

Effect of Different Chemical Disinfectants on the Flexural Strength of Heat-Polymerized Acrylic Resins

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Abstract - The purpose of this study was to evaluate the effect of chemical disinfectants on flexural strength of denture base acrylic resins. A total of 176 rectangular specimens (65x10x3mm) were made from four heat-polymerized acrylic resins (Triplex, QC-20, Meliodent and Acropars) (n=44). The specimens were thermal cycled for 5000 cycles 5-55°C and randomly divided into four groups (n=11). The specimens were immersed in 1% sodium hypochlorite, 2% glutaraldehyde, 10% Micro 10 or water for 30 minutes. The flexural strength was evaluated using a universal testing machine at a crosshead speed of 5mm/min. Data were subjected to 2-way ANOVA and Tukey HSD ($\alpha=0.05$). The highest flexural strengths of denture base resins were achieved after immersion in water (Triplex = 128.9 ± 12.8 , QC-20 = 125 ± 11.8 , Meliodent = 96.2 ± 11.4 and Acropars = 78.1 ± 12.3 MPa). Triplex and QC-20 showed the highest flexural strengths in all of the solutions ($P < 0.05$). The flexural strength of denture base acrylic resins was significantly affected by immersion in disinfection solutions but the reduction in flexural strengths of Triplex, QC-20 and Meliodent after disinfection by 1% sodium hypochlorite, 2% glutaraldehyde and Micro 10 were clinically insignificant.

KEYWORDS: Acrylic resins, Disinfectants, Flexural strength, Polymethyl methacrylate

INTRODUCTION

Dental instruments and laboratory equipments may be contaminated with pathologic organisms during dental practices and laboratory procedures. Blood and saliva are not only a potential source of hepatitis B and HIV viruses, but can also transmit the other hazardous viruses and bacteria which are responsible for diseases like common cold, herpes, pneumonia and tuberculosis¹.

Many items in prosthodontics like impressions, record bases and prostheses should be disinfected with chemical solutions as standard heat sterilisation is not an option. Dental prostheses constitute a potential health hazard to dental office and laboratory personnel. The common disinfection solutions for dental prostheses are chlorine, aldehyde compounds and iodophors¹⁻⁴. An infection control protocol was recommended for cross infection in dental laboratories. It was shown that 1% sodium hypochlorite, 4% chlorhexidine and 3.78% sodium perborate solutions are effective for reduction the number of microorganisms on the dentures in 10 minutes⁵.

Polymethyl methacrylate (PMMA) is one of the most common materials for denture base fabrication⁶. The cleanser and disinfection solutions may have adverse effect on transverse strength, hardness, and surface appearance of the resins⁷. Many studies have been evaluated the mechanical and physical properties of acrylic resins after disinfection⁷⁻¹³. Flexural strength can reflect the ability of a denture base material to withstand functional forces during mastication¹⁴ and can be affected by polymer bead size¹⁵, residual monomer level^{10,16}, plasticizer composition^{9,16}, amount of

cross linking agents^{8,12}, internal porosity of the polymer matrix^{10,14}, denture base thickness, patient factors¹⁴, type of polishing, and the disinfection methods¹¹.

The aim of this study was to evaluate the effect of different chemical disinfectants on the flexural strength of heat-polymerized acrylic resins. The null hypothesis was that the flexural strength of heat-polymerized acrylic resins would not be affected by chemical disinfection solutions.

MATERIALS AND METHODS

In this in vitro study, four heat-polymerized acrylic resins (Table 1) and three disinfection solutions were tested.

Specimens' preparation

Stainless steel rectangular master dies measuring 65x 10x3 mm (ISO 1567 standard)¹⁷ were used to provide moulds for making the specimens. The master dies were invested with type III dental stone (Moldano; Heraeus Kulzer, Wehrheim, Germany) in metallic flasks. To facilitate the removal of the processed acrylic resins from the flasks, the master dies were invested in 2mm of a silicon rubber (Speedex; Coltene AG, Altstätten, Switzerland). After setting of the stone, the flasks were opened and the master dies were removed. Two thin layers of separating medium were applied to dental stone surfaces. The acrylic resin specimens were prepared, packed, pressed and polymerized according to the manufacturer's instructions (Table 1). Then, the flasks were allowed to cool to room temperature. Forty four specimens were prepared of each acrylic resin.

After deflasking, the excess acrylic resins were trimmed with tungsten steel bur using low speed handpiece. The surfaces of specimens were polished using 400 grit silicon carbide papers for 30 seconds on each side by low

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Table 1. Heat-polymerized acrylic resins tested.

