Evaluation of the effect of sodium fluoride addition on some mechanical properties of heat cure acrylic denture base materials

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ABSTRACT

Background: The geriatric patients wearing removable partial dentures are increasing in proportion. At the same time, the root caries prevalence accompanied by gingival recession is increasing. A variety of vehicles can deliver fluoride into the oral cavity, including fluoride mouth-rinse, fluoride dentifrice, topical fluoride, and fluoride-releasing restorative materials, all of which effectively prevent root caries and suppress recurrent caries. This study aimed to evaluate the effect of sodium fluoride addition on some mechanical properties of heat cure acrylic denture base material.

Material and method: A total of 90 samples were prepared in this study, then divided into three main groups according to the type of test used (hardness, tensile and transverse strength tests). Each main group was subdivided into three main subdivisions according to percentage of sodium fluoride addition to the heat cure acrylic denture base material (control no addition, 2%NaF ,and 5%NaF sodium fluoride groups)

Results: The sodium fluoride addition to acrylic denture base materials showed slight but non significant increase in transverse strength and tensile strength tests while the results showed significant and highly significant differences for 2%NaF and for 5%NaF shore D hardness groups respectively.

Conclusions: Addition of 2% and 5% sodium fluoride to heat cure acrylic resin is considered advantageous as the mechanical properties of resin denture base materials in respect to hardness tensile and transverse strength were not adversely affected.

Key words: Sodium fluoride, heat cure acrylic. (J Bagh Coll Dentistry 2014; 26(4):9-13).

الخلاصة

خلفيّة : نسبة المرضى المسنين الذين يرتدون اطقم أسنان متحركة في ازدياد مستمر. في الوقت نفسه, نسبة تسوس الجذر المرافقة بفترة ركود لثويّة في ازدياد ايضاً. عدة مصادر استخدمت لغرض نقل مادة الفلورايد الى تجويف الفم, بما في ذلك المضمضة الفموية الحاوية على الفلوريد, معجون الأسنان ,الفلوريد المضاف لاسطح الاسنان, و حشوات الاسنان الباعثة للفلورايد, كل من هذه المصادر يمنع بشكل فعّال تسوس جذر الاسنان ويوقف معاودة التسوس. هذه الدراسة تهدف إلى تقييم تأثير إضافة صوديوم فلوريد على بعض الخواص الميكانيكية والفيزيائية لاطقم الاسنان المصنوعة من الراتنج الاكريلي الحراري

طرق ومواد: أعدّت مجموعة من 90 عينة في هذا الدراسة, بعد ذلك قسمت الى ثلاثة مجاميع رئيسيّة وفقا لنوع الإختبار المستعمل (الصلادة ,الشد و الشد العرضي). قسمت كلّ مجموعة رئيسيّة الى ثلاث مجاميع جزئية وفقا للنسبة المئويّة من مادة صوديوم فلوريد المضافة إلى مادة الراتنج الاكريلي الحراري (ما من إضافة, 2بالمئة, و 5 بالمئة صوديوم فلوريد)

النتائج :أبدت نتائج إضافة الصوديوم فلوريد إلى مادة الراتنج الاكريلي الحراري فروقات غير هامة لإختبارات الشد والشد العرضي بينما كانت الفروقات هامة وهامّة جدّا لاختبار الصلادة وللمجاميع 2بالمئة ول 5 بالمئة على التّوالي .

استنتاج :اعتبرت إضافة من 2% و5% صوديوم فلوريد إلى مادة الراتنج الاكريلي الحراري اضافة مفيدة بما أنّ الخواص المدروسة (الصلادة ,الشد و الشد العرضي) لم تتأثر بشكل سلبي.

INTRODUCTION

Polymethylmethacrylate (PMMA) is a derivative of acrylic acid, referred to us as acrylic resin, introduced for use in dentistry since 1930 and it became the most reliable material for denture construction [(1)].

The geriatric patients wearing removable partial dentures were increased in proportion [(2)]. At the same time, the root caries prevalence accompanied by gingival recession is increasing [(3,4)]. The more likely to be affected by caries and periodontal disease are Abutment teeth more than any other teeth [(5)]. Because abutment teeth anchoring removable partial dentures tend to be inadequately cleaned, preventing root caries in these teeth is crucial. Fluoride is the treatment choice to prevent caries development. Fluoride penetration in the enamel occurs through the replacement of relatively weak hydroxyl ions in the enamel mineral structure by more active fluoride ions thereby improving the chemical stability of enamel structure making it more resistant to acids [(6)].

