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A randomised controlled trial comparing the levels of salivary fluoride after brushing with and without rinsing

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Abstract

Background: Since the advent of toothpaste containing fluoride, the prevalence of caries has considerably decreased. Although there have been a number of advancements involving particular active fluoride compounds, there is not enough data to favour one over the other. This double-blind randomized controlled trial's goal was to assess the levels of salivary fluoride in individuals who used various fluoride toothpaste formulations with and without post-brushing water rinses.

Methods: 120 people were involved in the research project, and each of the 12 groups had ten respondents. Each participant was divided into one of the 12 groups through the use of block randomization. One of the six distinct toothpaste formulas, either with or without post-brushing water rinse, was used by participants to brush their teeth.

Results: There were no appreciable differences in the participant's demographic traits across the groups (P > 0.05). Saliva fluoride retention was significantly influenced by time, toothpaste composition, and post-brushing rinse practises (P 0.05). The only toothpaste formulation that demonstrated statistically substantially increased salivary fluoride concentrations at 90 minutes in both the rinsing and non-rinsing groups was amine fluoride-containing toothpaste.

Conclusions: According to the findings of this research, using toothpaste formulas containing sodium monofluorophosphate without rinsing after brushing is advised for adults.

Keywords: Fluoride, Block Randomization, Fluoride-Containing Toothpaste.

Introduction

Dental caries is the most prevalent chronic disease world- wide. One of the widely accepted cost-effective methods of caries prevention is toothbrushing with fluoridated toothpaste. This method of delivering high-dose fluoride over a low-frequency regimen has proven its effective- ness in reducing the incidence of caries [1–4]. Systematic reviews and meta-analyses have confirmed the benefit of 1000–1500 ppm F-containing toothpaste to achieve caries prevention [5–7].

It is possible to find toothpaste with fluoride in a variety of chemical and formulation forms. The most active fluoride components found in toothpastes are stannous fluoride (SnF2), sodium fluoride (NaF), sodium monofluorophosphate (Na2FPO3), and amine fluoride (AmF). Investigations supported the notion that toothpaste containing NaF is preferable to toothpaste containing SnF2 and Na2FPO3 [8–10]. Others claimed that AmF toothpaste significantly reduced caries remineralization when compared to toothpastes comprising NaF and Na2FPO3 and resulted in higher salivary fluoride concentrations [11–14].

Several investigators looking into the anti-caries efficacy of fluoride toothpastes are interested in the post-brushing rinse. Several research [12, 13, 15, 16] looked into the availability and rate of fluoride clearance from the oral cavity after brushing. In comparison to non-rinsing groups, salivary fluoride concentrations were shown to be significantly lower after post-brushing rinsing [12, 13, 16, 17]. The comparative efficiency of one active fluoride toothpaste formula over another, with or without post-brushing mouth rinse, has not been found to be supported by any high-quality trials, it has been determined [18]. Numerous earlier clinical trials that looked into this topic had methodological flaws, such as (1) unclear inclusion and exclusion criteria [9, 11-13, 16], (2) inaccurate sample size calculations [9, 11-13, 16, 17], (3) a lack of randomization [9, 11, 17], and (4) examiners who weren't blind to the group receiving the intervention [11, 17]. In order to assess salivary fluoride concentrations after brushing with various fluoride toothpaste formulations with and without post-brushing water rinsing, the goal of this study was to carry out a randomized double-blind clinical trial. The two null hypotheses were that: 1. There are no significant differences in salivary levels of fluoride among toothpaste formulations with similar fluoride concentrations when measured at different time intervals; and 2. For the examined toothpaste formulations, there are no significant differences between post-brushing rinsing and non-rinsing.

