Evaluation of the Addition of Tea Tree Oil on Some Mechanical Properties of Heat Cured Acrylic Resin

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Abstract:

Objectives: *the objective of this study was to evaluate the effect of tea tree oil on impact strength; transverse strength and hardness of heat cured acrylic.*

Materials and procedures: *Total number of (80) specimens have been intended .Twenty samples have been prepared without additive (control) and (60) samples were prepared with incorporation of tea tree oil in three different concentrations (10%, 15%, and 20%).*

Results: *the result showed a significant difference between control and experimental groups in the transverse strength and hardness tests while there was no significant difference between control and addition groups in impact strength test. The addition of tea tree oil (T.T.O) decreased the hardness in all different concentrations, and increased the transverse strength at concentration of 20%.*

Conclusion: *The addition of 20% tea tree oil to acrylic resin decreased its hardness, increased the transverse strength, and showed no significant difference in impact strength.*

Keywords: Tea tree oil, acrylic resin.polymethylmethacrylate.

Introduction

Poly (methyl methacrylate) is the most popular material used for the construction of denture. Its low cost, ease of manipulation and simple application have made PMMA a preferred base material; however this material is still far from ideal and because of its relatively low impact and transverse strength; several attempts have been made to improve the mechanical properties of acrylic resin[1]. Tea tree oil is the essential oil that can be obtained from its leaves by steam distillation from the Australian native plant, *Melaleuca alternifolia*. Tea tree oil is a mixture of various components, mainly monoterpene and sesquiterpene hydrocarbons and their alcohols. Numerous studies have demonstrated the capacity of tea tree oil as an antiseptic, antibacterial [2, 3, 4], anti-inflammatory and antifungal especially anticandidal properties [5, 6, 7].

The main benefits of natural medicinal plant extracts as antimicrobial agents include enhanced safety and stability without any side effects, which lack with both organic and inorganic antimicrobial agents. In the field of dentistry tea tree oil have been added to heat cure acrylic and soft liner and shown anticandidal effect which consider a new therapeutic approach towards denture stomatitis [8, 9, 10]. In spite of the beneficial antifungal effect of adding tea tree oil to polymer, the surface properties of PMMA denture base material after such addition have not been investigated. This study is under taken to investigate the effect of tea tree oil on some mechanical properties of heat cured acrylic resin.

Materials and procedures

1. Specimen's preparation

A. Transverse strength and surface hardness test; the plastic patterns (fig.1) were prepared with dimensions of (65mm× 10mm× 2.5mm length, width, thickness respectively) according to ADA No.12, 1999[11]. Ten specimen for control and thirty specimen for experimental were constructed for transverse strength and surface hardness test.

B. Impact strength test: the patterns (fig.1) were prepared with dimensions of 80×10×4 mm (length, width, and thickness respectively) according to ISO 179[12]. Ten specimen for control and thirty specimen for experimental were constructed for impact strength test.

2. Mold preparation

For the preparation of the stone mold, the prepared plastic patterns (for transverse strength and impact strength) were coated with separating medium .The lower portion of the metal flask was filled with dental stone. The plastic patterns were inserted to approximately one half on their depth; the upper half of the flask was filled with stone.

3. Specimens fabrication

Control group specimens (20 samples) were prepared from heat cure acrylic resin (super acryl, czech) with 44gm±0.2/20ml (powder/liquid) ratio according to manufacturer's instructions. While the experiment groups (60 specimens) were prepared from the same acrylic resin with incorporation of 100% pure T.T.O. (MASON, USA) of different concentrations (10%, 15%, 20%) by volume of monomer. The Curing process was carried out according to the manufacturer’s instructions.

Mechanical and physical tests:

A. Impact strength test: Specimens were construced,stored in distilled water at 37 °C for 48 hrs before being tested[11]. The impact strength test was performed with charpy impact testing device. The charpy impacted strength of un notched specimens was calculated by the following formula:

Impact strength= E/B.D x 10^3 [13]

E: is the absorbed energy for fracture in joules.

B: is the width of the samples in mm.

D: is the thickness of the samples in mm.

The specimen was supported horizontally and struck by free, swinging pendulum of 5 jouls, the scale reading give the impact energy in joules.

