Influence of Different Concentrations of Fluoride on The Porosity of Acrylic Resin Denture Base Materials


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ABSTRACT

Background: When reviewing the topic of materials containing fluoride acrylic resin, we found differences in fluoride release in addition to the improvement of the physical properties of acrylic materials.

Aim: The aim of this study was to evaluate the effect of adding sodium fluoride (NaF) (in different concentrations to the monomer of acrylic resin) on the porosity of denture base materials and its effect with long-term water immersion (after 4 months immersion in deionized water).

Materials and methods: Eighty circle-shaped specimens measured 30 mm diameter and 3mm thickness were divided into two groups according to water immersion, 40 specimens before immersion and 40 specimens after water immersion for 4 months (the deionized water was changed every day).Each of these groups was subdivided into four groups according to the concentration of NaF. NaFpowder was added to the monomer of the acrylic in these contractions: 1% NaF,2% NaF,5% NaF,0% NaF (the control group without adding NaF),then mixed with polymer according to the manufacturer's instructions,then conventional flasking,packing procedure were followed.The porosity was tested with a light microscope.

Results and conclusion:The results showed that the addition of fluoride to acrylic resin materials increased the porosity of acrylic. All concentrations of NaF showed more porosity than the control group (with a highly significant difference $p<0.01$),but after immersion for 4 months ,the porosity decreased with a highly significant difference in comparison to the groups before immersion .Highly significant differences were found($p<0.01$) between the groups after and before immersion in all concentrations (1%,2%,5% NaF), but there was no significant difference ($p>0.05$) (after immersion) betweenthe control group and the 1%NaF group.

KEYWORDS

Fluoride, acrylic resin, porosity.

CITE THIS ARTCLE:

Rashid A. Influence of Different Concentrations of Fluoride on The Porosity of Acrylic Resin Denture Base Materials. *Iraqi Dent. J.* 2015; 37(2):56-61. http://www.iraqidentaljournal.com

تأثير تراكيز مختلفة من الفلورايد على مسامية مواد قاعدة طقم الاسنان المصنوعة من راتنج الاكريلك

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المستخلص

المقدمة:عند مراجعة مواضيع المواد المحتوية على الفلوريد(راتنج الاكريليك)نجد اختلافا في تحرير الفلورايدبالاضافة الى تحسن الخواص الفيزيائية لمادة الاكريليك.

الهدف من الدراسة: هدف الدراسة تقييم تأثير اضافه فلوريد الصوديوم (بتراكيز مختلفة الى سائل راتنج الاكريليك المونيمير) على مسامية مادة قاعدة طقم الاسنان، و تأثيره لمدى طويل بالغمر في الماء الايوني (بعد ٤ أشهرغمر في الماء الأيوني).

المواد وطريقة العمل: تمصنع ٨٠ عينة بشكل دائري على نمط معدني قياس قطره ٣٠ملم وسمكه٣ملم لأختبارالمسامية وتم تقسيمها الى مجموعتينبالنسبة الى الغمر بالماء الايوني ,٤٠عينة قبل الغمر و٤٠ عينة بعد الغمر لمدة اربعة اشهر (مع تغيير الماء الايوني المغمورة فيه يوميا)وقسمت هاتين المجموعتين ثانويا إلى أربعة مجموعات فرعية وفقا لتركيز ماده فلوريد الصوديوم ، أضيف مسحوق صوديوم الفلوريد لسائل الاكريليك بنسبة ١ ٪ ، ٢ ٪ ، ٥٪, ٠٪(مجموعة السيطرة عدم احتوائها على صوديوم الفلورايد), ثم خلط سائل الطقم المونيمير مع مسحوق الاكريلك (البوليمر)وفقا لتعليمات الصنع.استعملت الطريقة التقليدية لتصنيع الطقم.تم اختبار المسامية بواسطة المكروسكوب الضوئي.

