Effect of sodium fluoride addition as a disinfectant on some properties of alginate impression material

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ABSTRACT

Background: Impression materials, impression trays, and poured stone cast have been said to be the main source of cross infection between patients and dentists. However, it was observed that disinfection of the impression is not performed systematically in routine dental practice. Disinfection of alginates either by immersion or spray technique was found to cause dimensional inaccuracies, although with proper disinfection of alginates there were small dimensional changes. A variety of fluoride releasing products designed for topical use is currently available. Following their use, varied amount of fluoride is systemically absorbed depending on the fluoride concentration and the manner of its use. The objective of this study was to evaluate the effect of addition (0%, 0.25%,0.5%,1%, 2%, 3%, 4%) of (NaF) as a self-disinfection to alginate impression material powder and its effect on setting time, tear strength, dimensional change and accuracy of alginate impression materials.

Materials and methods: A total No. of (700) specimen were used in this study.These specimens were divided into (5) main groups according to the tests used. Each of the four main groups contain (70) specimen divided into 7 subgroups (ten specimens to be tested for each (7)concentrations which is composed of six percentages of NaFwith alginate powder (0.25%,0.5%,1%, 2%, 3%, 4%)and one for control (0% NaF) , while the fifth group (Microbiological test) contain 420 specimen were divided between *Streptococcus mutans* and *Candida albicans* as (120) specimen for each one that was subdivided into three subgroups (specimens taken before impression casting, specimensafter pouring of alginate with stone andspecimens of stone were taken from the casts) in which it contain the same subgroups of the other concentrationsof (NaF) to test its efficacy against (*Streptococcus mutans* and *Candida albicans*).

Results: Tear strength for all experimental impression materials was greater than those of the control products. There were no statistically significant differences between the dimensional change tests and also reproduction of detail test.With regard to setting time of the impressions, statisticallyreduction were seen between the control and experimental groups of alginate impression materials that contain (NaF). Self-disinfection of alginate impression material containing NaF showed a significant reduction in the count of cell forming unit of microorganisms immediately after impressions were made.

Conclusion: In cooperation of specific concentrations of (NaF) as a disinfectant in alginate dental impression produced a significant reduction of contamination, also they caused non-significant effect on dimensional stability, detail reproduction and significant increase in tear strength. Therefore it is recommended as step in preventing cross contamination.

Keywords: Alginate, NaF, *Candida Albicans*, *streptococcus mutans*. (J Bagh Coll Dentistry 2015; 27(1):70-76).

INTRODUCTION

Dental alginates were the first chemical-set elastic polymer impression materialto be used in dentistry [1]. Impression disinfection is an integral part to prevent cross infection between dentists, dental office staff, dental technicians and patients. It is well documented the dental impressions harbors harmful bacteria due to their contact with blood and saliva [2]. Some of this bacterium can survive outside oral fluids for long time. Dental cast obtained from these infected impressions can transmit pathogens to dental laboratory, exposing dental laboratory personnel for cross infection [3].

Selected disinfectant should not adversely affect the dimensional stability of the impression and physical properties of subsequent dental cast. The practice of impression cross infection control in dental practice is a cause of concern. [4,5]. Irreversible hydrocolloid materials are widely used for both diagnostic and definitive impression procedures.

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It has been reported that irreversible hydrocolloid impression carries two to five times more microorganisms than elastomers [6]. The entire dental staff is routinely exposed to numerous viral and bacterial pathogens that have the potential to cause serious illness. Contamination of dental impressions with varying amounts of blood, saliva and debris is a routine occurrence in the dental operatory. Therefore these impressions must be considered the potential to transmit the serious disease to all dental personnel who routinely handle them. A major concern is the problem of disinfecting dental impressions, particularly irreversible hydrocolloid impressions; these materials are susceptible to dimensional distortion during disinfection because of their hydrophilic nature [7].