B. Transverse strength test: All the specimens were collected and stored in distilled water at 37°C for (48) hours to stimulate oral conditions (2). Test was performed using universal Instron testing machine CZL203. Each specimen was positioned horizontally on the bending fixture (Fig.2) which consists of two parallel supports that are (50) mm apart and the load was applied with a cross head speed of 1mm/min by a rod placed centrally between the supports making deflection until fracture occurs (Fig.3). The transverse bend strength was calculated using the following equation.

Transverse strength = $3PL/2bd^2$ [14]

P: is the peak load

L: is the span length (50mm)

b: is the sample width

d: is the sample thickness.

C. Surface hardness test: Test was performed using durometer hardness tester (TH 210, CHINA) (shore D hardness) as shown in fig.4.The usual method was to press down firmly and quickly on the indenter and to record the maximum reading. Three measurements were recorded on different areas of each specimen and an average of these three readings was recorded.

Results

Impact strength test:

The descriptive statistics data of the impact strength were shown in table (1).The mean value of experimental groups of three different concentrations of T.T.O (10%, 15%, and 20%) as compared to control group showed no difference between them and approximately the same. Table (2) shows analysis of variance (ANOVA) test. Anon significance difference between control and treated group was noticed ($p>0.05$).

Hardness test:

Table (3) showed descriptive data of tested groups .The mean of control group is higher than experimental (T.T.O) groups. The concentration 20% of T.T.O showed lower hardness than other concentrations (10% and 15%). One way analysis of variance (ANOVA) for hardness test showed in table (4), there was a highly significant difference among the groups (P value 0.000). So Tukey HSD of multiple comparisons among studied groups was conducted for hardness test as shown in table (5).

A highly significance difference between control and three different concentrations treated T.T.O treated groups ($P= 0.000$).

There was none significance difference between 10% and 15%experimental groups ($P>0.05$).

There was significance difference between 15% and 20%experimental groups ($P<0.05$).

Transverse strength test

Table (6) showed Mean, SD, SE, range of transverse strength results.as shown in table, the mean value of transverse strength test of 20% of T.T.O is highly significance than other concentrations(10% and15%).ANOVA test of transverse strength in table(7) shows a highly significance difference between control and experimental groups(P=0.000). So Tukey HSD of multiple comparisons between studied groups was done as displayed in table (8). As shown in table 8, there was none significance difference between 10%and 15% concentrations of tea tree oil and the mean of these concentrations was lower than control group ,while the transverse strength at 20% of addition of T.T.O increase significantly as compared with other groups .

Discussions

Acrylic resin is one of the most frequently used as denture base materials. However, it has several disadvantages as poor mechanical properties. Several attempts have been made to strengthen acrylic resin materials with either chemical modification with grafted co-polymers and stronger cross linkage or by the use of various reinforcing materials as inclusion of fibers, nanoparticles [15, 16]**.** This study have attempt to modify the mechanical properties of heat cured acrylic by addition of tee tree oil, which has wide range of applications in many felids such as pharmaceuticals, cosmetics and dentistry .T.T.O is composed of terpene hydrocarbons, mainly monoterpenes, sesquiterpenes and their associated alcohols. Terpenes are volatile, aromatic hydrocarbons and may be considered as polymers of isoprene which has the formula C5H8 [17]·It has many therapeutic properties but of interest are well described anti-bacterial capabilities [3]**.** T.T.O is bactericidal against organisms commonly implicated in medical implant infections such as S.aures and staphylococcus **[**18**]**. The hardness test has been considered a simple and useful method to determine the mechanical properties of polymer-based materials

due to its high sensitivity to the amount of monomer in dental polymers [19]. Hardness is important property as it is important in preventing abrasion and wearing of the PMMA denture base [20] and determines its flexibility. The results of this study revealed that as concentration of T.T.O increase, the hardness of acrylic resin decrease. The possible reason for such an effect is due to that oil will coat polymer particles and this coating will decrease the amount of conversion of monomer to polymer resulting in a large amount of residual monomer. The latter adversely affects the mechanical properties via a plasticizing effect [21]. Also another possible reason for decrease the hardness is the flexibility of samples increase significantly at concentration of 20% which lead to decrease the hardness. These results disagree with Al-Nema LM[22] that may be due to the type of essential oil used in the study or the difference in oil concentration applied.The results revealed that the impact strength nearly the same after the addition of tea tree oil at all concentrations and this may due to the concentration of added oil which act as elastomer to PMMA and this agree with Fernanda et al[23] who stated that the addition of elastomer in smaller proportions (10% and 20%),the improvement in the impact strength was not evident.

