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ORIGINAL ARTICLE

Oral fluoride retention in orthodontic patients with and without fixed appliances after using different fluoridated home-care products

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Abstract

Objective. To evaluate oral fluoride (F) retention after using fluoridated toothpastes, rinsing solutions and chewing sticks (Miswaks) in orthodontic patients with and without orthodontic appliances. ***Material and methods.*** Nine orthodontic patients, with a mean age of 16 years, were included in a randomized, cross-over, experimental study. Six different home-care F products, two NaF toothpastes (0.32% and 1.1%), two NaF mouthwash solutions (0.05% and 0.2%) and two NaF-impregnated Miswaks chewing sticks (0.05% and 0.5%), were used both during the orthodontic treatment and 1 week after debonding. Unstimulated whole saliva and approximal saliva were collected from two interdental sites, before and up to 60 min after using each product for 2 min. The retention of F was calculated as the area under the 60-min F-clearance curve (AUC). ***Results.*** In general, the F concentrations at the various sites were higher before than after debonding. Moreover, the products with a high F content (toothpaste, mouthwash and Miswaks) resulted in higher F retention than the corresponding products with a lower F content. In whole saliva, the highest AUC values were found in patients using 0.2% NaF mouthwash, followed by 1.1% NaF toothpaste ($p < 0.05$). In approximal saliva, the retention values were highest after using 0.5% NaF-impregnated Miswaks in patients wearing orthodontic appliances ($p < 0.001$). ***Conclusions.*** The insertion of fixed orthodontic appliances appears to favor oral F retention for all the tested home-care F products. In addition, products with a high F content increase oral F retention.

Key Words: *Approximal area, fluoride retention, fluoride solution, fluoride toothpaste, Miswaks, orthodontic patients, saliva*

Introduction

The prevalence of dental caries has declined in the Western world in recent decades, probably because of the widespread use of fluoride (F) toothpaste [1–3]. Adolescents treated with fixed orthodontic appliances may be regarded as a risk group for caries due to increased plaque accumulation, food retention and shifts in the oral microflora [4–6]. The incidence of enamel demineralization (white spot lesions), adjacent to the brackets, has been estimated to be 15%–85% [7,8]. The retention sites in orthodontic patients, such as brackets, arch wires, ligatures and elastics, may be regarded as a negative factor from a cariological point of view with respect to plaque accumulation and food retention [6]. On the other hand, they may be a positive factor when it comes to the retention of F [9,10].

Toothpaste is the most commonly used home-care F product. Supplementary F, in forms such as solutions, tablets, chewing gums and gels, is often recommended to orthodontic patients [11–13]. Fluoridated products have varying abilities to elevate the concentration and distribution of F in the oral cavity. Rinsing solutions and toothpaste considerably increase the F concentration in saliva [14,15]. Rinsing with F leads to an elevated F concentration in dental plaque for up to 3 h at least [14]. In many Muslim countries, Miswaks (chewing sticks) are used for cleaning purposes several times per day. A recent study in the eastern province of Saudi Arabia revealed that the use of Miswaks is about twice as common as that of toothbrushes among schoolchildren [16]. We have recently developed a procedure to impregnate Miswaks with F [17,18]. The data are promising and show that the release of F from the chewing stick

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is a rapid process and thereby suitable for caries prevention.

Our hypothesis was that the oral F concentration, and thereby F retention, would be higher and more prolonged in patients with fixed orthodontic appliances than those without, for example when brushing the teeth with toothpaste or Miswaks or after using a rinsing solution. The aim was therefore to study the retention of F in the oral cavity, both in saliva and in the approximal area, after using different fluoridated home-care products, such as toothpastes, rinsing solutions and chewing sticks (Miswaks) in orthodontic patients with and without orthodontic appliances.

