in dentistry. [2]

Potential sources of transmission of infection from patient to dental personnel are impressions, impression trays and gypsum casts, in addition the dental prosthesis at various stages of trial and insertion. [2]

Sterilization and disinfection have become popular and widely used methods for eradicating micro-organisms from the surface of denture base materials and controlling cross-contamination. [3]

Various methods of disinfection:

- Using disinfectant solutions as wetting agents for pumice.
- Using unit doses of pumice combined with sterile muslin wheels and clean pumice pans.
- Controlling aerosols produced while polishing.
- Scrubbing dentures with a soft tooth brush and soap.
- Using disinfectant solutions.
- Using ultrasonic cleanser to increase the biocidal activity of disinfectants.

Methods of sterilization

- Autoclaving
- Microwave irradiation. [1,3,4]
- Chemical disinfectant solutions like chlorine, 8% formaldehyde solution, Gluteraldehyde, Idophor have certain components that penetrate the resin and cause changes in their physical and mechanical properties, like hardness, flexural strength, and color stability. These disinfectants cannot be completely eliminated by rinsing the prostheses and are time consuming. [3,5]

Water used with disinfectant solutions produces a plasticizing effect on the polymerized material, as water absorption process facilitates the movement of polymeric chains under load, thus lowering the hardness of polymer. Microwave irradiation has been used to polymerize acrylic resins and is suggested as an useful alternative to disinfection of dentures by immersion and an adjunct to the treatment of oral candidiasis. Studies have demonstrated that microwave irradiation produced no clinically significant influence on the dimensional stability of acrylic resins and the flexural strength remained unaffected after microwave irradiation.

Acrylic resin denture tooth material should resist wear from the opposing enamel, porcelain, and metal restorative surfaces, and the hardness of the material is a parameter used to predict wear. [3]

A number of studies have examined the effects of microwave sterilization on the mechanical properties of the denture base resins, no information has been reported regarding

the effects on acrylic resin denture teeth and any potential increase in the wear resistance.

Hence, this laboratory study was conducted to evaluate the Vickers hardness of commonly available brands of denture teeth after microwave sterilization and water immersion for 3 months.

Aims and Objectives

1. To test the hypothesis that the Vickers hardness of acrylic resin teeth could be affected by microwave sterilization and water immersion.

2. To compare the Vickers hardness between two brands of commonly available acrylic resin denture teeth.

Materials and Methods

Method followed:

The study was carried out in the department of Prosthodontics, K.L.E.S's Institute of dental sciences, Belgaum and the tests were conducted to determine the Vicker's hardness at Suratkal Regional Engineering college, NITK, Mangalore.

1) Preparaton of Experimental Specimen:

The materials tested, brand names, identification codes, and manufacturers are listed in Tablel. For each brand of acrylic resin denture teeth selected in the study, 80 identical acrylic resin denture posterior teeth(molars) were positioned and mounted within the centres of polyvinyl chloride tubes (20x20mm) with the axial surfaces paralleled to the long axis of the tubes and each tube was previously filled with auto-polymerizing cold cure acrylic resin. A thin layer of petroleum jelly was smeared onto the inner surface of each tube before it was filled with the cold cure resin for the easy separation of the set resin from the PVC tube. According to the manufacturers, the acrylic resin denture teeth tested in this study were all cross linked.

Once the cold cure resin was polymerized and hardened, the cylindrical shaped specimens were retrieved by cutting away the PVC tubes with a silicone carbide disk. Then, the occlusal surfaces of the acrylic resin denture teeth were ground flat using silicon carbide paper held in a sand paper mandrel with a micromotor and running water as the coolant. The specimens were polished with a wet polishing wheel and slurry of pumice.

GROUP I: (C group)	Control specimens, hardness measurements were made after polishing.
GROUP II: (MwS Group)	Specimens were individually placed in 250mL beaker of distilled water, and subjected to 2 cycles of microwave sterilization at 650 W for 6 minutes. The sterilization procedure was performed twice simulating sterilization at the time contaminated dentures are sent to the laboratory and before they are returned to a patient.
GROUP III: (Wim Group)	To determine whether extended immersion in water would adversely effect the hardness of acrylic resin denture teeth, specimens when stored in distilled water for 90 days.
GROUP IV: (90-day Wim + MwS group)	Specimens were stored in distilled water for 90 days in the specimen jar and then subjected to 2 cycles of microwave sterilization.

Each specimen was washed in the distilled water, dried with absorbent paper and then was subjected to hardness tester.