النتائج والاستنتاجات : أظهرت النتائج أن إضافة الفلوريد إلى مادة راتنج الاكريليك تسببت في زيادة المسامية لمادة طقم الاسنان،وجميع تراكيز فلوريد الصوديوم اظهرت زيادة المسامية مقارنة مع مجموعة السيطرة مع وجود فروق ذات دلالة عالية ($p<0,01$), لكن بعد الغمر بالماء الايوني(لمدة اربعة اشهر) أظهرت النتائج نقصان مسامية الطقم مع وجود فروق ذات دلالة عالية($p<0,01$) مقارنة مع مجموعة قبل الغمر, هناك فروق ذات دلالة عالية ($p<0,01$) بين المجاميع قبل الغمر وبعده بجميع التراكيز ١٪ ،٢٪ ،٥٪ باستثناءبين مجموعة السيطرة ومجموعة ١٪فلوريد الصوديوم ٠بعد الغمر)فلا توجد فروق ذات دلالة($p<0,05$).

INTRODUCTION

Conventional denture cleaning methods cannot completely eliminate microorganisms from dentures. Specific materials when used in the manufacture of dentures can enhance the elimination of microorganisms to promote oral hygiene.The most widely used fluoride containing substances added to dental resin materials is sodium fluoride[1]. All denture base materials use polymethylmyethacrylate (PMMA) resin.The use of acrylic resin in prosthetic work is mainly due to its simple technique, less time consuming and less equipment required [2].The presence of porosity in the acrylic resin denture base is an undesirable feature of the acrylic resin after the curing process. After many years of using PMMA as a denture base material, porosity is apparently a complex phenomenon with multifactor origin[3]. Fluorinated resins present more stable properties compared with the conventional polymers[4, 5, 6]. Other interesting properties, which have expanded their use, have been their potential resistance to microbial adherence [7].A study showed that the incorporation

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of fluoride into acrylic resin did not alter porosity [8];still another study showed that acrylic was seen to be porous after the addition of fluoride[9]. The aim of our study was to study the influence of different concentrations of sodium fluoride on the porosity of acrylic resin materials and its effect after 4months immersion in deionized water.

MATERIALS AND METHODS

Mould preparation

Specimen preparation: Usinga circular metal pattern,80 specimens were from heat-cured acrylic denture base materials(Ivoclar Dental Material, Italy) as shown in figure(1). The disk diameter was 30 mm andthickness was 3 mm [10, 11, 12].

Figure (1) specimens of porosity

Concentration of NaF in acrylic samples

Sodium fluoride powder (BHD Chemicals Ltd Poole, England) was weighed withan electronic balance (AND. Co., Japan) and added to the monomer[8]according to the concentrations in this study:1%,2%,5%. For 1% concentration, 1gram of NaF powder was dissolved in 100 ml monomer,for2% concentration 2 grams, for 5% concentration 5 grams; then they were mixed with the monomer with a stirrer (Magnetic stirrer Janke and Kunkel, Germany).The suspension of monomer with NaF was immediately mixed with acrylic powder according to the manufacturer's instructions to reduce the possibility of particle aggregation and phase separation.

Distribution of the sample

The 80samples were prepared for the porosity test and divided into two groups according to water immersion. The first group contained 40 samples (before immersion in deionized water) and the second group contained40 samples (after immersion in deionized water for 4 months; the deionized water was changed every day). Each group(before and after immersion)was subdivided into four groups according to Naf concentration(10 samples for each concentration) :-1% concentration of Naf,2% concentration of NaF, 5% concentration of NaF and0% concentration of NaF. which is the control group (without NaF).

Proportioning and Mixing of the acrylic resin

The proportion for mixing of acrylic resin was (2.5/1 by weight) (P/L). The mixing and manipulation was according to the manufacturer's instructions. Table (1) shows the percentages and amounts of polymer, monomer, and Naf powder used in the study [13].

Table (1) Mixing ratio of acrylic resin

NaF Percentage	*Amount of NaF*	*Amount of polymer*	*Amount of monomer*
0%	0	100g	40ml
1%	1g	99g	40ml
2%	2g	98g	40ml
5%	5g	95g	40ml

METHODS

The conventional flasking, packing procedures were followed in the preparation of the specimens[14].

Polymerization

All specimens were polymerized by water bath (fast procedure) by placing the clamped flask in the water bath and processed by heating at 74 ˚C for 1,1/2 an hour and the temperature then was increased to the boiling point for half an hour according to (ADAS, No 12, 1999)[15].After completion and curing, the acrylic specimens were removed carefully from the stone mold. All the acrylic resin specimens were finished and polished according to the conventional procedure until a glossy surface was obtained. The final measurements were obtained using a micrometer and vernier.