Material and methods

Subjects and study design

Nine orthodontic patients, two males and seven females, almost at the stage of debonding, were recruited from the specialist orthodontic clinics at the University of Gothenburg; their mean age was 16 years (range 14–19 years). They all had fixed orthodontic appliances in both the upper and lower jaws and had been treated due to bimaxillary crowding. The participants were scheduled for six visits with the appliances and another six shortly after debonding (i.e. without any appliances). The total study period for these 12 visits was 3 months (12 weeks). Figure 1 shows a schematic outline illustrating the design of the study. The Ethics Committee at the University of Gothenburg had approved the study (code number 355-09). Informed consent was obtained from the subjects before the start of the study.

F products

This experimental in situ study had a cross-over design, in which all nine participants used all six F products on two occasions in a randomized order. The washout period between each test was a minimum of 1 day. The participants were not allowed to use any fluoridated product on the day of examination. The following six products were included in the study: (1) toothpaste containing 0.32% NaF (Pepsodent; Lever Fabergé, Stockholm, Sweden); (2) toothpaste containing 1.1% NaF (Duraphat; Colgate Palmolive, Glostrup, Denmark); (3) mouthwash solution containing 0.05% NaF (Dentan; Meda, Stockholm, Sweden); (4) mouthwash solution containing 0.2% NaF (Dentan); (5) Miswaks impregnated in 0.05% NaF for 1 day at our laboratory; and (6) Miswaks impregnated for 1 day in 0.5% NaF. The impregnation procedure has recently been described in detail [17,18].

F administration

Before each test, the subjects chewed on paraffin wax for 5 min and rinsed with distilled water for 30 s.

Toothpaste. One g of paste was applied to a wet toothbrush and the subject brushed his/her teeth for 2 min. After brushing, the remaining toothpaste was spat out and the mouth was rinsed with 5 ml of water for 5 s.

Mouthwash solution. Ten ml of the solution was swirled around the mouth for 2 min with active movements of the cheeks and lips.

Miswaks. The cover was first removed and the participants then chewed on the stick for a short time (3–5 s), before it was moved around the dentition to clean all the buccal tooth surfaces and all the buccally oriented approximal surfaces, for 2 min, as described previously (Figures 2A and 2C) [17,18].

Sampling procedure

Resting whole saliva and approximal saliva from two sites were collected just before (0-min sample; baseline) and after 1, 3, 5, 10, 15, 30 and 60 min, making eight samples per test. In all, 2592 saliva samples were collected for the whole study (nine subjects×six

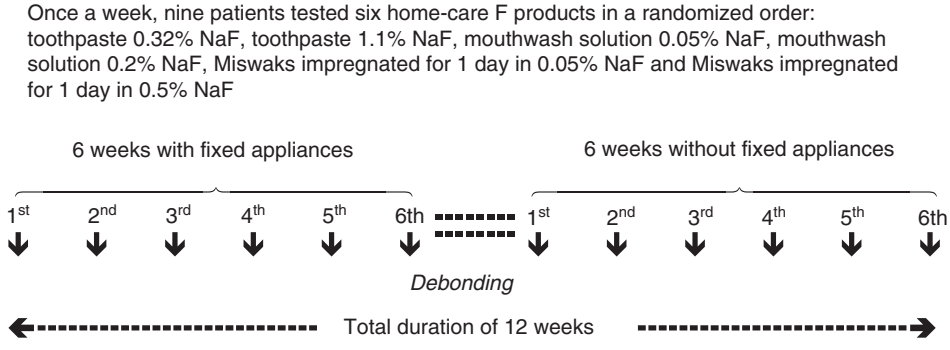

Figure 1. Schematic outline summarizing the design of the study.

