ORIGINAL ARTICLE

Studying the Effect of Ascorbic acid on some properties of Autoclave and Heat cure denture base material

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ABSTRACT

Background: Still Heat cure acrylic is the Most widely used denture base materials.but it has some inadequate properties like strength and antimicrobial activity .the present aimed to study the use of ascorbic acid as fillers with water bath and autoclave heat cure denture base material .And evaluate its effect on some properties of heat cure acrylic.
Materials and Method: in this study , vertex regular heat polymerized resin were used to prepare specimens in two method of polymerization autoclave and water bath polymerization .the curing cycle for autoclave was (134 °C ,2bar,15minutes).while for heat cure (20 °C to100 °C, for 30 minutes at 100 °C). The effect of Ascorbic acid was used in two form addition for and immersion form with a concentration of 1%. And 30 minutes was the time for immersion. the data were analyzed using ANOVA tests which was considered statistically significant at a level of< 0.05.
Results: Autoclave polymerized showed a non-significant increase for flexural strength with incorporation and immersion form with highest mean value (101.05+SD 5.02) (100+SD 4.19) respectively. Also, for hardness the water bath showed a non-significant increase in incorporation form with highest mean value (83.76+ SD1). While a non-significant decrease in the flexural and impact for water-bath with two form, and non-significant decrease in the immersion form for water bath. Also, there was a non-significant decrease for autoclave in hardness and impact with two forms
Conclusion: Adding 1% ascorbic acid to the heat cure acrylic showed no effect on the mechanical properties for heat cure polymerized by Autoclave and water-bath meanwhile there was a significant increase in the mean value of Autoclave polymerized when compare with water-bath polymerized.
Keywords: Ascorbic acid, Autoclave polymerization, water-bath polymerization, Micro-Particles, impact strength, flexural strength, hardness.

INTRODUCTION

Polymethylmethacrylate was introduced as a denture base material In 1937 (1,2) . Heat cure acrylic resin provided adequate physical properties that were readily available, inexpensive, and easily manipulated (3). However, this material still has some disadvantages that the material has barely adequate strength (4). Also It has been shown that the material has inadequate antimicrobial activity especially if the patient is a carrier to a certain virus or bacterium (5) .Different methods of polymerization used such as: heat, light, chemical, and microwave energy and this was to improve the physical and mechanical properties of resin material (6). Ascorbic acid is a potent reducing and antioxidant agent that functions in reducing bacterial infections.Ascorbic acid used as effective disinfectant solution on the soft contact lens in a concentration range from 0.1% to 20% by weight was an effective concertation in killing bacteria(7). so the present study aimed to study the effect of ascorbic acid on some mechanical properties of heat cure resin cured by water bath or autoclave .

MATERIALS AND METHOD

Grinding of ascorbic acid: There is a wide range of difference between particle size of the ascorbic acid powder and heat cure acrylic powder grinding of ascorbic acid powder was performed by using an electrical grinding machine (Retsch DM 200).
Fourier transforms infrared analysis (FTIR): FTIR spectrophotometer used to analyze the chemical structure of natural material ascorbic acid (8) . And this was performed to evaluate the effect of grinding procedure on the structure of ascorbic acid. .
Particle size analysis: The particle of ascorbic acid was analyzed by using a laser particle size analyzer, the mechanism of the device use a beam with the dual-lens that recognize the scattered signals from nano to micro size particles. Powder mixed with water before particle size been tested (9)
Pilot study: The pilot study was done to select the proper concentration based on the result of the transverse strength test. The ascorbic acid was added to the heat cure acrylic powder in two form each form cured by autoclave and water-bath. The first form, ascorbic acid powder was incorporated in acrylic with concentration 0.5% ,1%,2%,3%.The second form powder was mixed with water for immersion the acrylic with concentration 0.5%,1%,2%,3%. Also three times were used for immersion 30, 60 & 90 minutes. For result of pilot study,1% ascorbic acid whether incorporation and immersion showed the highest mean value of Transvers strength in both type of heat curing autoclave and water bath . And the appropriate time for the immersion is 30 minutes when the result compares to control group.
Specimens' Preparation: This step started with mold preparation from plastic patterns as following:
For the transverse test, the plastic pattern was prepared with these dimensions (65x10x2.5) mm length, width, and thickness respectively (10). While for the surface hardness test, it followed the instructions of the device which were the same dimensions for the transverse strength test used. Impact strength test (80 x 10 x 4) mm length, width, and depth respectively (11) .The procedure for sample

