Journal of Trace Elements in Medicine and Biology 41 (2017) 107–110

Contents lists available at ScienceDirect

Journal of Trace Elements in Medicine and Biology

journal homepage: www.elsevier.com/locate/jtemb

Toxicology

Long-term release of fluoride from fissure sealants—*In vitro* study

Piotr Kosior[a], Maciej Dobrzyński[a,*], Mariusz Korczyński[b,c], Katarzyna Herman[a], Agnieszka Czajczyńska-Waszkiewicz[a], Małgorzata Kowalczyk-Zając[a], Dagmara Piesiak-Pańczyszyn[a], Katarzyna Fita[a], Maciej Janeczek[d]

[a] *Department of Conservative Dentistry and Pedodontics, Wroclaw Medical University, Krakowska 26, 50-425 Wroclaw, Poland*
[b] *Department of Environment Hygiene and Animal Welfare, Wroclaw University of Environmental and Life Sciences, Chełmońskiego 38c, 51-630 Wroclaw, Poland*
[c] *Department of Experimental Surgery and Biomaterials Research, Wroclaw Medical University, Poniatowskiego 2, 50-326 Wroclaw, Poland*
[d] *Department of Biostructure and Animal Physiology, Wroclaw University of Environmental and Life Sciences, Kożuchowska 1, 51-631 Wroclaw, Poland*

ARTICLE INFO

Article history:
Received 26 November 2016
Received in revised form 4 February 2017
Accepted 27 February 2017

Keywords:
Fissure sealant
Fluoride ions
Release

ABSTRACT

The intensity of the cariostatic activity of fluoride ions can be attributed to their multidirectional influence on the caries process. They are an irreplaceable factor that helps sustain mineral balance of dental tissues, simultaneously demonstrating antibacterial properties. As a consequence, many manufacturers of fissure sealants include fluoride ions in their products. The aim of this *in vitro* study was to determine long-term fluoride release from four fissure sealants (Conseal F, Fissurit FX, Delton Fs+, Admira Seal). During a 14-week-long observation, all the materials showed a relatively constant level of F- release; however, it is crucial to mention that within the first 48 h, the most significant increase in fluoride release was found for Fissurit and Delton sealants. Based on the overall assessment, the highest total amount of the released fluoride ions was observed for Delton, and the lowest level was reported for Admira Seal.

1. Introduction

The intensity of the cariostatic action of fluoride ions can be attributed to their multidirectional influence on the caries process [1–5]. Starting from their endogenous activity impacting hard dental tissues in the mineralization period, to external protection in the oral cavity environment, they are an irreplaceable factor that helps sustain mineral balance of the teeth. As a result of concentrating in the dental plaque and constant dissociation from the saliva, they show considerable potential for inhibiting the demineralization processes by supporting the remineralization processes. They stimulate restoration of apatites, and they reduce loss of calcium ions from the enamel surface which is connected with the activity of acids present in oral cavity environment.

The mechanisms of the preventive action of fluoride are various [1,4–6]. Fluorides react with hydroxyapatites of the enamel by replacing hydroxide ions. As a result of this reaction, some of the hydroxyapatites transform into fluorapatites which have better crystalline properties, and are more acid-resistant. In the apatite, strong ionic bonds between fluoride and the NH group of the organic enamel matrix are formed, which contributes to greater stability of fluorapatite crystals. Fluoride may also react with apatite by stimulating the growth of fluorapatite crystals, as well as it may cause apatite dissolution and forming calcium fluoride. The formation and stimulation of fluorapatite growth may occur during frequent exposure to low fluoride concentration in the solutions (below 0.1%).

Many researchers have confirmed the significant role of fissure sealants in the prevention of dental caries in molars and premolars [7–15]. Slow release of the fluoride that they contain has a considerable influence on the intensification of the cariostatic action.

2. Aim

The aim of this *in vitro* study was to determine long-term fluoride release from selected fissure sealants.

3. Material and methods

The study involved four fissure sealants (Conseal F, Fissurit FX, Delton Fs+, Admira Seal) which contained the following:

- Conseal F (SDI, Australia) – by weight 93% acrylic monomer, 7.0% silica, 0.01% titanium dioxide and 0.01% NaF.

* Corresponding author.
E-mail address: maciejdobrzynski@op.pl (M. Janeczek).

http://dx.doi.org/10.1016/j.jtemb.2017.02.014
0946-672X/

Table 1
Cumulated *in vitro* F^- ion release from fissure sealants into a saline solution (μg/mm²).