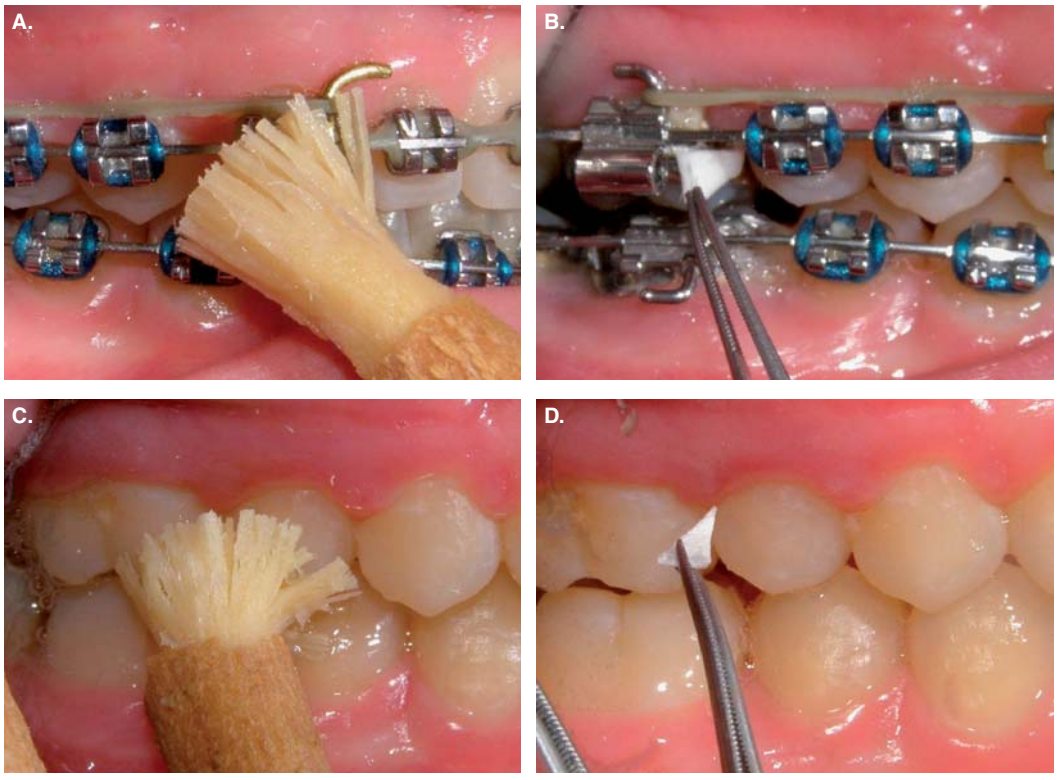

Figure 2. (A, C) Use of a Miswak for cleaning the teeth with and without orthodontic appliances. (B, D) Sampling of approximal saliva with triangular paper points is also shown.

products×three sites×eight time points×two occasions). Small, standardized, triangle-shaped paper points (base: 1.5 mm; length: 5 mm) were inserted in the two approximal areas (mesial 16 and mesial 25) for 30 s (Figure 2B and 2D) in order to suck up around 4 µl of saliva [19]. The paper points were then transferred to plastic Eppendorf tubes containing 200 µl of deionized water and 20 µl of Total Ionic Strength Adjuster Buffer (TISAB) III buffer solution (dilution 10:1; Thermo Electron, Waltham, MA, USA).

F analysis

Prior to the F analyses, the samples were mixed by vibration for 10 s. The F concentration was determined by means of an F-sensitive electrode connected to an expandable ion analyzer (Orion Research, Boston, MA, USA) by placing the surface of the electrode in close contact with the solution. Analysis of F concentration was performed using a set of standard solutions from 0.526 µM F (0.01 ppm) to 5.26 mM F (100 ppm), according to the manufacturer's instructions. The same technician analyzed all 2592 samples blindly.

Statistical analysis

A simplified power calculation was performed before starting the study. Means and standard deviations (SDs) were calculated for each F product with and without the fixed orthodontic appliances. The area under the clearance curve for 0–60 min (AUC) was measured using the KaleidaGraph software program (Version 4.0; Synergy Software, Reading, PA, USA) for each individual and each product. The mean differences between the AUC values with and without orthodontic appliances and between the various products were compared using a paired *t*-test. $p < 0.05$ was considered to be statistically significant. Statistical comparisons using three-way ANOVA, followed by multiple comparison tests with Student–Newman–Keuls were also performed, which confirmed the result of the paired *t*-test.