preparation including flasking, it was done as the same procedure applied for complete denture fabrication. Ascorbic acid in percentages of 1% wt. were added to monomer and dispersed by prope sonicator apparatus(Soni prep– 150/England) then acrylic powder quickly added to monomer containing ascorbic acid according to manufacturer instructions of regular conventional heat-cured acrylic denture base material by Vertex (P/L ratio 2.2g/1ml). After that, the acrylic dough was loaded into a stone mold and a pressure of (100KPs/cm2) using a hydraulic press for 5 min., then the flask was placed in a water bath (20 °C to100 °C, 30 minutes at 100 °C) and for Autoclave (134 °C, 2bar) Later those specimens were finished and polished using a dental lathe machine (Germany). All specimens were kept in distilled water for 48 hr. before testing [12].

Testing procedure

Transvers strength test: The Instron testing machine had been used to perform this test, the specimen was carried on a fixed holder with a distance of 50mm apart and the load was applied with speed 1 mm/min by putting the bar in the middle between the two supports of the holder to make the deflection until fracture occurred. It was calculated through the following equation:

$$Transvers\ strength = \frac{3PL}{2bd^2}$$

Where [13]

T = Transverse strength (N/mm^2), P = maximum force exerted on specimens (N), L = distance between supporting wedges (mm), b = width of specimens (mm)d = depth of specimens (mm)

Impact strength test: the impact test procedure was done, with an impact testing machine and charpy method according to ISO 179- 2000. The specimen was held horizontally from each end and hit by swinging pendulum which was released from a fixed height in the center. the pendulum had been used with capacity 2 joules. The impact force to break the specimen was in joule and impact strength of the specimen calculated in KJ/mm2 as shown in the following equation:

$$Impact\ Strength = \frac{E}{p.d}\ x\ 10^3$$

Where [13]

E: The impact force in Joules, b: The diameter of the specimen in millimeters , d: The thickness of the specimen in millimeters

Surface hardness test: shore D hardness test was used for this test as shown in figure (1) .

Each specimen was marked at standardized sit with marker into three equal parts .The hardness value measured by read the penetration depth of the indenter (0.8) mm , reading show on digital scale range between (0-100) then the mean of three reading selected.

Figure 1: Shore D hardness tester

Scanning electron microscope examination: This was performed for control specimen (0% ascorbic acid) and specimen containing (1% ascorbic acid) by using field emission SEM (TESCAN/Czech).

RESULT

Ascorbic acid powder's size confirmation: The particle size of ascorbic acid was 1.6618 μm.

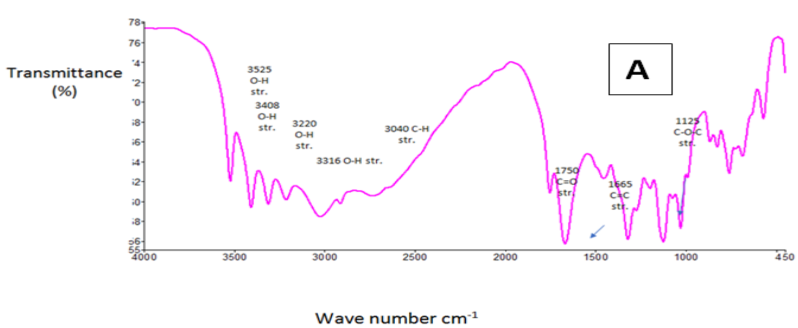
FTIR analysis: FTIR spectrum of non grinding particle and grinding particle of ascorbic acid showed the same chemical structure for both as shown In figures 2.