Disinfection of the dental impressions is the most important barrier system in infection control [8]. Although, sterilization is more effective than disinfection, dental impressions cannot be subjected to sterilization as it is associated with significant dimensional changes. [9].Bergman found that immersion of alginate impressions in

disinfectant solutions for one hour caused unacceptable changes in surface detail and accuracy. When the alginates were sprayed with the disinfectant solutions, all had acceptable dimensional stability; however, only surfaces sprayed with Cidex, Technosept, and chloramine showed no deterioration in surface detail [10]. To avoid dimensional inaccuracies associated with disinfection process, manufacturers have incorporated disinfectant materials into the alginate. A disinfectant material that is added to the alginate must be efficient enough without affecting the clinically important properties and the castability of the recorded impression. Antimicrobial compounds which are water soluble and easily dispersible materials such as quaternary ammonium compounds, bisquanidine compounds, dialkyl quaternary compounds, quinoline compounds, substituted phenols, chlorhexidine, didecyldimethyl ammonium chloride, and a mixture of these materials are generally employed. [11].

MATERIALS AND METHODS

A total No. of (700) specimen was used in this study.These specimens were divided into (5) main groups according to the tests used which include:

1. Setting time test.
2. Dimensional change test.
3. Dimensional accuracy test. (Detail reproduction)
4. Tear strength test.
5. Bacteriological test:
    a) Cell count test (cfu/ml) for *Streptococcus mutans*.
    b) Cell count test (cfu/ml) for *Candida albicans*.

Each of the four main groups contain 70) specimen divided into 7subgroupswhich is composed of six percentages of NaF with alginate, one for control (0% NaF) while the fifth group (bacteriological test) contain 40 specimen were divided between *Streptococcus mutans* and *Candida albicans*, as specimen of alginate used before impression casting, after pouring of alginate with stone and specimen of stone were taken from the casts.

A. Setting time test

The setting time were tested in air conditioned laboratory room with temperatures of (23 ±2) °C, at 40% ± 10% relative humidity, measuring the final setting time has been done using Digital Vichatronic apparatus as shown in (Fig.1).

Figure 1: Vichatronic apparatus

B. Dimensional change test

Dimensional change test was measured using the protocol for dental elastomeric impression materials, as described in American National Standard Institute/American Dental Association Specification No. 19 [12]. A flat glass plate was placed over the mold and pressed the impression material firmly against the die assuring a positive metal to metal contact between the mold and the die then a metal flat weight of 1 Kg simulating the operator's finger pressure on a tray was placed over the glass plate as shown in Fig.(2).

The impression material was separated from the test block and placed under a Dino-Lite digital measuring microscope.Measurements have been done from the inner profile of the two cross horizontal lines of the stainless steel die and compare it to the same lines copied from the impressions of all percentages of NaF, and control alginate (Figure 3).

Figure 2: Flat glass plate pressed over the mold

Figure 3: Dino-Lite imaging of the samples with its calibrations.

Impression was inspected visually without magnification and the accepted impressions were those that passed the ANSI/ADA specification for detail production which reproduced the full length of the 75µm-wide line for the alginate without interruption, according to ANSI/ADA specification No.18. , detail reproduction of stone casts stone poured inside the gypsum mold on a vibrator and wait to set, then removed from the mold and inspected, according to the following scoring system: [13].

1- Rating (1) Well-defined, sharp detail and continuous line.
2- Rating (2) Continuous line but with some loss of sharpness.
3- Rating (3) Poor detail or loss of continuity of line.
4- Rating (4) Marginally or completely not discernible line.

For grading purposes the 75µm wide lines were assessed for alginate assessment of surface quality.

c. Tear strength test

The mold used was prepared with v-notch according to the ISO 1563. The sample was held in place with pneumatic clamps and extended at a constant rate of 5 N load cell, the force at failure was measured in an Instron testing machine at a crosshead speed of 500 mm/min. [14].