Materials and methods

The study was carried out at Department of Pediatrics and Preventive Dentistry, S.C.B. Dental College and Hospital, Cuttack, Odissa. Sample size calculations were performed using Power Analysis and Sample Size was calculated using G Power software. The study aimed to test 12 groups; each group was tested at 6 different time intervals. For this study, the confidence intervals were set at 95%, with 100% power. Sample size calculations were performed using raw data from a previous study [13]. A sample of at least three participants was needed for each group to achieve significant differences. It was decided to increase the final number of par ticipants to 10 participants in each group, giving a total number of at least 120 participants. A circular email with an invitation to participate in the study was sent along with the recruitment flyer, the information sheet, and the consent sheet to students across the S.C.B. Dental College and Hospital, Cuttack

every two months starting from September 20121 until April 2022. Written consent was obtained from each participant.

Adults with American Society of Anaesthesiologists (ASA) grades I or II and a resting salivary flow rate of 0.1 ml/minute or above were required for participation in the trial. Inability to fast for four hours, inability to retain toothpaste after brushing, edentulousness, allergies to any study materials, inability to retain toothpaste after brushing, and orthodontic braces were among the list of exclusion criteria for volunteers. The participants in the groups (1–12) were given participation numbers (1–120) using block randomization.Employing the same website, a qualified study dental assistant randomly assigned the tooth-paste formulations with and without rinsing to the groups (1–12). She labelled the toothpaste tubes after which she hid them. The toothpaste formulation was hidden from both the subjects and the lead researcher. The statistical analysis has been carried out by the lead investigator, who was also blinded to the rinse techniques.

The Decayed, Missing owing to caries, and Filled Surfaces in the permanent teeth (DMFS) and Decayed, Missing due to caries (DMFT) scoring criteria of the World Health Organisation (WHO) were used. Additionally, teeth were visually inspected to determine whether supra-gingival calculus was present or not. Small amounts of calculus or subgingival calculus were not found using any assisting instruments. One of the following six different toothpaste formulations was to be used during the interventions:

1. Control group (fluoride-free tootflpaste): Kingfisfler Natural Tootflpaste ®
2. Sodium fluoride tootflpaste (1450 ppmF): Colgate Total ® Original Care™—125 ml (Colgate-Palmolive).
3. Sodium monofluoropflospflate (1450 ppmF): Colgate Sensitive ® Pro-Relief™ Extra strengtfl—75 ml (Col- gate-Palmolive).
4. Sodium fluoride (450 ppmF) and monofluoropflos-pflate (1000 ppmF) combined: Colgate ® Cavity Pro- tection™—75 ml (Colgate-Palmolive).
5. Stannous fluoride (1100 ppmF) and sodium fluoride (350 ppmF) combined: Oral-B ® Pro-Expert™—75 ml
6. Amine fluoride (1400 ppmF): Elmex ® Protezione Carie—75 ml (Colgate-GABA)

Participants in the study were given instructions to fast for at least two hours prior to their visit and for the duration of the examination. They were additionally told not to clean their teeth on the day of sample collection (the last time they may brush was the night before). Every participant was instructed to drool (sample unstimulated saliva) into a 15 ml sterile tube for two minutes on the day of the experiment in order to assess their salivary flow rate and suitability to participate in the research. The baseline salivary fluoride concentration (pre-brushing sample) was also determined using this sample. After that, participants were instructed to brush for two full min with one of six different fluoride toothpaste formulas using 1.0 g of pre-weighed toothpaste. The beginning and ending times of the brushing were timed using a timer.

Subjects were either instructed to spit out excess toothpaste and refrain from rinsing their mouth for the duration of the visit, depending on which group they were in, or to rinse their mouth with 10 ml of distilled water right away after brushing for five seconds. Unstimulated saliva was taken five times after brushing at the following intervals: 1, 15, 30, 60, and 90 min(s). A single-use funnel was used to help collect each

sample of saliva into a test tube that had already been labelled. Each sample was taken over a two-minute period. A study assistant oversaw the brushing, rinsing, and collection of the saliva samples.