2) Measurements Of The Vickers Hardness Number (Vhn):

The Vickers hardness number of all the specimens was obtained using a Vickers hardness tester (Holmarc, model MV-PC, SR No:12/2003-647, Maximum capacity-1000gf , FUEL INSTRUMENTS AND ENGINEERS PVT. LMT. Yadrav-416145, Maharastra, India) which consisted of a diamond Indentator and a microscope lens connected to an external computer display which had the software installed for VHN calculations Fig:2. The amount of magnification obtained with the microscope lens was 20x. The amount of load applied over the specimen could be adjusted conveniently with a screw that had graduations ranging from 50g to 1000g. The diamond indentator fixed vertical to the platform of the tester could apply a determined amount of load for a fixed amount of time over the specimen fixed rigidly over the platform Fig: 3. The platform could be moved in both the horizontal and vertical directions

between the indentator and the lens in order to view the indentation made over the specimen.

Figure 1: Materials used.

Figure 2: Microvickers Hardness Indentator System.

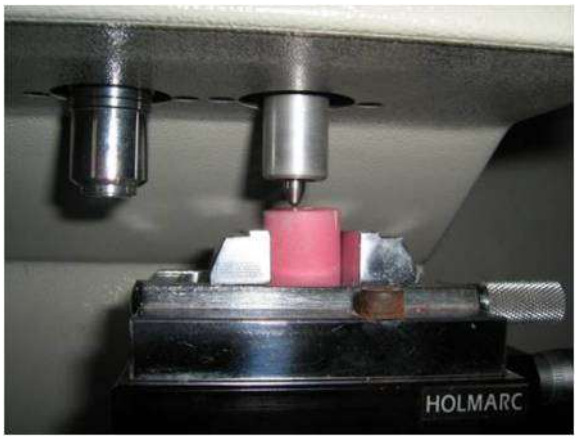

Figure 3: Acrylic resin denture teeth specimen subjected to indentation.

Figure 4: Measuring the horizontal diagonal of the indentation using on screen point and click method.

Methodology Followed

Measurements of Vickers Hardness Number (VHN) of the individual specimen was obtained by placing each specimen over the platform of the tester. With the help of a rotating screw, the platform was moved in the horizontal and vertical directions in order to focus the specimen under the microscope lens until a clear view of the testing area was obtained over the computer screen.

- The platform was then moved towards the right to place the specimen below the diamond indentator.
- Another screw was rotated to adjust the load to 100-gram/force and for a time period of 30 seconds.
- A load of 100-gram/force was used so that the indentation could be properly measured.
- On pressing an automatic button, the diamond indentator proceeded to indent the specimen with a constant load of 100-gram force for a time period of 30 seconds.
- The red light indicated the start of the indentation, while the yellow light indicated the completion of the indentation.
- The specimen was then moved to focus the area of the indentation below the Microscope lens.
- The area of indentation that appeared was

- rhomboid in shape and had a darker hue compared to the adjacent un-indented area.
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- The lengths of the diagonals D1 and D2 were read immediately after each indentation was made by on screen point and click method with a minimal (as short as 10 seconds) period of time elapsing between making and reading the indentations Fig: 4.
- It was assumed that due to the short time interval between making and reading the indentation, the viscoelastic recovery of the diagonals after the indentation was minimal.
- The values of D1 and D2 were fed into the system and the equipment automatically converted these measurements to VHN numbers (kg/mm2) by using the following formula:

$$VHN = \frac{1.854 \times P}{L^2} \text{ kg/mm2}$$

Results

- Where "VHN"is the Vickers hardness number, 'P' is the load applied that is (100-gram force) 'L' is the mean diagonal.
- 8 indentations were made on each specimen and the mean was calculated.

The mean values and the standard deviation for each of the test Groups considered are shown in Table II: A, Table II: B, Table II: C. The results were subjected to Student's Unpaired 'T' test for statistical analysis, which revealed significant differences among the test Groups. The analysis was conducted with an alpha level of significance of .05

- It can be seen from Table II: A that microwave sterilization had no significant effect on the hardness(VHN) of acrylic resin denture teeth PT and OT when the specimens were not previously stored in distilled water (MwS).
- In contrast, there was a significant increase in the hardness(VHN) values of acrylic resin denture teeth PT and OT when the specimens were previously stored in distilled water and then subjected to 2 cycles of microwave sterilization(90-dayWim + MwS).
- When the specimens from Group C and 90-day Wim were compared, OT specimens showed reduced hardness values, in contrast the PT specimens showed increased hardness values as shown in Table II:B, Table II:C.