Experimental tests: Table 1 showed non-significant increases in the Mean value of the flexural strength (N/mm^2) for Autoclave groups with two forms while in water bath groups showed non-significant decrease in the two form

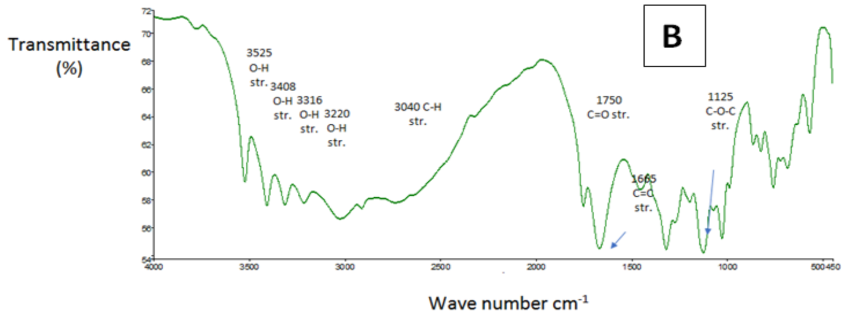
Table 2 showed non-significant decrease in the Mean value of the impact test (KJ/mm2) for the Autoclave groups and water bath groups.

Table 3 showed non- significant increase in the hardness strength (kg/mm2) with incorporation form for water bath group and non-significant decrease for immersion form of water bath group and non-significant decrease for Autoclave groups with two forms

Figure 2: FTIR spectrum of A: Ascorbic acid non-grinding particle B: Ascorbic acid grinding particle



(A) Ascorbic Acid-Non grinding particle



(B) Ascorbic acid -grinding particle

Scanning electron microscope examination: Figure (3) shown field emission SEM image for control specimens for Autoclave control group and water bath control group(A,B) and the 1% of ascorbic acid for both Autoclave and water bath groups (C,D)

Figure 3: Field emission SEM image for A: Control specimen water bath ,B: control specimen Autoclave , C: 1% incorporation water bath , D: 1% incorporation Autoclave

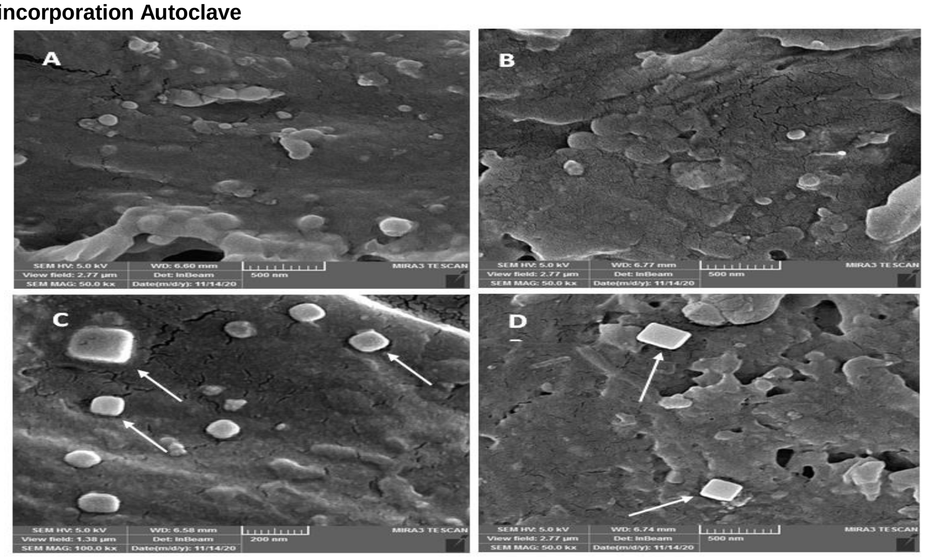


Table 1: Mean value (N/mm^2) of flexural strength for Autoclave and water-bath groups and ANOVA test

Transverse								
	Water-bath				**Auto-clave**			
	Mean	**SD**	**Confidence interval 95%**		**Mean**	**SD**	**Confidence interval 95%**	
			Lower bound	**Upper bound**			**Lower bound**	**Upper bound**
Control	90.6140	3.23229	88.3018	92.9262	98.0270	5.68912	93.9573	102.0967
Addition	90.1210	2.62597	88.2425	91.9995	101.0510	5.02173	97.4587	104.6433
Immersion	90.6080	4.35216	87.4947	93.7213	100.0030	4.19443	97.0025	103.0035
F-test	.066				.941			
P-value	.936				.403			
F-test	.837							
P-value	.439							