Acrylic resin	Manufacturer	Batch no.	Polymerization cycle
QC- 20	Dentsply Int Inc, Weybridge, Surrey, UK	05MP04	Flask immersion in 100°C boiling water; regaining temperature to 100 °C; maintain for 20 minutes.
Triplex	Ivoclar Vivadent AG, Schaan, Liechtenstein	E23571	Flask immersion in cold water; raise temperature to 100 °C; maintain for 45 minutes.
Meliodont	Heraeus-Kulzer GmbH, Wehrheim, Germany	A1145B-1	Flask immersion in cold water; raise temperature to 70°C; maintain for 10 minutes; raise temperature to 100 °C; maintain for 20 minutes.
Acropars	Marlic Medical Instruments CO, Tehran, Iran	PH84064	Flask immersion in 100°C boiling water; regain temperature to 100 °C; maintain for 20 minutes.

Table 2. Mean (standard deviation) of flexural strength of the tested acrylic resins in different media (MPa).

Acrylic resin	Water	Glutaraldehyde	Sodium Hypochlorite	Micro 10 +
QC- 20	125.2(11.8) ^{A a}	109.4(7.9) ^{B a}	115.5(7.6) ^{AB a}	97.9(7.4) ^{B a}
Triplex	128.9(12.8) ^{A a}	107.0(9.2) ^{B a}	113.8(8.8) ^{B a}	102.0(9.0) ^{B a}
Meliodont	96.2(11.4) ^{A b}	84.3(4.6) ^{AB b}	78.4(6.2) ^{B b}	76.0(13.2) ^{B b}
Acropars	78.1(12.3) ^{A c}	73.9(9.0) ^{A b}	64.8(11.7) ^{AB b}	55.9(7.9) ^{B c}

Significant differences between the means in row (uppercase letter) and column (lowercase letter) are characterized by different letters ($p < 0.05$).

Table 3. Two-way ANOVA.

Source	Sum of square	df	Mean square	Sig.
Acrylic resin	64569.5	3	21523.1	0.000
Disinfection solution	12475.1	3	4158.3	0.000
Acrylic resin × Disinfection solution	2161	9	240.1	0.011
Error	15357.3	160	95.9	
Total	1656654.8	176		
Corrected Total	94562.9	175		

speed dental hand piece (KaVo Dental, Charlotte, NC). The specimens were conditioned in distilled water for 48 ± 2 h and thermal cycled for 5000 cycles 5-55 °C with 30 second dwell time in each water bath and a 10 second transfer between temperature baths.

Disinfection method

The specimens of each acrylic resins were randomly divided into four groups ($n=11$). The first group were immersed in water for 30 minutes as control. The other groups were disinfected twice (total 30 minutes), simulating when dentures are sent to the dental laboratory and return to the patient. These specimens were immersed in one of the following disinfection solutions: 1% sodium hypochlorite, 2% glutaraldehyde and 10% Micro 10(Unident, Geneve, Switzerland). After disinfection, the specimens were immersed in water for 5 minutes.

Flexural strength testing

Flexural strength was determined using a 3 point bending test in a universal testing machine (Instron 4302, Bucks, UK) at a crosshead speed of 5mm/min. The specimens were centred on the device with a 50 mm distance between the specimen supports. The specimens were loaded at the centre until fracture occurred. The fracture force was

recorded in Newton. The flexural strength was calculated in MPa using the following equation:

$$S = 3PL/2bd^2$$

in which P is the fracture load, L is the distance between the supporting wedges, b is the specimen width and d is the specimen thickness.

Statistical analysis

The mean flexural strength values were subjected to 2- way ANOVA and followed by Tukey HSD post hoc test. ($\alpha=0.05$)

RESULTS

The mean values of flexural strength and standard deviation of all groups are presented in table 2. The highest flexural strength of denture base resins were achieved after immersion in water. Two -way ANOVA showed that there were significant differences between denture base resins, disinfection solutions and their interactions (Table 3). Triplex and QC-20 showed the highest flexural strengths in all of the solutions ($P < 0.05$). The flexural strength of Acropars was significantly reduced in Micro 10 ($P < 0.05$). There was no significant difference between the flexural strengths of QC-20, Triplex and Meliodent specimens after immersion in each of the disinfection solutions.