The transverse (flexural) strength is a combination of compressive, tensile and shears strength, all of which directly reflect the stiffness and resistance of material to fracture. The study also was designated to compare the transverse strength of heat cured acrylic resin (control) and additive groups of tea tree oil in three different concentrations (10%, 15%, 20%). The results showed that 20% of T.T.O group has higher transverse strength than control group and other two concentrations (10%, 15%) which may explained that the T.T.O may act as elastomeric to PMMA and this agree with Hatim et al 2010 [24] which showed the addition of natural oils (thyme and nigella oil) to heat cured acrylic resin increase its transverse strength. Another possible reason for such an effect is that the maximum saturation of the matrix formation between PMMA and oil occurred at concentrations of 20%.

Conclusion

Within the limitations of this study, it could be concluded that: The adding of tea tree oil in concentration of 20% to heat cured acrylic resin significantly decreases the latter's hardness and increase its transverse strength. While T.T.O has no effect on the impact strength of PMMA at all concentrations.

References

[1] Meng TR, Latta MA., "Physical properties of four acrylic denture base resins", J. Contemp. Dent. Pract. 6: 93-100, 2005.

[2] Carson CF, Riley TV., "Antimicrobial activity of essential oil of Melaleuca alternifolia. Lett". Appl. Microbiol. 16:49-55,1993.

[3] Carson CF, Mee BJ, Riley TV. "Mechanism of action of Melaleuca alternifolia (tea tree) oil on Staphylococcus aureus determined by time-kill, lysis, leakage, and salt tolerance assays and electron microscopy". Antimicrobial Agents Chemother. 48:1914-1920, 2002.

[4] Mondello F, De Bernardis F, Girolamo A, Salvatore G, Cassone A. "In vitro and in vivo activity of tea tree oil against azolesusceptible and resistant human pathogenic yeasts". J. Antimicrob. Chemother. 51:1223-1229, 2003.

[5] Hammer KA, Carson CF, Riley TV. "In vitro activity of essential oils, in particular Melaleuca alternifolia (tea tree) oil and tea tree products, against Candida spp". J. Antimicrob. Chemother. 42:591-595,1998.

[6] Hammer KA, Carson CF, Riley TV. "Melaleuca alternifolia (tea tree) oil inhibits germ tube formation by Candida albicans". Med.Mycol. 38:355-562, 2000.

[7] Noumi E, Snoussi M, Bakhrouf A. "In vitro effect of Melaleuca alternifolia and Eucalyptus globulus essential oils on mycelial formation by oral Candida albicans strains". Afr. J. Microbiol. Res. 4(12):1332-1336, 2010b.

[8] Al-Mashhadane FAM. "Tea tree oil: A new antifungal agents against candida albicans cells on heat cured acrylic resin denture

base material. An invitro study".Al – Rafiadain Dent J.; 7:54-7s, 2007.

[9] Noumi Emira,Snoussi Mejdi and Mahjoub Aouni. "In vitro activity of Melaleuca alternifolia (Tea tree) and Eucalyptus globulus essential oils on oral Candida biofilm formation on polymethylmethacrylate": journal of medical plant and research.7 (20):1461-1466, 2013.

[10] Koteswara Rao Pachava, Laks hmi Kavitha Nadendl a, Leela Subhashini Choudary All uri, Huma Tahseen, Navya poojitha Sajjapunica. "Invitro Antifungal Evaluation of Denture Soft Liner Incorporated with Tea Tree Oil: A New Therapeutic Approach Towards Denture Stomatitis Journal of Clinical and Diagnostic Research". 9(6):62-64, 2015.

[11] American dental association specification No. 12 for denture base polymer guide to dental materials and devices. 7th ed. Chicago Illinois, 1999.