D.Microbiological tests

Microbiological tests: After proper Sterilizations andpreparation of Mitis-Salivarius Bacitracin Agar (MSB Agar) media, isolation of mutans streptococci from salivary sample were performed under the conditionsfollowing the criteria described by Tenovuo [15]. The plates were incubated anaerobically using a gas pack for 48 hr at 37^{o} C, then aerobically for 24 hr at room temperature.as shown in (Fig.4)

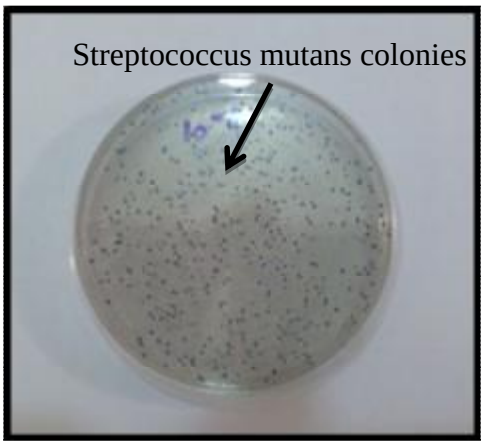

Figure 4: Mutans Streptococci on MSBA.

Isolation and purification of Candida albicans been done after Preparation of Sabouraud Dextrose Agar (SDA) from patient with denture stomatitis, swab was cultured on sabourauds dextrose agar (SDA) and incubated at 37°C for 72 hr and then kept at 4°C for further investigation, [16] (Fig. 5).

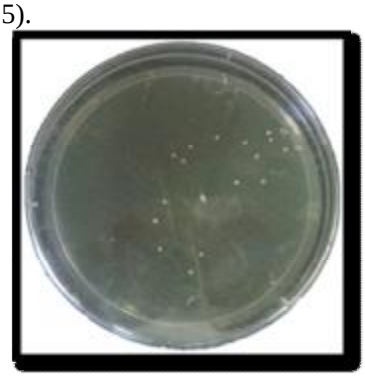

Figure 5: *Candida albicans* colonies on SDA.

The colonies of Mutans streptococci and Candida Albicans were determined according to:

1. Morphological characteristic. [17].
2. Gram's stain. [18].
3. Biochemical Tests [19]:
   - **A-** Catalase production test.
   - **B-** Carbohydrate fermentation test.
4. VITEK 2 systems product information. [20].

The addition of NaF to alginate powder was done by geometric mixing procedure. [21].

Experimental method

The procedure start with contamination of brass model by immersing it in suspension of microorganismthe standard inoculums were prepared to match the turbidity of 1.5×10^{8}cfu/ml (equivalent to 0.5 McFarland) using McFarland standard device, The brass model was with a flat polished surface divided into twelve 10×10mm-square separated by 2mm deep grooves (Fig. 6)

Figure 6: Brass master model with its aluminum tray

This model was subjected for 5 min in a suspension of either Candida albicans or Streptococcus mutans, standardized with a McFarland standard device, after removal from the suspension; the models were shaken and placed on a sterile paper for 1 min before the impressions were taken. [22].
Impression was taken to the mold, after complete setting, brass model has been removed from the impression. A flat square section of the impression material was cut off and removed with a number 10 surgical blade as slices with 2 mm thickness as shown in (Fig.7). [4].

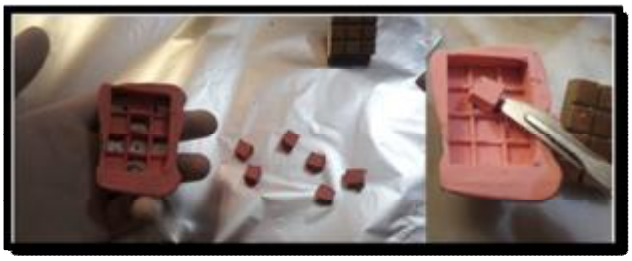

Figure 7: Alginate sample taken from the impression

Each sample (impression material or dental stone) was transferred to a tube containing 1 ml of sterile physiological saline then the sample was vortex-mixed for 60 sec and serially diluted 10-fold to 10^{-3}, then 100 µl from each dilution was inoculated on blood agar plates, which were incubated aerobically for 48 hr at 37°C and the numbers of cfu/ml were calculated [3].