Table 2: Mean value (KJ/mm2) of impact strength for Autoclave and water-bath groups and ANOVA test

Impact								
	Water-bath				**Auto-clave**			
	Mean	**SD**	**Confidence interval 95%**		**Mean**	**SD**	**Confidence interval 95%**	
			Lower bound	**Upper bound**			**Lower bound**	**Upper bound**
Control	9.9460	.97041	9.2518	10.6402	10.2390	.50260	9.8795	10.5985
Addition	9.1040	1.38304	8.1146	10.0934	9.6460	1.03495	8.9056	10.3864
Immersion	9.0170	1.24332	8.1276	9.9064	9.5420	1.33441	8.5874	10.4966
F-test	1.795				1.366			
P-value	.185				.272			
F-test	.077							
P-value	.926							

Table 3: Mean of hardness strength (kg/mm2) for Autoclave and water-bath groups and ANOVA test

Hardness								
	Water-bath				**Auto-clave**			
	Mean	**SD**	**Confidence interval 95%**		**Mean**	**SD**	**Confidence interval 95%**	
			Lower bound	**Upper bound**			**Lower bound**	**Upper bound**
Control	83.4930	.92873	82.8286	84.1574	85.5700	2.22415	83.9789	87.1611
Addition	83.7670	1.00159	83.0505	84.4835	85.2000	1.52688	84.1077	86.2923
Immersion	83.4630	.86125	82.8469	84.0791	85.0500	1.61744	83.8930	86.2070
F-test	.323				.217			
P-value	.727				.806			
F-test	.271							
P-value	.763							

DISCUSSION

Ascorbic acid proves its antimicrobial effect especially when used with eye lenses. The effect of ascorbic acid play role as disinfecting solution especially when ascorbic acid compound killed bacteria in concentration range from 0.1% to 20% by weight of the total aqueous composition[7] . The present work study the effect of ascorbic acid as incorporated and immersed with heat cured acrylic resin powder and study its effect on mechanical properties. Due to wide range of difference between particle size of ascorbic acid and heat cure acrylic powder grinding of ascorbic acid powder was done with electrical grinding machines as to have a match between particle size of two material. Fourier transform infrared analysis (FTIR) analysis was performed to evaluate the effect of grinding procedure on the chemical structure of ascorbic acid.

Flexural strength: The transverse (flexural) strength test is mainly helpful in comparing denture base materials in which a pressure of this type is applied to the denture during mastication. The transverse (flexural) strength is a mixture of compressive, tensile, and shears strengths, all of which directly reflect the stiffness and resistance of a material to fracture[14]. The results in ANOVA test showed that there was a non-significant increase in the flexural strength for Autoclave polymerized group with two form incorporation and immersion form also with water-bath group the flexural strength showed non-significant increase when compare to control group, but the result showed a significant increase in the flexural strength for Autoclave group when compared Autoclave polymerized group with water-bath polymerized group this increase due to the pressure which play important role in accelerate the initial polymerization by increasing the temperature of the steam and elevating the boiling temperature of the monomer and thus might suppose a reduction in the residual monomer content due to reduce in porosity [(15)] and this result agree with Gad et al., 2019[16].

Impact strength: Impact strength is defined as the energy required to fracture a material under an impact force [(17)] . impact strength is an essential property for acrylic denture base materials which have a tendency to fracture if randomly dropped onto a hard surface [(18)]. The results in ANOVA test showed that there was showed non-significant decrease in the impact test for the Autoclave groups and water bath groups while significant increase in the impact strength for Autoclave group when compared Autoclave polymerized group with water-bath polymerized group this increase agree with result of (Abdulwahhab, 2013)[19] due to complete polymerization and reduction of residual monomer and porosity.

Hardness strength: Hardness may be broadly defined as the resistance to permanent surface indentation or penetration[20]. In this study, shore (D) hardness tester was used which is suitable for measuring the hardness of acrylic resin .The results in ANOVA test showed that there was showed non- significant increase in the hardness strength with incorporation form for water bath group and non-significant decrease for immersion form of water bath group and non-significant decrease for Autoclave groups with two forms ,but the result showed significant increase in the hardness strength for Autoclave group when compared Autoclave polymerized group with water-bath polymerized group this increase agree with result of (Abdulwahhab, 2013)[19] due to complete polymerization and reduction of residual monomer and porosity, considering that the hardness should establish an inversely proportional relationship with the amount of residual monomer[21].