Time (hours)	Conseal F (±SD) (μg/mm²)	Fissurit FX (±SD) (μg/mm²)	Delton FS+ (±SD) (μg/mm²)	Admira Seal (±SD) (μg/mm²)
1	1.25 (±0.04)	4.04 (±0.21)	3.8 (±0.69)	0.19 (±0.02)
3	2.98 (±0.9)	5.78 (±0.5)	5.21 (±0.96)	0.52 (±0.32)
24	5.31 (±1.46)	8.08 (±1.28)	11.4 (±3.16)	0.65 (±0.3)
48	6.58 (±1.94)	9.18 (±1.56)	14.93 (±3.96)	0.76 (±0.31)
72	7.74 (±2.14)	9.75 (±1.7)	18.11 (±4.87)	0.88 (±0.25)
168	9.39 (±2.17)	11.04 (±2.1)	23.93 (±4.84)	0.99 (±0.23)
336	11.13 (±2.2)	12.19 (±2.35)	29.44 (±6.16)	1.27 (±0.21)
504	12.97 (±2.27)	12.92 (±2.33)	31.55 (±6.83)	1.36 (±0.21)
672	14.97 (±2.62)	14.42 (±2.07)	34.2 (±7.7)	2.55 (±0.27)
840	17 (±2.92)	15.64 (±2.01)	36.16 (±7.96)	2.92 (±0.25)
1008	17.48 (±2.97)	16.84 (±2.47)	37.83 (±7.97)	3.28 (±0.24)
1176	17.92 (±2.93)	18 (±2.73)	39.62 (±7.98)	3.74 (±0.23)
1344	18.22 (±2.92)	19.17 (±2.98)	41.86 (±8.41)	4.25 (±0.25)
1512	18.77 (±2.85)	20.43 (±3.15)	44.78 (±7.96)	4.66 (±0.25)
1680	19.01 (±2.73)	21.59 (±3.14)	46.48 (±8.1)	5.28 (±0.3)
1848	19.13 (±2.75)	22.83 (±3.14)	48.33 (±8.51)	5.87 (±0.34)
2016	19.15 (±2.75)	24.13 (±3.15)	51.93 (±9.49)	6.34 (±0.37)
2184	19.23 (±2.79)	25.58 (±3.09)	55.81 (±10.67)	6.83 (±0.42)
2352	19.83 (±2.8)	28.08 (±3.1)	61.91 (±12.07)	7.36 (±0.3)
Correlation coefficient	0.8925	0.982	0.9531	0.9971
T-test for two variables				
Admira Seal	0.0000	0.0000	0.0000	xxx
Delton FS+	0.0000	0.0000	xxx	
Fissurit FX	0.0009	xxx		
Conseal	xxx			

Friedman's ANOVA and Kendall's Coefficient of Concordance.
Chi ² ANOVA (N = 19, df 3) = 50.55789 p 0.00000.
Coefficient of Concordance = 0.88698 r average range = 0.88070.

- Fissurit FX (Voco, Germany) – composed of a monomer matrix which consists of methacrylic acid ester (BIS-GMA) and urethane dimethacrylate (around 99%) and a filler – borosilicate glass with the particle size above 1 μm (99%), and 3% NaF which corresponds to1.3% fluoride content.
- Delton FS+ – it contains two sources of fluoride, by volume 55% of the filler.
- Admira Seal – mainly composed of borosilicate glass (16%).

The release of fluoride ions from the aforementioned materials to a saline solution was examined for 14 weeks (*i.e.* 98 days or 2352 h). Samples of the studied materials were formed as cylinders with the use of a polyethylene matrix. The polymerization of a material was conducted according to the recommendations of the manufacturer. After the samples have been hardened, they were polished and their contact surface was calculated in mm^2. Samples were then immersed in the examined solution and left undisturbed in closed containers at the temperature of 37 °C (oral cavity conditions) for a period of time necessary for measurements of the level of fluoride release from the materials. Three samples were made for each material.

The ion selective ORION electrode model 9609, and a microcomputer pH/ionometer CPI- 551 Elmetron were used for measurements. The system was calibrated before every examination. Each sample was examined three times, and an average value was calculated based on the three results. The results were collected after 1 and 3 h, next after 1, 2, and 3 days, and then at weekly intervals for 14 consecutive weeks.

For individual measurements series, the average as well as the standard deviation of average were calculated. Obtained results of cumulated content of fluorine ions in saline solution were statistically analyzed using Friedman test for repeated data as well as T-student test for dependent data. Coefficient of Pearson's line correlation between cumulated concentration of fluoride ions and exposure time of the material in saline solution were also calculated. Results of fluoride ions concentration at each time-point were analyzed statistically using of T-student test for dependent data. All the calculations were performed for the level of significance $p < 0,05$.

4. Results

The levels of fluoride release from the samples of fissure sealants into a saline solution are shown in Table 1 and on Fig. 1. The highest cumulated level of ion release was demonstrated by Delton FS+ (61.91 ± 12.07 μg F/mm^2), and a lower on by Fissurit FX (28.08 ± 3.10 μg F/mm^2), Conseal F (19.83 ± 2.80 μg F/mm^2) and Admira Seal (7.36 ± 0.30 μg F/mm^2) respectively. Extended time of the materials remaining in the saline solution equaled a higher level of released fluorides.

All the examined materials showed the highest rate of emission after 1 h; the highest rate was demonstrated by Fissurit FX (4.0400 μg F/mm^2/h.), lower by Delton FS+ (3.800 μg F/mm^2/h.) and Admira Seal (0.1900 F/mm^2/h.), and the lowest by Conseal (1.2500 μg F/mm^2/h.). The rate of fluoride release for all the materials within the following 2 h decreased; the smallest decrease was observed for Admira Seal (of 13%), and the largest for Delton FS+ (of 81%) (Table 2).

5. Discussion

The antibacterial activity of fluoride is visible in local concentrations ranging from 0.16 to 0.31 mol/l. In normal conditions, lower amounts of fluoride are observed in the dental plaque [16]. However, it has been demonstrated that low concentrations (around 1 mmol/l) may effectively inhibit the production of bacterial acids, and at the same time, reduce the demineralization of the tooth surface [4,17].

Most of the research conducted so far on fluoride release from dental materials is inconclusive with regards to the solution the measurements should be taken in. The diversity of environments used for taking the measurements is to show their influence on the release level and the significance of the differences [1].