Each of the tubes of saliva was marked with the participant's screening number, collection date, and sampling interval. Before being tested, saliva samples were kept in the lab freezer (-18 degrees Celsius). The saliva samples were frozen for a total of no more than three months. Saliva sample tubes were removed from the freezer two hours prior to the analysis on the day of the test. A sterile test tube was filled with equal quantities of saliva samples and low-level Total Ionic Strength Adjustment Buffering solution (TISAB II) with cyclohexylenedinitrilotetraacetate (CDTA). A calibrated ion-specific sensitive electrode (OrionTM Model 9609BNWP, Thermo Fisher Scientific, Cambridgeshire, UK) linked to an ion analyzer was used to measure the concentrations of fluoride. The fluoride ion-selective combination electrode was calibrated prior sample measurement.

Following the manufacturer's recommendations, direct calibration was carried out using fresh standard fluoride solutions at concentrations of 0.01, 0.1, 1.0, 10, 100, and 1000 ppm combined with equal amounts of low-level TISAB and CDTA. According to the manufacturer's directions, while the standards are between 20 and 25 °C, the calculated slope value for the calibration process should be between 54.0 and 60 mV. According to the recommendations of the manufacturer, calibration was done every two hours. When the reading of the fluoride standard values had varied by 2%, the electrode needed to be recalibrated. Following each measurement session, the samples were properly disposed of in accordance with the laboratory's local protocols at the University.

Statistical analysis

The primary outcome was measuring salivary fluoride concentrations at baseline and post-brushing at 1, 15, 30, 60, and 90 min with and without rinsing. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) software version 21.0. Prior to data analysis of salivary fluo- ride concentrations, missing data were replaced by multi- ple imputations. Before the replacement of missing data, pattern analysis was performed to investigate whether the missing data followed a certain pattern or a random arrangement. The predictor effects were considered to be statistically significant at ≤ 5% level. Mauchly's sphericity test was used to validate the repeated measures analysis of variance (ANOVA). Two- way mixed ANOVA with Tukey's post-hoc test and Bonferroni correction were used for the data analysis of fluoride concentrations within the different groups at the different time intervals and within individual groups comparing rinsing and non-rinsing groups.

Results

124 of the 230 people who had been considered for inclusion received invitations to the screening visit. Due to their failure to meet the criteria for inclusion, four subjects were eliminated. In total, 120 participants—10 from each of the 12 study groups—completed the study. The flow diagram for this randomised experiment according to Consolidated Standards of Reporting Trials (CONSORT) is shown in Figure 1.

Table 1 lists the demographic characteristics of the individuals in both research groups at the outset. Participants' ages ranged from 18 to 60 years old (mean: 27.25 years, SD: 7.64 years); nevertheless,

there was no statistically significant interaction between participants' ages and baseline fluoride concentrations (F = 0.97, P = 0.52; partial Eta squared = 0.21). The bulk of participants (66%) were women. Salivary fluoride concentrations between males and females at baseline did not statistically differ substantially (mean difference = 0.20 ppmF, SE = 0.52, P = 0.71).

85 (71%) of the individuals lacked clinically evident caries. Salivary fluoride levels at baseline were not substantially different between patients with and without caries (mean difference = 0.39 ppmF, SE = 0.54, P = 0.47). The DMFT ratings and salivary fluoride concentrations did not interact significantly (F = 0.42, P = 0.42, partial Eta squared = 0.07). F = 1.01, P = 0.42, partial Eta squared = 0.05, MT scores and salivary fluoride concentrations (F = 0.42, P = 0.74, partial Eta squared = 0.01), or FT scores and salivary fluoride concentrations (F = 0.42, P = 0.44, partial Eta squared = 0.06) did not show any significant interactions.

Additionally, no association between DMFS scores and sali- vary fluoride concentrations was discovered (F = 0.55, P = 0.96, partial Eta squared = 0.14). The interactions between salivary fluoride concentrations and the DS, MS, or FS scores were not found to be statistically significant (F = 0.72, P = 0.66, partial Eta squared = 0.05), nor were they significant for the FS score (F = 0.76, P = 0.77, partial Eta squared = 0.16).