CONCLUSIONS

it could be concluded that Adding 1% ascorbic acid to the heat cure acrylic showed no effect on the mechanical properties for heat cure polymerized by Autoclave and water-bath while there was significant increase in the mean value of Autoclave polymerized when compare with water-bath polymerized, more detailed studies should be carried out in the future.

REFERENCES

1. Chaing BKP, Polymers in the service of prosthetic dentistry, J Dent 1984,12:203
2. Parvizi an et al , comparison of the dimensional accuracy of injection molded denture base materials to that of conventional pressure pack acrylic resin J Prosthodont 13;83
3. Charles H Heartwell Jr ,text book of complete denture ,ed 5, 373- 380
4. Noort, R. van, 2013. Introduction to Dental Materials, 4th (3).p 180 ch 3.2
5. Kahn RC, Lancaster MV, Kate W. The microbiologic cross-contamination of dental prostheses. J PROSTHET DENT 1982;47:556-9.
6. Azzari MJ, Cortizo MS, Alessandrini JL. Effect of the curing conditions on the properties of an acrylic denture base resin microwave polymerized. J Dent ; 2003; 31: 463-468.
7. Sherman, G.J., Sherman Labs, 1983. *Soft contact lens ambient temperature disinfectant solution containing ascorbic acid or salt thereof*. U.S. Patent 4,367,157.
8. Lopes, C. de C.A., Limirio, P.H.J.O., Novais, V.R., Dechichi, P., 2018. Fourier transform infrared spectroscopy (FTIR) application chemical characterization of enamel, dentin and bone. Applied Spectroscopy Reviews.
9. SHUKUR, B.N., (2014). Study different nano surface modifications on CPTi dental implant using chemical and thermal evaporation methods: Mechanical and Histological

Evaluation (Doctoral dissertation, Thesis submitted in fulfillment of the requirements for the degree of Master of Science, College of Dentistry, University of Baghdad, Iraq).
10. Mikael J, Al-Samaraie S, Ikram F. Evaluation of Some Properties of Acrylic Resin Denture Base Reinforced with Calcium Carbonate Nano- Particles. Erbil Dental Journal (EDJ). 2018 Jun 6;1(1):41-7.
11. ISO 179-1. Plastics -- Determination of Charpy impact properties -- Part 1: Non-instrumented impact test ; 2000.
12. Swaney AC, Paffenbarger GC, Caul HJ, Sweeney WT. American Dental Association specification No. 12 for denture base resin: second revision. The Journal of the American Dental Association. 1953 Jan 1;46(1):54-66.
13. Anusavice K.J. Philips science of dental material. 11th Ed, Middle East and African edition, 2008. Ch7, Ch22, p: 143-166,721-756.
14. Jagger DC, Jagger RG, Allen SM, Harrison A. An investigation into the transverse and impact strength of high strength denture base acrylic resins. J Oral Rehabil 2002;29:263–7.
15. Undurwade JH, Sidhaye AB. Curing acrylic resin in a domestic pressure cooker: a study of residual monomer content. Quintessence Int 1989;20:123–9.
16. Gad, M.M., Fouda, S.M., ArRejaie, A.S., Al-Thobity, A.M., 2019. Journal of Prosthodontics 28, 458–465.
17. Anusavice KJ. Phillips's sciences of dental materials, 11th ed., Phila- delphia: Saunders Co.; 2007.
18. McCabe JF, Walls AWG. Applied dental material, 9th ed., Blackwell Publishing Ltd.; 2008.
19. Abdulwahhab, S.S., 2013. Journal of Prosthodontic Research 57, 288–293.
20. Powers JM, Sakaguchi RL. Craig's restorative dental materials, 13th ed., Philadelphia, PA: Mosby Co.; 2012.
21. Jagger RG. Effect of curing cycle on some properties of PMMA denture base materials. J Oral Rehabil 1978;5:151–7.