MATERIAL	CODE	MANUFACTURER
PERI-ROCK	PT	RUTHINIUM DENTAL PRODUCTS PVT. LTD. GURARAT
ORA-DENT	OT	GAURAV PRODUCTS Pvt. Ltd. BELGAUM

TABLE No. I: Acrylic resin denture teeth, dentification codes and manufacturers

TREATMENT	PERIROCK Mean ± SD	ORADENT Mean ± SD	P-VALUE	INFERENCE
Control	16.72 ± 0.48	16.91± 0.16	0.0973	Not Significant
MwS	16.83± 0.22	16.97± 0.20	0.0516	Not Significant
Wim	17.03± 0.23	16.90± 0.36	0.1702	Not Significant
Wim + MwS	17.35± 0.47	17.19± 0.27	0.2018	Not Significant

MwS: Microwave Sterilization

Wim: Water immersion

Wim + MwS: Water immersion + Microwave Sterilization

TABLE NO. II: A VHN number (kg/mm2) mean values and SDs of acrylic resin teeth under four treatment Groups

Table II: A shows the following results:

- Within the control group C, the VHN mean values of PT and OT specimens had no significant differences either.
- In group 90-day Wim , PT specimens showed significantly higher mean hardness values than OT specimens.
- Moreover, in group Wim + MwS, OT specimens showed significantly lower mean hardness values than the PT specimens.

PERIROCK TEETH			
	MEAN	**P - VALUE**	**INFERENCE**
CONTROL	16.72 ± 0.48		
MwS	16.83 ± 0.22	0.3295	Not Significant
Wim	17.03 ± 0.23	0.0110	Significant
Wim+ MwS	17.35 ± 0.47	0.0001	Significant

TABLE NO. II: B Comparison between control and other groups for Perirock teeth

		MEAN	P – VALUE	INFERENCE
	CONTROL	16.91 ± 0.16		
	MwS	16.97 ± 0.20	0.3081	Not Significant
	Wim	16.90 ± 0.36	0.9324	Not Significant
	Wim + MwS	17.19 ± 0.27	0.0002	Significant

TABLE NO. II: C Comparison between control and other groups for oradent teeth.

Discussion

Dental Prosthesis has been identified as a source of cross contamination between patient and dental personnel. In addition the presence of denture stomatitis among the denture patients, the recent increase in the incidence of communicable diseases such as Hepatitis B and Acquired Immuno-deficiency syndrome (AIDS) has been reported, and acrylic resin dentures are an important predisposing factor, as these prosthesis may act as a reservoir of infection. [2,3]

The other potential sources of transmission of infection between patient and dental personnel are impressions, impression trays, gypsum casts. [2]

Since it is not possible to screen every patient for all infectious diseases and patients with unknown infections must be treated, transmission should be blocked by a method that is practical, easy and satisfactory, therefore, improved barrier techniques in handling dental prostheses

are necessary to protect dental personnel and patients from bacterial and viral infections that can be transmitted through procedures associated with dental procedures. [2,3]

Over the decades, various methods for sterilization and disinfection have been used that are:

Methods of disinfection:

1) Using disinfectant solutions as wetting agents for pumice.

2) Using unit doses of pumice combined with sterile muslin wheels and clean pumice pans.

3) Controlling aerosols produced while polishing.

4) Scrubbing dentures with a soft tooth brush and soap.

5) Using disinfectant solutions for denture immersion.

6) Using ultrasonic cleanser to increase the biocidal activity of disinfectants.

Methods of sterilization:

1) Autoclaving.

2) Microwave irradiation. [1,3,4,7,8,13]

4 categories of chemical disinfectants were accepted by the dental therapeutics, that were chlorine(5.25% sodium hypochlorite solution), 8% formaldehyde solution, Gluteraldehyde in 2% solution, iodophor with 1% available iodine, for chemical disinfection. In choosing a chemical disinfectant for dental prosthesis, consideration should be given to its biocompatibility with the type of material to be disinfected to avoid the adverse effects. But the disadvantages of these disinfectant solutions were formaldehyde irritates the skin and releases an offensive odour, while iodophor and sodium hypochlorite stains/whitens plastic components of the prosthesis.[4,9,14]

However it has also been demonstrated that the hardness, flexural strength and color stability of denture base resins can be significantly affected by gluteraldehyde, chlorhexidine, phenolic based, alcohol based and hypochlorite disinfectants5, these components of the disinfectant solutions may penetrate the material and may not be completely eliminated by rinsing, and also these components may be unintentionally introduced into the oral cavity. In addition the use of disinfectants has been considered to be time consuming and inappropriate. Also, water used with disinfectant solutions produces a plasticizing effect on the poylmerized material, as water absorption process facilitates the movement of polymeric chains under load, thus lowering the hardness of polymer. [3,10,12]

Nishii et all [6] reported the use of microwave energy to polymerize denture base materials in 1968.