Microbiological samples were taken at three different stages to detect the presence of contaminating bacteria. These stages were: the impression before pouring, the impression after pouring, and the hardened stone model after separation from the impression

RESULTS

Effect of (NaF) on the setting time of alginate impression material show a decrease in setting time of alginate as the concentration of (NaF) increased in all groups of alginate material with the lowest mean values of (91.1) sec at 4% NaF appear in Table (1)

Table 1: Mean, SD, ANOVA and LSD for setting time test (sec) for different disinfectant concentrations

Groups	Mean	S D	One-way ANOVA P value
Control (0%)	196.6	2.5	0.000 HS
NaF (0.25%)	196.7	1.5*	
NaF (0.5%)	191.8	0.7*	
NaF (1%)	184.7	2.6**	
NaF (2%)	143.9	2.4**	
NaF (3%)	133.2	1.8**	
NaF (4%)	91.1	1.9**	

(*)= significant difference from control
(**)= Highly significant at P ≤ 0.01

Effect of (NaF) on the dimensional change of alginate impression material, there is a decrease in dimensional change as the concentration of (NaF) increased, with lowest mean value (23.802) at 4% NaF. Also the results of ANOVA test appeared a highly significant differences (P<0.05) among all tested groups of alginate mixed with different concentration of (NaF) as shown in Table (2).

Table 2: Mean, SD, ANOVA and LSD for dimensional change test (mm).

Groups	Mean	S D	One-way ANOVA P value
Control (0%)	24.109	0.003	0.000 HS
NaF (0.25%)	24.109	0.001	
NaF (0.5%)	24.107	0.001	
NaF (1%)	24.076	0.019*	
NaF (2%)	24.063	0.007*	
NaF (3%)	23.984	0.014**	
NaF (4%)	23.802	0.019**	

(*)= significant difference from control
(**)= Highly significant at P ≤ 0.01

Effect of (NaF) on the detail reproduction of alginate and stone casts: there is a well-defined, sharp detail and continuous line at concentration of 0.25%, 0.5%, 1%, 2% NaF and control group, with non-significant differences (P<0.05) among these tested rank groups. While the result of 3% NaF has some loss of sharpness and the 4% NaF concentration has Poor detail and loss of continuity of line, these results were subjected to statistical analysis using Kruskal-Wallis test =49.537

Effect of (NaF) on the tear strength of alginate impression material: there is an increase in strength as the concentration of (NaF) increased, with highest mean value (1.099) at 2% concentration of NaF .While the results of 3% NaF and 4% NaF were (0.540) and (0.464) respectively. As shown in Table (3) the results of ANOVA test appeared a highly significant differences (P<0.05) among all tested groups of alginate mixed with different concentrations of (NaF).

Table 3: Means, SD, ANOVA and LSD for tear strength (N/mm^2).

Groups	Mean	S D	One-way ANOVA P value
Control (0%)	0.837	0.033	0.0000 HS
NaF (0.25%)	0.838	0.0103*	
NaF (0.5%)	0.84	0.0105*	
NaF (1%)	0.925	0.0302*	
NaF (2%)	1.099	0.1064**	
NaF (3%)	0.54	0.0278*	
NaF (4%)	0.463	0.0333*	

(*)= significant difference from control
(**)= Highly significant at P ≤ 0.01

Effect of (NaF) as Antimicrobial against Streptococcus mutans and Candida albicans: Statistical analysis revealed that alginate mixed with NaF have remarkable decrease in Candida albicans and Streptococcus mutans Cell count test (cfu/ml). Mean, SD , ANOVA and LSD had been used for different groups of alginate impression materials in testing of the Antimicrobial effect before and after pouring of the impressions and on the stone cast, Table (4) show different groups of alginate impression materials in testing of the Candida albicans before casting of the impressions.

DISCUSSION

The ADA has recommended high disinfection standards for dental equipment, including dental impressions, to prevent cross infection between members of dental teams. [23]. It has been reported that irreversible hydrocolloid impression carries two to five times more microorganisms than elastomers. [6]. This can be disinfected by immersion or spraying in any compatible disinfectant. Irreversible hydrocolloids are susceptible to dimensional distortion during disinfection procedure because of its hydrophilic nature [24].

Many impressions are sent to dental laboratories without proper disinfection, some of which are clearly contaminated with blood and food debris. Studies have reported that 67% of all the dental impression, crown, denture, wax and other materials send to laboratory have harmful bacteria on them [25].