[12] ISO 179-1: Plastics -- Determination of Charpy impact properties -- Part 1: Non-instrumented impact test, 2000.

[13] Anusavice KJ. Philips Science Of Dental Material. 11th ed. Middle East and African edition. p. 143-166,721-756; 2008.

[14] American Dental Association, Specification No.12, (2000). Chicago IL: ANSI/ADA.

[15] Uzun G, Hersek N, Tincer T. "Effect of five woven fiber reinforcements on the impact and transverse strength of a denture base resin". J Prosthet Dent; 8: 616-20, 1999.

[16] Jordan J, Jacob KL, Tannenbaum R, Shart MA, Jasiuk I." Experimental trends in polymer Nano composites-A review". Mater Sci Eng 393(1): 1-11, 2005.

[17] Sharp, D. W. A., Ed. The Penguin Dictionary Of Chemistry. Penguin Books Ltd., Middlesex, United Kingdom;1983..

[18] Cox,S.D.,Mann,C.M.,Markham,L.J.,Bell,H.C.,Kustafson,J.E .,Warmington,J.R.&Wylie,S.G." The mode of antimicrobial action of essential oil of melaleuca lternifolia".Journal of applied microbiology; 88,170-175, 2000.

[19] Azevedo, A., Machado, A. L., Vergani, C. E., Giampaolo, E. T. & Pavarina, A. C. "Hardness of denture base and hard chair-

side reline acrylic resins". Journal of Applied Oral Science, 13, 291-295,2005

[20] Consani, R. L. X., Folli, B. L., Nogueira, M. C.,Correr, A. B. & Mesquita, M. F.." Effect of Polymerization Cycles on Gloss, Roughness, Hardness and Impact Strength of Acrylic Resins". Brazilian dental journal, 27, 176-180, 2016.

[21] Faltermeier, A., Rosentritt, M. & Müssig, D. "Acrylic removable appliances: comparative evaluation of different post polymerization methods". American Journal of Orthodontics and Dentofacial Orthopedics, 131, 301. E16-301. e22, 2007.

[22] Al-Nema LM. Al-Irhayim RN. Khuder H. "Evaluation of Addition of Plant Fixed Oil Extracts (Ginger, Maramia, Eucalyptus) on Some Properties of Heat Cured Denture Base Material". Al–Rafidain Dent J.; 14(1): 132-138, 2014.

[23] Fernanda De Carvalho Panzeri Pires-De-Souza, Heitor Panzeri, Marcelo Aparecido Vieira, Lucas Da Fonseca Roberti Garcia ,Simonides Consani" impact and fracture resistance of an experimental acrylic polymer with elastomer in different proportions". Materials research J.; 12(4):1516-1439, 2009.

[24] Hatim NA, Taqa AA, Abbas W, Shuker AM."The effect of thyme and nigella oil on some properties of acrylic resin denture base". AlRafidain DentJ.; 10(2):205-213, 2010.

Fig (1): plastic patterns

Fig (2): Specimen under stress in instron testing machine

Fig (3): Transverse specimens after testing

Fig(4):Durometer hardness tester

Table (1): Descriptive Statistics data of impact strength test (Kj/m^2)

	Control	T.T.O (10%)	T.T.O (15%)	T.T.O (20%)
N	10	10	10	10
Mean	5.16	4.77	5.93	5.69
SE	.070	.256	.395	.543
SD	.220	.811	1.248	1.716
Minimum	5	4	5	4
Maximum	6	6	7	9

Table (2): ANOVA test of impact strength test

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.250	3	2.750	2.113	.116
Within Groups	46.856	36	1.302		
Total	55.106	39			

Table (3): Descriptive Statistics data of hardness test

	Control	T.T.O (10%)	T.T.O (15%)	T.T.O (20%)
N	5	5	5	5
Mean	81.10	73.60	72.06	69.88
SE	.490	.777	.098	.420
SD	1.095	1.736	.219	.939
Minimum	80	72	72	69
Maximum	82	75	72	71

Table (4): ANOVA test of hardness test

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	356.028	3	118.676	92.265	.000
Within Groups	20.580	16	1.286		
Total	376.608	19			