More recently, microwave irradiation has been suggested as an useful alternative for disinfection of dentures by immersion and an adjunct to treatment of oral candidiasis. Some studies have demonstrated that microwave irradiation produce no clinically significant influence on the dimensional stability of the acrylic resins and the flexural strength remains unaffected after microwave irradiation. [3]

The wear rate is an important physical property of the artificial teeth because of the influence on the maintenance of maximum intercuspation at centric jaw relation position, masticatory efficiency and occlusal stability. In the past, the materials most often used to fabricate the denture teeth were porcelain or acrylic resin. Porcelain denture teeth are brittle and prone to fracture and acrylic resin denture teeth have less wear resistance.

Newer material combinations have been developed for denture teeth that claim improved wear resistance, and are of 2 types:

1) “Micro-filled composite type”.

2) “Interpenetrating – Polymer network type”. [14,15,16]

Acrylic resin denture tooth material should resist wear from the opposing enamel, porcelain, and metal restorative surfaces, and the hardness of the material is a parameter used to predict wear. [3,6,11]

Vickers indentation is a valid tool for evaluating the hardness of viscoelastic and other responses of rigid polmers. [6]

In this study, 2 brands of acrylic resin denture teeth were investigated with respect to the effect of microwave sterilization and water immersion on the Vickers hardness. The data obtained under the conditions of this study confirmed the hypothesis that the hardness of acrylic resin denture teeth could be affected by microwave sterilization and water immersion.

According to the results of this study when the specimens of Group II were compared with the Control Group specimens, microwave sterilization procedure did not affect the hardness of the both PT and OT brands of acrylic resin denture teeth, when the specimens were not previously immersed in water.

To evaluate whether water uptake would influence the effect of microwave sterilization on the hardness of the acrylic resin denture teeth, the study also included 2 water immersion specimen groups. With respect to the effect of water immersion on the hardness of the acrylic resin denture teeth, softening was observed when the Oradent acrylic resin denture teeth(OT) from group III were compared to the control specimens, but not statistically significant. The possible explanation for the decreased hardness resulting from immersion in water might be the water’s plasticizing effect. 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 acrylic resin denture teeth.

In a study evaluating indentation resistance of denture base polymers before and after storage in water, Von Franhofer and Suchatlampong3 showed that such storage produced softening of the surface in denture base acrylic resin. The results of the present study are also consistent with the finding of a previous study in which 90-day water immersion decreased the hardness of Oradent acrylic resin denture teeth. In contrast, the PT specimens showed a statistically significant increase in the hardness when the specimens from Group III were compared to the control specimens. The possible explanation for this increased hardness was due to the process known as “Weathering”.

Weathering is a process in which, due to continuous exposure to moisture, the specimens become harder over a period of time.

However, when group IV specimens were compared with the control specimens, for both OT and PT acrylic resin denture teeth, there was a statistically significant increase in the microhardness when the specimens were previously immersed in water and then subjected to microwave sterilization. The possible explanation for this result was probably the duration needed to stabilize the water uptake of materials OT and PT, and the effect of microwave heating on the water uptake was therefore minimal.

The limitations of this in vitro study include the fact that the specimens were submitted to only 2 cycles of microwave sterilization. Thus, any cumulative effect of successive microwave sterilization cycles should be a topic for further investigations.

Conclusion

Within the parameters of this study design and the materials used, the following conclusions were drawn:

1) Two cycles of microwave sterilization did not affect the hardness of the two types of acrylic resin denture teeth(PT and OT) when the specimens were not previously immersed in water.

2) Two cycles of microwave sterilization increased the VHN of the 2 types of acrylic resin denture teeth tested(PT and OT) when the specimens were previously immersed in water.

3) A decrease in the hardness values was observed after the OT acrylic resin denture teeth were stored in the water for 90 days, with the exception of PT acrylic resin denture teeth.

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