Table 4: Means, SD, ANOVA and LSD for Candida albicans cell count test (cfu/ml) before casting of impression

Groups	Mean	S D	One-way ANOVA P value
Control (0%)	571.7	2.413	0.0000 HS
NaF (0.25%)	571.5	2.172	
NaF (0.5%)	571.5	2.670	
NaF (1%)	253.5	2.057*	
NaF (2%)	79.38	0.326**	
NaF (3%)	47.24	0.616**	
NaF (4%)	27.53	0.941**	

(*)= significant difference from control
(**)= Highly significant at P ≤ 0.01

In the present study alginate impressions were disinfected with NaF, and chosing recommended concentration that can produce self-disinfecting alginate impression material.

By mixing alginate with (1%, 2%, 3%, 4%NaF), setting time was decreased from (196.6) sec to (91.1) sec respectively, significant decrease in these values, these results was in agreement with results obtained from mixing of alginate with 2%NaF [26] and disagree with the results of 1% NaF alginate material as they use fluoride solution in 100ppm, this might be due to different methodology and addition procedure.

The decrease setting time test this may be due to strong activity of fluoride ions and their affinity to calcium ions, sodium ions will be increased in the reaction speed and decreased setting time this could be explained, that sodium phosphate which control the setting characteristics of alginate materials (inhibitor of the reaction) sediments down wards while the other reactive components sediments upwards, so there will be sufficient calcium ions that required to complete the cross linking of alginate chains and thus accelerate the setting time of the material together with the exothermic reaction that produce more heat to accelerate the reaction and also observed that the extent to which the setting time increased was dependent on the type of irreversible hydrocolloid impression material.

There is an increased in dimensional change as the concentration of (NaF) increased, with lowest mean value (23.802) at 4% NaF. A reduction in measurement represented alginate shrinkage. Based on the obtained results, the null hypotheses were not accepted at 3% NaF, 4% NaF (The null hypothesis for these experiments was that the mean distances measured in the control group were the same, irrespective of the impression

being mixed with NaF.). The differences attained 0.3 mm (3×10^{-4} m), however, it was possible to observe statistically significant differences, although these changes were well below the ADA specification stander of < 0.5%. These study results are consistent with those of Taylor et al [24] who reported that an overall improvement of the dimensional change of alginate impression material after chlorhexidine disinfection compared with controls and meet ADA recommendation. In contrast to those findings, Kern et al [27] showed for the same alginate material a significant deterioration of disinfected impressions.

The surface detail reproduction of alginate impression material and stone models were not significantly affected by the choice of concentrations with (0.25%, 0.5%, 1%, 2% NaF) alginate impression material, this was in agreement with Guiraldo et al [28]. While 3% NaF has some loss of sharpness and the 4% NaF concentration has Poor detail and loss of continuity of line this was in agreement with a previous study done by Hiraguchi et al [29] which appeared that stone casts resulted from pouring decontaminated alginate impressions using the employed disinfectants showed slight dimensional shrinkage and the surface detail reproduction of stone modelsand dimensional change of other alginate products was changed. In the present study the observed differences in the behavior of the impression materials with different concentrations of NaF which affect some changes in the dimensions of the resultant casts may be attributed partly to the different characteristics of the impression material composition themselves, and partly to the different chemical reaction containing alkaline PH caused bubbles and macroscopic alterations, like little craters in alginate molds. As there were non-significant differences in the surface detail reproduction and dimensional accuracy of stone models produced using low concentrations of the alginate impression materials with NaF or disinfectant solutions, the alginate materials with its additives evaluated in this study are factors of choice regarding surface detail reproduction and dimensional accuracy of stone models.

Detail reproduction is mainly influenced by flow of the unset irreversible hydrocolloid into the details and its compatibility with the gypsum products. NaF reduced the detail reproduction in irreversible hydrocolloids which could be attributed to the accelerated setting preventing it from flowing into the details; also NaF may decrease the wettability of the impression and poor detail reproduction. Further, it may also be related to the compatibility between gypsum product and set irreversible hydrocolloid impression material.