A variety of vehicles can deliver fluoride into the oral cavity, including fluoride mouth-rinse, fluoride dentifrice, topical fluoride, and fluoride-releasing restorative materials, all of which effectively prevent root caries and suppress recurrent caries [(7-11)].

Previous studies of resin composite containing a filler of surface pre-reacted glass-ionomer (S-PRG) has the valuable property of being fluoride rechargeable, have revealed some aspects of its clinical value [(12-15)]. Other study examined an experimental heat cure polymethyl methacrylate (PMMA) resin containing S-PRG filler in terms of both the initial fluoride release and the fluoride release after recharging with fluoride solution and concluded that increase in fluoride concentration led to more releasing of fluoride but with more deterioration of mechanical properties [(16)].

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The purpose of this study was to examine some mechanical properties of an experimental heat cure polymethyl methacrylate (PMMA) resin containing sodium fluoride, suggesting that the development of a fluoridated denture base resin with proper mechanical properties will make a significant contribution to reduce root caries in the abutment teeth of people who wear partial dentures.

MATERIALS AND METHODS

Materials

The materials that used in this research were summarized in table 1.

Table 1. Some of the materials used in the study

	Material	Manufacturer
1	Heat-cured resin for denture.	Powder and liquid. Vertex, Holland
2	Sodium fluoride powder	Germany

Samples grouping

Total of 90 samples were prepared in this study, then divided into three main groups according to the type of test used (transverse test, tensile test and hardness test groups) Each main group was subdivided into three main subdivisions (10 samples each) according to the percentage of sodium fluoride (NaF) addition to the heat cure acrylic denture base material (controlled group (no addition), 2% NaF and 5% NaF sodium fluoride groups).

Preparation of specimens for transverse strength, tensile strength and hardness tests

Metal patterns were constructed by cutting the stainless steel plates with the dimensions of (65mm x 10mm x 2.5mm) length, width, thickness respectively for transverse strength test [9].While for tensile test dumble shaped metal pattern were constructed with the dimension of (75mm x 12.5mm x 2.5mm) length, width, thickness respectively [17] as shown in Figure 1.

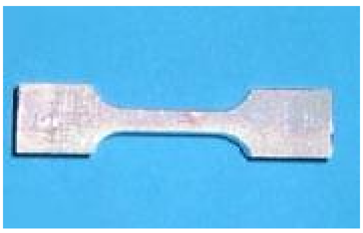

Figure 1: Metal pattern for tensile strength test

Mould preparation

The conventional flasking technique for complete dentures was followed in preparation of the mould.

Proportioning and mixing of the acrylic with NaF

White Sodium Fluoride powder was added to PMMA powder at 2% and 5% by weight and dispersed with a mixing machine for 15 minutes. The resin polymers containing well dispersed NaF were mixed with monomer. The proportion of mixing of acrylic resin was (12gm: 6ml) P/L ratio.

All materials were mixed according to the manufacturer's instructions and as showed in table (2).

Table 2: Percentages and amounts of polymer, monomer and sodium fluoride powder

NaF %	Amount of NaF	Amount of polymer	Amount of monomer
O%	0g	12g	6 ml
2%	0.240g	11.760g	6 ml
5%	0.600g	11.400g	6 ml

Packing and curing of heat cure resin

The packing process was performed while the acrylic was in dough stage. Curing was carried out by placing the clamped flask in a water bath and processed by short curing cycle 90min at 74C° then temperature was increased to the boiling point 100°C for 30 minutes.

Finishing, polishing and conditioning

All the specimens were finished and polished by the same investigator as follows: Silicon carbide grit papers starting with grade 120, 240, 320, 400 and 500 were used in sequence during finishing procedure with continuous water cooling. The accuracy of the dimensions was verified with a vernier at three locations of the specimen. Polishing was accomplished by using Tripoli compound with a dry rag wheel in a lathe-polishing machine. Water was used during polishing to avoid excessive heat, which may lead to distortion of the specimens. All the tested specimens were conditioned in distilled water at 37C° for 48 hours before they were tested [18].

Mechanical tests utilized to examine properties

<u>1- Transverse strength test</u>

The transverse strength of specimens was measured in air by three points bending on an (Micro computer controlled electronic universal testing machine, model WDW 50 E class 1). The device was applied with a central loading plunger and two supports with polished cylindrical surface 3.2mm in diameter placed 50mm apart. The test was carried out with a constant cross head speed of 2mm/min, the load was measured by a compression load cell of maximum capacity of 50KN.

The test specimens were held at each end of the two supports, and the loading plunger placed midway between the supports. The specimens were deflected until fracture occurred [19].