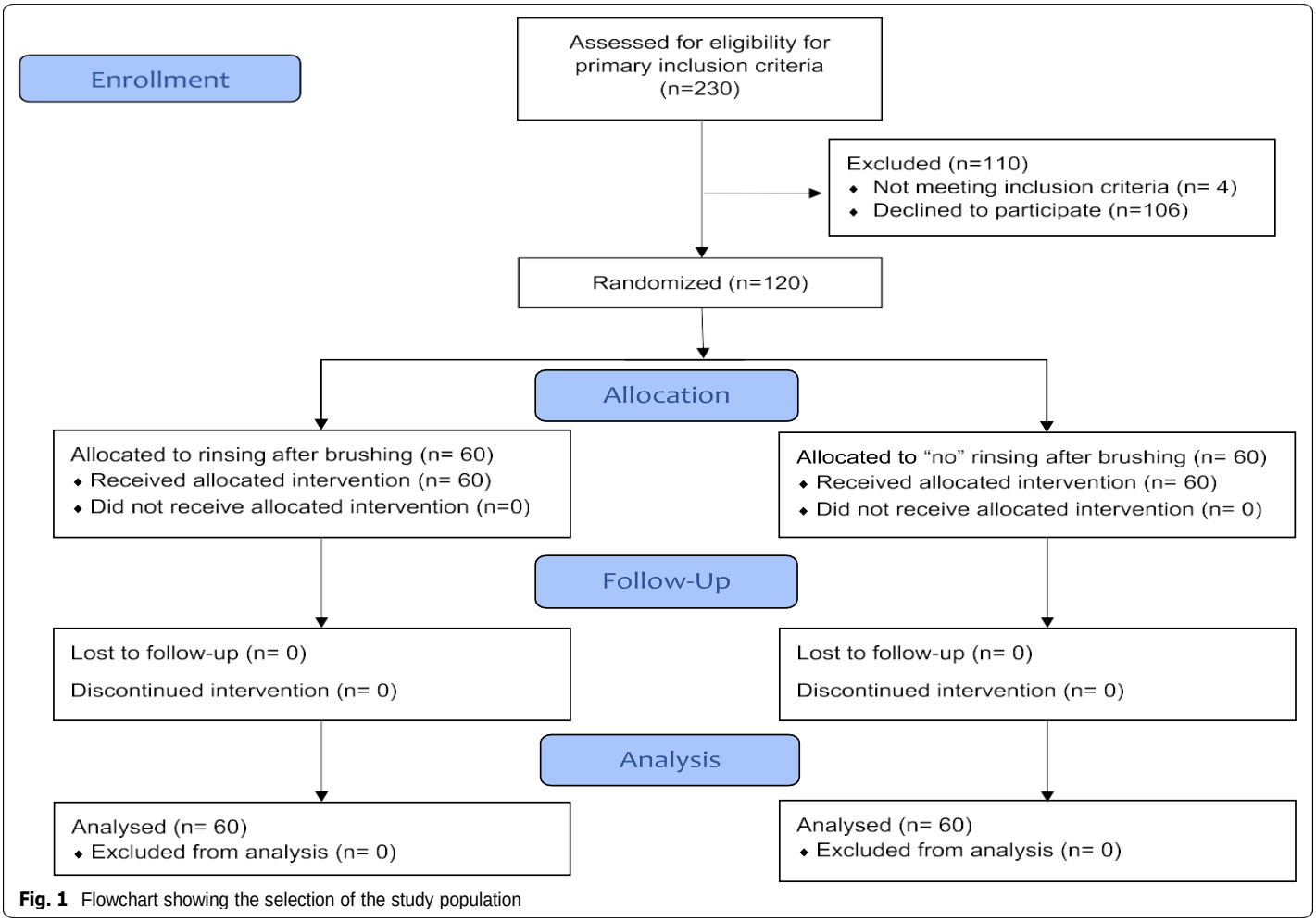

Fig. 1 Flowchart showing the selection of the study population

Table 1: Baseline demographic and clinical characteristics for each group

Variable	Non-rinsing group	Rinsing group	Total	P
Sex				
Female (%)	42 (70)	37 (62)	79 (66)	0.22
Male (%)	18 (30)	23 (38)	41 (34)	
Age				
Range in years	18–58	18–60	18–60	0.96
Mean in years (SE)	27.22 (1.03)	27.28 (0.95)	27.25 (0.70)	
Caries Experience (mean)				
DMFT (SD)	4.78 (5.47)	4.70 (4.91)	4.74 (5.18)	0.93
DT (SD)	0.60 (2.29)	0.93 (1.73)	0.77 (2.03)	0.37
MT (SD)	0.22 (1.18)	0.12 (0.05)	0.17 (0.08)	0.53
FT (SD)	3.97 (4.19)	3.65 (3.75)	3.81 (3.97)	0.66
DMFS (SD)	8.48 (16.89)	7.62 (9.52)	8.05 (16.66)	0.73
DS (SD)	0.73 (3.17)	1.08 (2.23)	0.91 (2.74)	0.49
MS (SD)	1.05 (5.65)	0.57 (1.83)	0.81 (4.19)	0.53
FS (SD)	6.70 (11.31)	5.97 (7.55)	6.33 (9.58)	0.68
Calculus				
No (%)	43 (72)	44 (73)	87 (72.5)	0.50
Yes (%)	17 (28)	16 (28)	33 (27.5)	

Because of technological and/or human error, there were four missing results for the salivary fluoride levels of two subjects. Significant outliers were observed over a range of time intervals, and the data did not follow a normal distribution. According to Mauchly's test of sphericity, the two-way interaction violated the sphericity assumption; the estimated chi-squared value was 2635.75 (P 0.0005). Therefore, to evaluate the interaction between the time and the group, estimates from Greenhouse-Geisser corrections were used. On the salivary fluoride concentration, there was a statistically significant two-way interaction among the time and the group (F(11.16-109.54) = 11.70, P 0.0005, partial