Results

Generally, the F concentration values for all products and for all patients with fixed orthodontic appliances showed higher F retention than without the appliances.

Figure 3 shows the means and SDs of AUCs in saliva from the patients with orthodontic appliances; the six F products are given in ranking order. 0.2% NaF mouthwash and 1.1% NaF toothpaste produced the highest F values, which were significantly higher compared with the other four products ($p < 0.05$). The same ranking order was found without orthodontic appliances but with generally lower

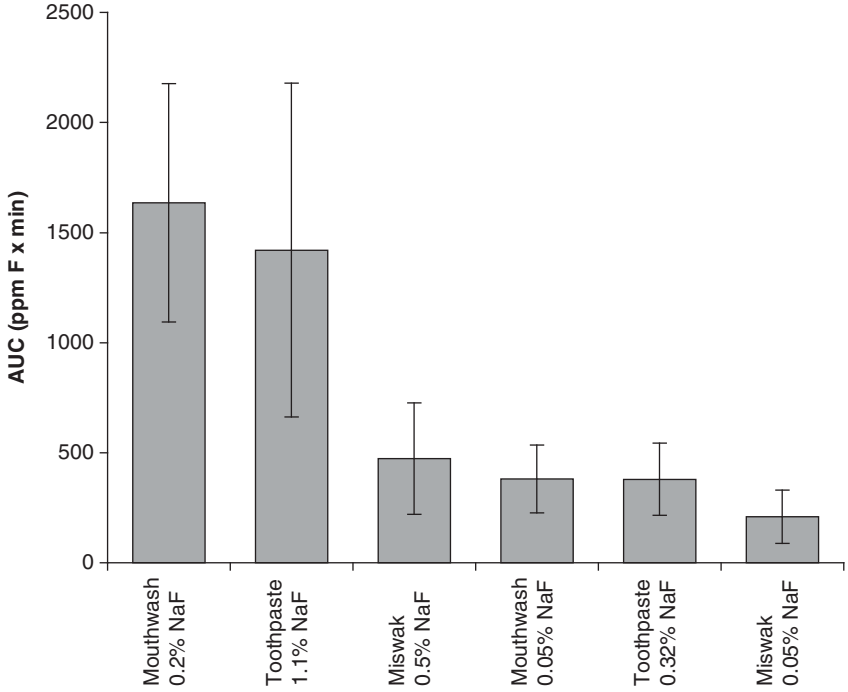

Figure 3. The AUC values (Mean ± SD) values of the F concentration in saliva from six different F products, arranged from the highest to the lowest F concentration, in patients (n = 9) wearing fixed orthodontic appliances.

F values compared with orthodontic appliances (data not shown).

Figure 4 shows the mean F concentrations during the 60 min and the AUC values in saliva and at the two approximal sites with orthodontic appliances. Only data for 0.2% NaF mouthwash solution, 1.1% NaF toothpaste and 0.5% NaF Miswaks are shown. The F concentration was high, especially during the first 10 min; there were no significant differences between the three sampling sites, except for Miswaks, which produced higher values at the two approximal sites than in whole saliva ($p < 0.05$). Both the F concentration and the AUC were about 1.5-times higher for 0.5% NaF-impregnated Miswaks compared with 0.2% NaF mouthwash solution and 0.5% NaF toothpaste ($p < 0.05$).

Figure 5 shows the AUC values for the two approximal sites with and without orthodontic appliances. Generally, in all the tests, the highest F release was obtained for mesial 25, followed by mesial 16 (even if the differences were not always statistically significant). Using 0.5% NaF-impregnated Miswaks, both with and without orthodontic appliances, resulted in the highest F retention in approximal saliva, especially at mesial 25, with statistically significant differences compared with all the other F products ($p < 0.001$).