Table (5) Tukey HSD of multiple comparisons for hardness test between studied groups

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1control (0%)	2(10%)	7.500*	.717	.000	5.45	9.55
	3(15%)	9.040*	.717	.000	6.99	11.09
	4(20%)	11.220*	.717	.000	9.17	13.27
2	1	-7.500-*	.717	.000	-9.55-	-5.45-
	3	1.540	.717	.181	-.51-	3.59
	4	3.720*	.717	.000	1.67	5.77
3	1	-9.040-*	.717	.000	-11.09-	-6.99-
	2	-1.540-	.717	.181	-3.59-	.51
	4	2.180*	.717	.035	.13	4.23
4	1	-11.220-*	.717	.000	-13.27-	-9.17-
	2	-3.720-*	.717	.000	-5.77-	-1.67-
	3	-2.180-*	.717	.035	-4.23-	-.13-

*. The mean difference is significant at the 0.05 level.

Table (6): Descriptive Statistics of transverse strength N/mm^2

	Control	T.T.O (10%)	T.T.O (15%)	T.T.O (20%)
N	10	10	10	10
Mean	92.8334	63.3610	53.7370	140.2800
SE	4.41539	2.41727	.56878	13.57525
SD.	13.96268	7.64409	1.79864	42.92870
Minimum	77.05	42.73	50.54	101.58
Maximum	106.15	68.78	55.76	190.02

Table (7): ANOVA test of transverse strength N/mm^2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	45367.939	3	15122.646	28.812	.000
Within groups	18895.472	36	524.874		
Total	64263.411	39			

Table (8):Tukey HSD of multiple comparisons for transverse strength test between studied groups

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1control (0%)	2(10%)	29.472*	10.246	.033	1.88	57.07
	3(15%)	39.096*	10.246	.003	11.50	66.69
	4(20%)	-47.447-*	10.246	.000	-75.04-	-19.85-
2	1	-29.472-*	10.246	.033	-57.07-	-1.88-
	3	9.624	10.246	.784	-17.97-	37.22
	4	-76.919-*	10.246	.000	-104.51-	-49.32-
3	1	-39.096-*	10.246	.003	-66.69-	-11.50-
	2	-9.624-	10.246	.784	-37.22-	17.97
	4	-86.543-*	10.246	.000	-114.14-	-58.95-
4	1	47.447*	10.246	.000	19.85	75.04
	2	76.919*	10.246	.000	49.32	104.51
	3	86.543*	10.246	.000	58.95	114.14

*. The mean difference is significant at the 0.05 level.

تقييم اضافة زيت شجرة الشاي على بعض الخواص الميكانيكية للراتنج الاكريلي الحراري

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المستخلص

الاهداف: تهدف هذه الدراسة الى تقييم تأثير زيت شجرة الشاي على قوة الانثناء المتبقي وعلى صلادة مادة الراتنج الاكريلي الحراري ومقاومة الصدمة.

المواد وطرائق العمل: تم تحضير(80)، عينة عشرين عينة تم تحضيرها بدون إضافات (نماذج قياسية) و(60) عينة تم تحضيرها مع إضافة زيت شجرة الشاي في ثلاثه تراكيز مختلفة (10و15و20)بالمائة لتقييم قوة الانثناء، والصلادة ومقاومة الصدمة.

النتائج: أظهرت النتائج بان هناك فروقات واختلافات معنوية بين المجاميع القياسية والمجاميع المضاف إليها الزيت في فحص الصلادة وفحص قوة الانثناء وعدم وجود فروقات معنوية بين المجاميع القياسية والمجاميع في مقاومة الصدمة. اضافة زيت شجرة الشاي قلل من الصلادة في جميع تراكيزه وزاد من قوة الانثناء بتركيز 20%.

الاستنتاجات: نستنتج من هذه الدراسة ان إضافة زيت شجرة الشاي ب تركيز 20% للراتنج الاكريلي زاد من قوة الانثناء لتلك المادة وقلل من الصلادة ولم يكن هناك اختلاف معنوي في مقاومة الصدمة.

الكلمات الرئيسية: زيت شجرة الشاي, الراتنج الاكريلي, بولي مثيل ميثاكريلات