Methods of evaluation

Before examination,the thickness of all specimens was reduced in both sides to be examined clearly under microscope. Grinding the specimen was done using carbide bur with continuous water-cooling, then the surfaces were smoothed using silicon carbide grit paper 240 followed by grade 400 and 600 until a very thin section (0.4- 0.5mm) was obtained. After that they were polished with a pumice and rag wheel, immersed in a solution of permanent black ink for 30 minutes, washed for 10 seconds, and dried with absorbed paper. A surface area of1cm^2 length and width (square shape) was limited in the center of each specimen and observed under40 X with a light microscope(Olympus, Japan). The number of pores per area was determined for each specimen and an average value was calculated for each [10, 11, 12].

RESULTS

Visual examination of the porosity of the specimens was not efficient in determining the degree of porosity in the tested specimens. Microscopically at a magnification power (40 x); voids of different sizes and locations were observed in all tested specimens.

Well-condensed matrix with little and small voids were seen in the tested specimens before immersion with deionized water,while in the specimens after immersion in deionized water, the voids were very small, spherical and distributed throughout the tested specimens.Small and scattered voids were observed in tested specimens without sodium fluoride(the control group).

Table(2) and Figure (2)show the mean values of porosity , SD, SE, Min, and Max value. The degree of porosity varied according to the ratio of sodium fluoride, which increased when the concentration of Naf was increased,and in all concentrations (1%,2%,5%NaF). The mean values were higher in the groups before immersion than in the groups after immersion. As shown in table (2), the maximum mean value of porosity of 5% NaF before immersion(18), while the minimum mean value of the control group before immersion was (6.3).

Table(2) Description of porosity test

	Control		*1% NaF*		*2% NaF*		*5% NaF*	
	before	*after*	*before*	*after*	*before*	*after*	*Before*	*after*
Mean	6.3	7.1	7.8	6.8	12	9.4	18	12.4
SD	0.483046	0.875595	1.229273	0.788811	1.885618	1.074968	1.490712	2.170509
SE	0.152863	0.277087	0.38901	0.249624	0.596715	0.34018	0.471744	0.68687
Min	6	6	6	6	10	8	16	10
Max	7	8	9	8	15	11	20	16