Discussion

To our knowledge, there are no similar studies in the literature comparing oral F retention with and without fixed appliances in orthodontic patients after using different home-care F products. The main result of the present investigation was that the F concentration for all products showed higher retention when patients wore the appliances. This held true both in whole saliva and at approximal sites. The three products tested in this study (toothpaste, mouthwash and Miswaks) were evaluated in forms with both a low and a high NaF concentration. As expected, the high-F products generally produced a higher salivary F concentration and higher AUC values than the low-F products on both test occasions, i.e. with and without orthodontic appliances. This may be an advantage from a cariological point of view, as oral F reservoirs on the teeth, oral mucosa and around the brackets can have a protective effect against caries [10].

The large variation in F retention between the products could be explained by the F concentrations in the products themselves, by the presence and absence of the orthodontic appliances and by the sampling site [20,21]. For example, 0.5% NaF Miswaks produced the highest values in the approximal area compared with all other products, followed by 0.2% NaF mouthwash solution. On the other hand, 0.2% NaF mouthwash solution and 1.1% NaF toothpaste produced the highest values in whole saliva.

The preventive effect of rinsing with F on dental caries has been reported in several studies [22–24]. The fact that the mouthwash solution raised F concentrations more than toothpaste or Miswaks indicates that the F distribution in the oral cavity was