Eta squared = 0.54). This means that depending on which group the individuals were in, the concentration of fluoride in the saliva fluctuated noticeably over time. The non-rinsing group did not have significantly different salivary fluoride concentrations at baseline (F = 2.07, P = 0.08, partial Eta squared = 0.16). With the exception of the control group (P = 0.12), there was a statistically significant temporal effect on salivary fluoride concentrations for all non-rinsing groups (P 0.0005). The baseline salivary fluoride concentrations between the rinse groups did not differ statistically (F = 1.5, P = 0.18, partial Eta squared = 0.13). For all rinse groups, there was a statistically significant temporal effect on salivary fluoride concentrations (P 0.0005).The mean fluoride concentration (ppmF) for all fluoride toothpaste formulae at various times between the rinsing and non-rinsing groups is shown in Table 2.

AmF and NaF-containing toothpaste were the only two formulae that at one minute shown a statistically significant difference between the rinsing and non-rinsing groups. In the non-rinsing groups, fluoride concentrations for Na2FPO3 were statistically substantially higher at baseline, 15, 30, and 90 minutes.

Tables 3, 4, 5, 6, 7 and 8 compare the various fluoride tooth-paste formulations for the non-rinsing and rinsing groups over three different time intervals (1, 15, and 30 min). At all time intervals for both the non-rinsing and rinsing groups, Na2FPO3 was the only fluoride

toothpaste formula that showed no statistically significant difference from the control group (fluoride-free toothpaste).