Figure 2: Specimen under transverse strength test

2-Surface hardness test

Surface hardness was determined using durometer hardness tester from type shore D, (hardness tester-TH 210, time group Inc. Italy) which is suitable for acrylic resin material. The instrument consists of a cylinder 1.6mm in diameter that tapers into a blunt-pointed indenter 0.8mm in diameter. The indenter is attached to a digital scale that is graduated from 0 to 100 units; measurements were taken directly from the digital scale reading. Ten measurements were done on different areas of each specimen (the same selected area of each specimen), and an average of ten readings was calculated [20].

3- Tensile strength test

The specimens were tested for tensile bond strength using (Micro computer controlled electronic universal testing machine, model WDW 50 E class 1) the specimens subjected to tensile load with cross head speed (2mm /min) using load cell capacity (50kN)[21]. Tensile strength was calculated according to the following formula:- Tensile bond strength= F(N)/A(mm^2) (ASTM. Specification D-638m, 1986).

RESULTS

Mean values, standard deviation (SD), maximum (Max) and minimum (Min) values of the tests result are presented in Tables (3, 4 and 5).

One-way ANOVA between groups of the same test and LSD test for hardness test are presented in tables (6 and 7).

Table 3: Descriptive data of transverse strength (N/mm^2)

Studied groups	Mean	S.D.	Min.	Max.
Control	70.24	2.01	66.53	73.24
2%NaF	71.14	1.58	68.49	73.45
5%NaF	72.72	2.80	68.57	76.89

Table 4: Descriptive data of surface hardness test

Studied groups	Mean	S.D.	Min.	Max.
Control	85.38	1.28	83.5	87.2
2%NaF	86.84	1.27	85.1	89.1
5%NaF	87.67	1.04	86.2	89.1

Table 5: Descriptive data of tensile strength test (N/mm^2)

Studied groups	Mean	S.D.	Min.	Max.
Control	42.41	2.53	38.5	46.4
2%NaF	43.66	3.12	39.1	47.5
5%NaF	44.93	2.75	40.2	48.7

Table 6: One-way ANOVA between groups of the same test

Variables	Groups	Groups' difference (d.f.= 29)	
		F-test	p-value
Hardness	Control	9.286	0.001 (HS)
	2%NaF		
	5%NaF		
Transverse Strength (N/mm^2)	Control	3.288	0.053 (NS)
	2%NaF		
	5%NaF		
Tensile Strength (N/mm^2)	Control	2.010	0.153 (NS)
	2%NaF		
	5%NaF		

Table 7: Least significant difference (LSD) test between hardness test groups

Variable	Groups		Mean Difference	p-value
Hardness	Control	2%	-1.46	0.011 (S)
		5%	-2.29	0.000 (HS)
	2%	5%	-0.83	0.134 (NS)

In general, the results of the transverse strength, surface hardness and tensile strength tests for heat-cured acrylic (H.C.A.) specimens showed that control group specimens had the lowest mean values while 5%NaF group specimens had the highest mean values. One-way (ANOVA) test revealed a non significant (NS) difference (P>0.05) between the different groups of tensile and of transverse tests while one-way (ANOVA) showed a highly significant (HS) difference (P<0.01) between the different groups of hardness test.

The LSD test between hardness groups showed a significant difference between control and 2%NaF groups and a highly significant difference between control and 5%NaF groups while a non significant difference appeared between 2%NaF and 5%NaF.

DISCUSSION

Previous study suggested that the percentage of fluoride addition to acrylic denture base resin preferred to be less than 10% to maintain proper mechanical properties of acrylic resin [16], thus the experimental denture base resins used in the present study, containing 2 and 5 wt % of NaF.

In the present study, the results revealed that a non significant difference between control, 2%NaF and 5%NaF groups for tensile and transverse test groups despite of slight increase in mean values with increase of NaF % this may be due to the small amounts of NaF were added to the acrylic resin which did not affect the chain arrangement of the polymer and thus did not affect the tensile and transverse strength. There might be no reaction between NaF and polymer beads which should be evaluated in other studies.

The results of hardness test showed that a significant and a highly significant difference between (control and 2% groups) and (control and 5%NaF groups) respectively, that may be due to the increase of crystals per unit area as a result of increase in NaF% in acrylic resin as NaF crystals may be harder than acrylic polymer so more resistance to indenter penetration and more hardness values obtained. So addition of 2% and 5% sodium fluoride to heat cure acrylic resin is considered advantageous as the mechanical properties of resin denture base materials in respect to hardness tensile and transverse strength were not adversely affected.

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