It can be noticed that addition of NaF fluoride to alginate in 1%, 2% NaF resulted in minor increase in tear strength of alginate impression materials. This may be due NaF has an effect to increase the consistency of the material and increase the elastic and decrease the plastic qualities of the alginate. Also this was in agreement with Mac et al [30] who attribute it as function of the rate at which the material is deformed, and the time at which the material is tested, and the consistency of the mix.

Candida albicans, and streptococcus mutans were selected to investigate the disinfection efficacy of NaF disinfectant agents.

The results revealed that the NaF has a bacteriostatic effect on the streptococcus mutans, and this was in agreement with Lobo et al [31].

In conclusions; mixing of alginate impression material with a disinfectant may alter their properties depending on the type and concentration of the disinfectant. Among these methods that are used in the present study, NaF that can be considered as a suitable disinfectant liquid for mixing with alginate impression material as it did not significantly affect the properties of the material.

NaF at high concentration had altered the properties of alginate impression materials, and their effect on the properties was concentration dependent. Hence, 2% NaF was the optimum concentration with minimum effect on the other properties with the benefit of internal disinfection that is most convenient because not only the surface of the impression need to be subjected to a chemical disinfection that may not always reach the internal portion to attack entrapped microbes.

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الخلاصه

المقدمة : تلوث طبعات الاسنان مع اللعاب والدم من تجويف الفم يحصل مباشرة في عيادات الاسنان ومختبرات صناعة الاسنان يجعل من طبعات الاسنان الملوثة فقرات يصعب التعامل معها من وجهة نظر انتشار الاخماج . اشارت التقارير السابقة الى امكانية الطبعات الملوثة بتلويث القوالب الجبسية المصبوبة مقابل الطبعة ؛ على اية حال غمس او رش طبعات الاسنان من مادة الالجنيت الشائعة الاستعمال مع المعقمات لها تأثير سلبي على دقة القوالب او اجزائها .

المواد واساليب العمل:في هذه الدراسه تم تحضير 800 عينه, تم تقسيمها الى خمس مجاميع رئيسيه طبقا لنوع الفحص المستعمل (قوة التمزق,فحص وقت التصلب,فحص تغيير الابعاد وفحص دقة الابعاد وعينات الفحص البكتيري التي تم تقسيمها بين المكورات المسبحيه ميوتان والفطريات البيضاء.
كل مجموعه رئيسيه تم تقسيمها الى ثمان تقسيمات فرعيه طبقا لتراكيز(الصوديوم فلورايد) المستعمله .
استعملت ست تراكيز لفلوريد الصوديوم من(0.25-4%) قد مزجت مع مادة طبعة الالجنيت وقد تم مقارنتها مع الالجنيت العادي بدون اي معقم.

النتائج: مادة الطبعه ذاتية التطهير المحتويه على فلوريد الصوديوم قد اظهرت قتل معنوي للجراثيم بعد عمل الطبعات.كانت قوة التمزق لجميع الطبعات المختبره هي اعلى من المنتجات القياسيه.ليس هناك فرق احصائي معنوي بين نتائج اختبارات تغير الابعاد وكذلك اختبارات دقة الطبعه المحتويه على صوديوم فلورايد والاخرى غير المحتويه عليها,اما بالنسبه لوقت التصلب للطبعات فقد كان هناك فرق احصائي بين المواد القياسيه الغير محتويه على صوديوم فلورايد والمواد المختبره حيث ان المواد المختبره الغير محتويه على صوديوم فلورايد كان لها وقت تصلب اطول من جميع المواد المختبره الاخرى.ان مواد الطبعات ذاتية التطهير تم تطهيرها بشكل كلي خلالها وليس فقط على سطحها كما هو يحصل عادة.

الاستنتاج:ان استعمال فلوريد الصوديوم عند اخذ طبعات الالجنيت للاسنان يعتبر اجراء جيد في تقليل التلوث وانتقال العدوى وله تاثير قليل على تغير الابعاد وهو موصى به كخطوه لحماية طبيب الاسنان وفريق مختبرات الاسنان.

الكلمات المفتاحيه:مادة طبعة الألجنيت, صوديوم فلورايد, المكورات المسبحيه ميوتان والفطريات البيضاء