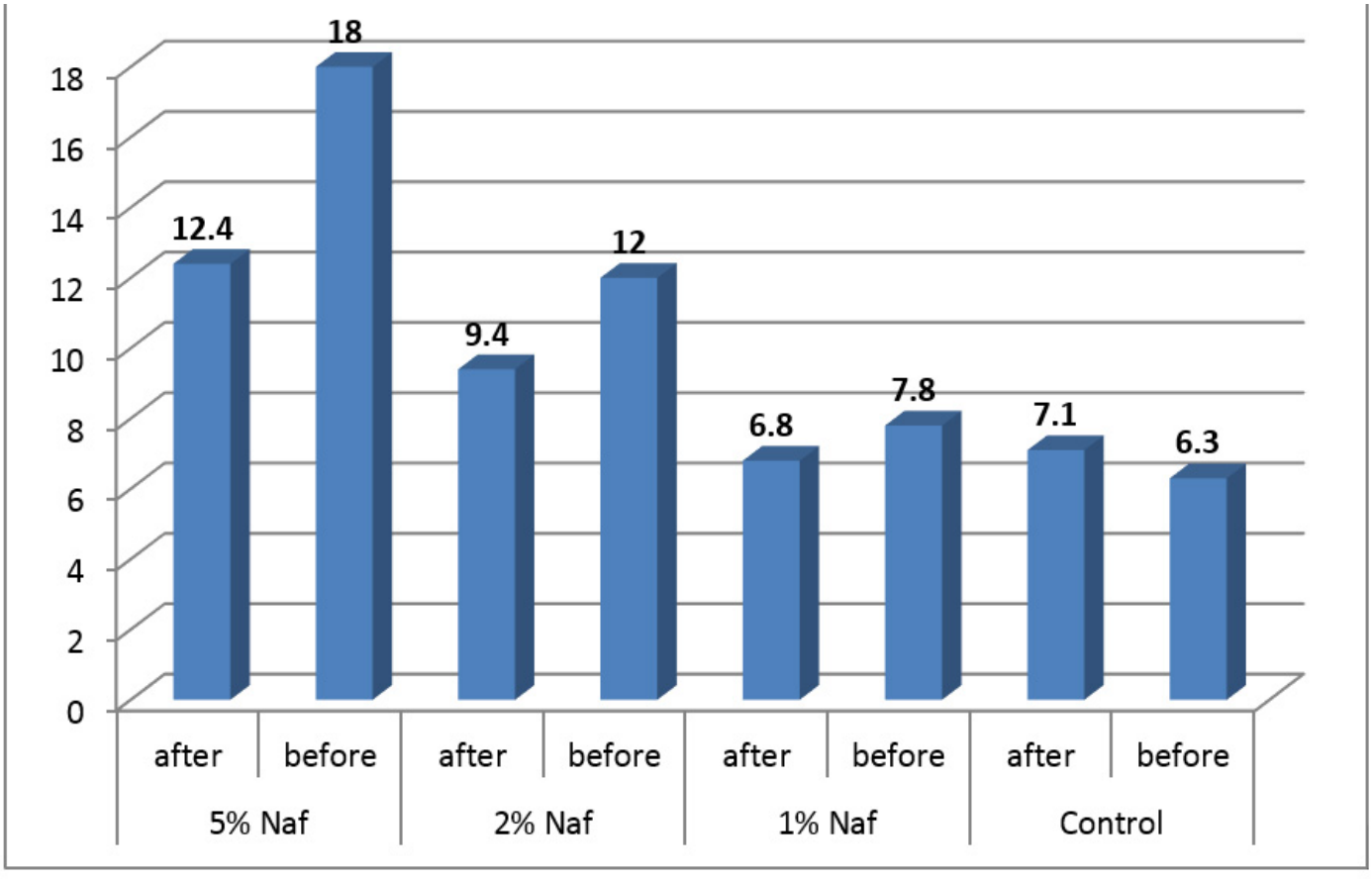

Figure (2):bar chartof the mean valuesof porosity test

Table(3) demonstrates the t-test results between all groups(control,1%,2%, 5%NaF) before and after

immersion.There were highly significant differences of porosity (p<0.01)between NaF groups (1%,2%,5%) before and after immersion,except for the control there was no significant difference (p>0.05).

Table (3):t-test before and after immersion

Control		1% NaF		2% NaF		5% NaF	
t-test	p-value	t-test	p-value	t-test	p-value	t-test	p-value
1.922	0.087	4.743	0.001	3.027	0.014	5.857	P<0.01

ANOVA test for porosity among the groups before immersion and groups after immersion are shown in Table (4).There were highly significant differences among them (p<0.01).

Table (4): ANOVA testof porosity test

	F-test	P-value	Sig
Before	145.928	P<0.01	HS
After	37.023	P<0.01	HS

LSD test results of the porosity among the groups are shown in table (5) , there were highly significant differences between all groups (control, 1%,2%,5%) before and after immersion (p<0.01), except between control and 1% NaF(after immersion) there were no significant differences (p>0.05).

LSD porosity test

		Mean difference	P-value	Sig
Before	**Control&1%NaF**	-1.500	0.019	HS
	Control&2%NaF	-5.700	P<0.01	HS
	Control&5%NaF	-11.700	P<0.01	HS
	1%NaF&2%NaF	-4.200	P<0.01	HS
	1%NaF&5%NaF	-10.200	P<0.01	HS
	2%NaF&5%NaF	-6.000	P<0.01	HS
After	**Control&1%NaF**	0.3000	0.621	NS
	Control&2%NaF	-2.300	0.001	HS
	Control&5%NaF	-5.300	P<0.01	HS
	1%Naf&2%NaF	-2.600	P<0.01	HS
	1%NaF&5%NaF	-5.600	P<0.01	HS
	2%NaF&5%NaF	-3.000	P<0.01	HS

Table (6) shows the person correlation of porosity. For the groups before immersion, there were positive relation between the control group and (1%Naf, and 5%Naf) , and between 1% Naf and 5%Naf ,after immersion also there were positive relation between 1%Naf with (2%Naf ,5%Naf) and control with 5%Naf and{ there were negative relation between control and 2%NaF , 2%NaF with (2%NaF5%NaF) before immersion} , and after immersion between the control and (1%NaF, 2%NaF) ,and between 2%NaF with 5%NaF .