DISCUSSION

The results of this study revealed that disinfection solutions can adversely affect the flexural strength of the studied denture base resins. Thus, the null hypothesis was rejected. Pavarina *et al.*⁵ showed that the flexural strength of QC-20 was not significantly affected after immersion in 1% sodium hypochlorite. This could be related that in the present study, the immersion time in 1% sodium hypochlorite was longer (30 min) and the specimens were subjected to thermal cycling.

In line with the results of this study, Orsi and Andrade¹¹ demonstrated a significant reduction of QC-20 flexural strength after disinfection with 1% sodium hypochlorite. Likewise, Robinson *et al.*¹⁸ also reported differences in the transverse strength for acrylic resins that were immersed in water and sodium hypochlorite. In addition, it has been suggested that denture cleansers had adverse effect on the flexural strength of heat-polymerized acrylic resins⁹.

The flexural strength of microwave-polymerized acrylic resin was not affected by immersion in NaOCl solutions during 180 days¹⁰. It was shown that microwave-polymerized materials presented higher values of flexural strength in comparison to heat-polymerized and auto-polymerized acrylic resins. Ellakwa and El-Sheikh¹⁹ suggested that Triplex acrylic resin was not significantly affected by sodium hypochlorite and %2 glutaraldehyde after repairing with heat or auto-polymerized acrylic resins, but was significantly different in comparison to control specimens without repair and disinfection.

It has been reported that sodium hypochlorite disinfectant produced color changes of the resins²⁰ and whitening can reduce the flexural strength of the acrylic resins⁵. On the other hand, it has been suggested that the temperature of the disinfection solutions played an important role in the bleaching effect and reducing the flexural strength^{18,21}.

It was suggested that a boiling cycle provides a high degree polymerization but it causes more residual monomer in comparison to overnight cycles plus terminal boil²². The curing cycle for Acropars and QC-20 provided a marked temperature increase during the early stages of polymerization that could result in a higher level of residual monomer. The residual monomer may affect the mechanical properties of the acrylic resins by plasticizing effect^{23,24} which can be reduced the transverse strength²⁵.

The other factor which can be affected the transverse strength of acrylic resins is porosities. The porosities may reduce the tensile strength to one-sixth to one-eighth less compared to dense acrylic resins²⁶. Increasing of the temperature above 100 °C during processing results in boiling and vaporizing of the monomer and porosity in acrylic resins²⁷. Despite Truong and Thomasz reported porosity in QC-20 which was cured in boiling water according to manufacturer's instructions, it had no clinical significant. The liquid of QC-20 contains a chemical agent which is incorporated to increase the boiling point of the monomer⁵.

The chemical disinfection solutions used in this study may have a plasticizing effect on the resin matrix, thus decreasing the strength of resin¹¹. Polymethyl methacrylate absorbs relatively low amounts of water after immersion in aqueous medium. Water molecules interfere with the

polymer chains and act as a plasticizer and it may cause adverse effects on mechanical properties²⁷.

Despite the significant reduction of the flexural strengths of Triplex, QC-20 and Meliodent after disinfection, the mean flexural strength values comply with the least value (65 MPa) set forth by the ADA specification no.12²⁹ and it may have clinically insignificant outcomes. These results may be related to the fact that QC-20 and Triplex contain cross-linking agents which increase the resistance to solvents and surface stresses and may increase the flexural strength²⁷. In addition, the polymerization method of Triplex and Meliodent is a long cycle plus terminal boil which produces less residual monomer and improve the flexural strength^{22,25}.

In this study, the flexural strength of denture base resins was evaluated after short-term immersion in disinfection solutions. However, the dentures may be exposed several times to disinfection procedures during its service life. Thus, long-term evaluation of denture base acrylic resins flexural strength after immersion in chemical solutions is recommended. Furthermore, the denture bases are subjected to fatigue stresses during function in oral cavity, while in this study the flexural strength was tested under monotonic loading.

CONCLUSION

Within the limitations of this study the following conclusions were drawn:

1. The flexural strength of denture base acrylic resins was significantly affected by immersion in disinfection solutions used in this study.
2. The reduction in flexural strengths of Triplex, QC-20 and Meliodent after disinfection by %1 sodium hypochlorite, %2 glutaraldehyde and Micro 10 were clinically insignificant.

ACKNOWLEDGEMENT

This study was supported by Isfahan University of Medical Sciences Research Grant # 384147. The manuscript was based on a thesis submitted to the Postgraduate School of Isfahan University of Medical Sciences in partial fulfillment of the requirement for the Master of Science Degree.

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