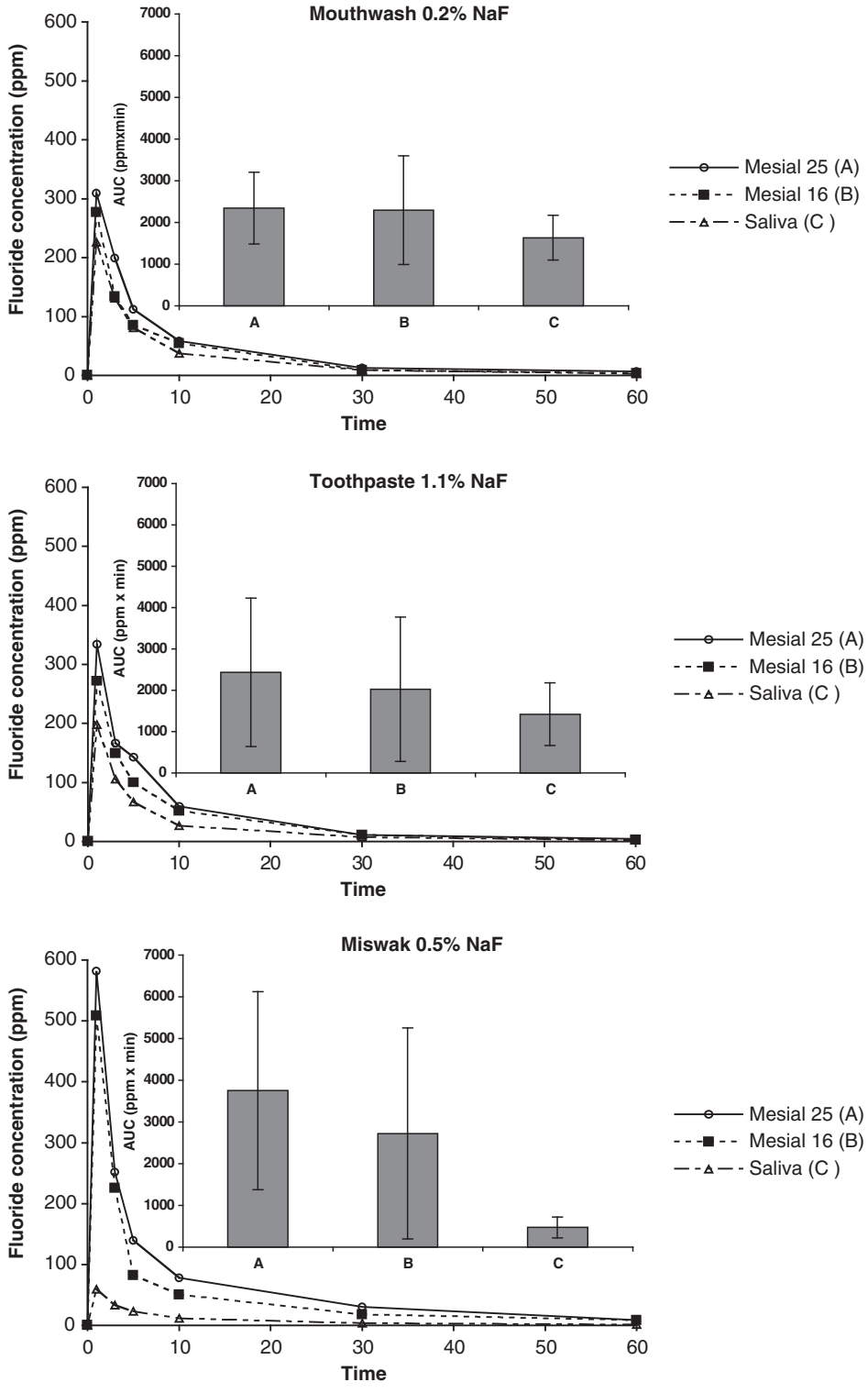

Figure 4. Mean values ($n = 9$) of F concentration both in saliva and at two approximal sites up to 60 min after using three F products (0.2% NaF mouthwash, 1.1% NaF toothpaste and 0.5% NaF-impregnated Miswaks) in orthodontic patients with fixed appliances. The AUC values (0–60 min), expressed as the mean ± SD are also inset.

more complete. This is in agreement with a recent study [25] which showed that rinsing with NaF resulted in higher approximal F concentrations compared with fluoridated toothpicks and dental flosses. The reason why the mouthwash is more powerful in terms of F retention than other products may be that it penetrates different areas, such as between the brackets and wires, more easily when swirled around the mouth.

We have recently studied F uptake and release from NaF-impregnated Miswaks and found that the release is a rapid process [17,18]. The use of fluoridated