Table (6)Person correlation of porosity

		Control	1%NaF	2%NaF	15%NaF
Before	Control	-	0.487	-0.244	0.463
	1%NaF	0.487	-	-0.767	0.606
	2%NaF	-0.244	-0.767	-	-0.076
	15&NaF	0.463	0.606	-0.076	-
After	Control	-	-0.290	-0.401	0.152
	1%NaF	-0.290	-	0.367	0.441
	2%NaF	-0.401	0.367	-	-0.648
	15&NaF	0.152	0.441	-0.648	-

DISCUSSION

Controlling oral hygiene is very important especially for dental caries the pathological factor for which is oral bacteria[16].Fluoride containing dental acrylic resin demonstrated superior effectiveness to promote proper denture hygiene[7] particularly for elderly persons requiring nursing care or who have a decreased ability to perform normal activities of daily living and children who wear acrylic appliance. Fluoride containing dental acrylic resin material can improve properties of acrylic resin[4, 5, 6].

Different concentrations of fluoride were used in the present study (1%,2%,5%) following previous studies[8, 9, 17] which studied different concentrations of NaF.Other high concentrations of NaF were also studied[9](10%, 20%),20% which represent the maximum concentration for NaF,because dough stage was not reached for 25% or more; therefore, concentrations higher than 20% were not viable, during polymerization; the monomer diffuses in the polymer and partially dissolves it. If the dissolution of the polymer beads does not occur, the dough stage might not be reached after mixing; in addition, benzoyl peroxide from the beads might not be available for initiating polymerization[18, 19].Therefore,the maximum concentration that enabled packing and curing was 20%.

Virtually all denture base materials use the conventional polymer/monomer dough molding process [19]. The polymer beads contain the initiator, benzoyl peroxide; thus, the incorporation of fluoride into the monomer component should be able to dissolve the polymer.

In this study, the porosity of acrylic denture base materials was evaluated after the addition ofdifferent concentrations of fluoride (1%, 2%,5%). The results showed higher porosity acrylic specimen with all concentrations of NaF. Porosity increased when the concentration of NaF was increased with highly significant differences compared with the control group,because NaF interfered in the polymerization. This would happen by the exposure of polymer beads that lead to an increase in the porosity [20]. The incorporation of fluoride into dental resins is an inherent incompatibility caused by a large difference in polarity between the ionic fluoride and the low-polarity dental resin. This incompatibility usually causes phase separation with the resin so fluoride releases within time.

The addition of fluorideto the acrylic resin reside in the intermolecular interaction.The presence of fluoride in methacreylic polymers results on different intermolecular distances.Fluoride acrylic usually has effect on the porosity more than conventional materials due to the decrease of cohesive energy that reduces the effect of polymer chain entanglement [7]. This result disagrees with the results of another study [8],which showedthat the incorporation of fluoride did not effect in the porosity of acrylic resin, but it is in agreement with another study [9], which showed that acrylic was seen to be porous after the addition of fluoride.

The microscopic observation of negligible voids in hot-cured acrylic resin might be due to the exothermic heat of reaction which increases the temperature of the resin dough above the boiling-point of monomer which tends to produce such type of porosity [21]; this finding is consistent with [2]and[22.]

During the immersion period for four months,high fluoride release was observed within the first two days, then decreased after day 2. Fluoride release become in small concentrations and its duration of release depends on the types of fluoride used[6], for example CaF2,fluoride releases up to six months,but for NaF the release continue to rise for four months[9]. Therefore, in this study the immersion period was 4 months following a previous result[9, 23]. After 4months of water immersion, porosity decreased with highly significant differences ($p<0.01$) compared with the groups before immersion.This may be due to fluoride release and its effect became negligible. This result disagrees with [9],which showed the acrylic surface was seen to be porous in during fluoride release process.

CONCLUSION

All concentrations of NaF showed more porosity than the control group (with a highly significant difference $p<0.01$),but after immersion for 4 months ,the porosity decreased with a highly significant difference in comparison to the groups before immersion .Highly significant differences were found($p<0.01$) between the groups after and before immersion in all concentrations (1%,2%,5% NaF), but there was no significant difference ($p>0.05$) (after immersion) between the control group and the 1%NaF group.

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