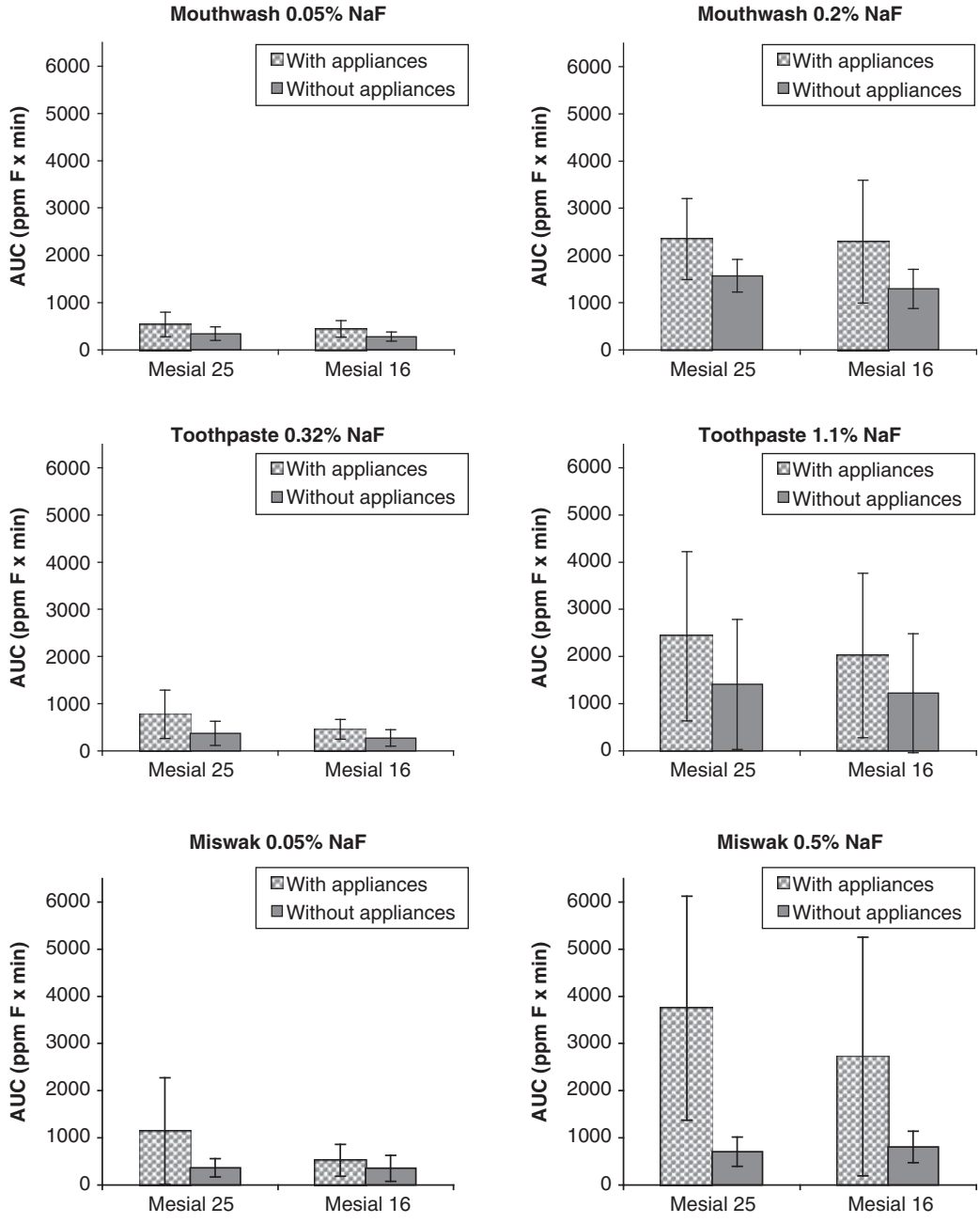

Figure 5. The AUC values (Mean ± SD) of the F concentration at two approximal sites (mesial 25 and mesial 16) after using six F products in orthodontic patients ($n = 9$) with and without fixed appliances.

Miswaks may not only be restricted to poor countries; it can also be applied in modern countries by patients with orthodontic appliances. The F-containing bristles appear to increase oral F retention, especially between the brackets. The present results showed that 0.5% NaF Miswaks produced F retention that was 1.5-times higher than 0.2% NaF mouthwash solution and 0.5% NaF toothpaste in approximal saliva. Another advantage of Miswaks is that there is no need for post-brushing water rinsing as there is after using toothpaste.

A systematic review by Twetman et al. [26] in 2003 reported strong scientific evidence showing that the daily use of F toothpaste is an effective method for preventing dental caries. Several studies indicate that there is a more or less linear relationship between the F concentration in the toothpastes and the extent of caries reduction [15,27,28]. Various factors, including the concentration of F in the paste, the amount of toothpaste applied to the brush, the frequency of brushing and post-brushing water rinsing, influence the efficacy of F toothpaste [29]. Adults and teenagers with a high risk of caries are suitable target groups for using a dentifrice containing 5000 ppm F (equal to 1.1% NaF). Adolescents run an increased risk of caries when their teeth have just erupted. A dentifrice with a high F content, like the one used in the present study, has also been

recommended for optimal caries prevention strategies during orthodontic treatment [12]. An interesting observation made recently is that post-brushing water rinsing has a negative impact on the retention of F in the approximal area [15]. This can be extended to orthodontic patients, who should be advised to use just a minimum amount of water after brushing their teeth with F toothpaste.

It seems logical that the residual volume of saliva and salivary flow increase after insertion of fixed orthodontic appliances [30] and that those two factors may shorten the F retention time in the oral cavity. The appliance consists of many retentive components that provide numerous recesses where F may be trapped. The present study showed that F retention was somewhat prolonged for patients with than without appliances. It should be remembered that in most cases these differences were rather small.

In conclusion, the retention of F from fluoridated mouthwash solution, toothpaste and Miswaks is somewhat more pronounced in patients with orthodontic appliances than without. Products with a high F concentration may have a favorable effect on orthodontic patients as they considerably increase the retention of F. Moreover, fluoridated Miswaks is an interesting product in orthodontic patients in countries where it is used frequently, since it has a 'dual effect', i.e. both brushing and F delivery.

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