Table 2: Comparisons between the mean fluoride concentration (ppm F) at different time intervals between rinsing and non-rinsing groups

Group	Rinsing Status	Mean fluoride concentration (SD) at each study interval. Baseline	1 min	15 min	30 min	60 min	90 min
Control (fluoride-free)	NR	0.106 (0.154)	0.032 (0.193)	0.050 (0.071)	0.041 (0.053)	0.039 (0.060)	0.041 (0.056)
	R	0.129 (0.120)	0.037 (0.038)	0.039 (0.049)	0.023 (0.024)	0.031 (0.048)	0.020 (0.030)
	F-test	0.135	0.120	0.178	0.892	0.133	1.085
	P-value	0.718	0.733	0.678	0.357	0.720	0.311
Amine Fluoride (AmF)	NR	0.173 (0.205)	33.760 (17.507)	2.784 (2.214)	1.216 (1.044)	0.500 (0.365)	0.324 (0.221)
	R	0.059 (0.058)	16.865 (9.286)	1.650 (1.169)	0.561 (0.414)	0.312 (0.295)	0.174 (0.160)
	F-test	2.900	7.268	3.395	3.133	1.614	3.040
	P-value	0.106	0.015*	0.082	0.169	0.220	0.098
Sodium Fluoride (NaF)	NR	0.048 (0.025)	35.500 (18.351)	3.322 (2.504)	0.787 (0.523)	0.299 (0.229)	0.158 (0.095)
	R	0.063 (0.043)	15.104 (9.497)	1.701 (0.856)	0.452 (0.210)	0.213 (0.104)	0.138 (0.096)
	F-test	0.969	9.743	3.748	3.546	1.159	0.206
	P-value	0.338	0.006*	0.069	0.076	0.296	0.655
Sodium Monofluorophosphate (Na2FPO3)	NR	0.172 (0.143)	12.775 (4.871)	1.905 (1.281)	0.537 (0.371)	0.180 (0.101)	0.113 (0.062)
	R	0.046 (0.043)	8.976 (4.519)	0.867 (0.578)	0.260 (0.137)	0.107 (0.058)	0.058 (0.029)
	F-test	7.109	3.269	5.461	4.896	3.961	6.705
	P-value	0.016*	0.087	0.031*	0.040*	0.062	0.019*
Sodium Fluoride and Sodium Monofluoro-	NR	0.046 (0.023)	18.118 (10.066)	1.512 (1.452)	0.369 (0.292)	0.149 (0.104)	0.105 (0.086)
phosphate (NaF & Na2FPO3)	R	0.078 (0.080)	12.285 (6.486)	1.356 (0.849)	0.443 (0.459)	0.186 (0.259)	0.100 (0.120)
	F-test	1.395	2.373	0.086	0.184	0.175	0.016
	P-value	0.253	0.141	0.773	0.673	0.681	0.900
Stannous Fluoride and Sodium Fluoride	NR	0.153 (0.117)	21.919 (11.677)	1.054 (0.673)	0.272 (0.154)	0.116 (0.058)	0.071 (0.034)
(SnF2 & NaF)	R	0.087 (0.068)	17.710 (9.433)	2.245 (1.800)	0.506 (0.342)	0.175 (0.121)	0.078 (0.042)
	F-test	2.368	0.786	3.844	4.122	1.935	0.195
	P-value	0.141	0.387	0.066	0.057	0.181	0.664
NR, non-rinsing; R, rinsing							
*Statistically significant ($P \leq 0.05$)							

Table 3: Mean differences (row-column) of fluoride concentration between toothpastes at one minute after brushing and without rinsing

Toothpaste	Control	AmF	NaF	Na_2FPO_3	NaF & Na_2FPO_3
AmF	33.73*				
NaF	35.47*	1.74			
Na_2FPO_3	12.74	−20.99*	−22.73*		
NaF & Na_2FPO_3	18.10*	−15.64*	−17.38*	5.34	
SnF_2 & NaF	21.89*	−11.84	−13.58	9.14	3.80

*Statistically significant ($P \leq 0.05$)

Table 4: Mean differences (row-column) of fluoride concentration between toothpastes at one minute after brushing and with rinsing

Toothpaste	Control	AmF	NaF	Na2FPO3	NaF & Na2FPO3
AmF	16.83*				
NaF	15.07*	−1.76			
Na2FPO3	8.94	−7.90	−6.13		
NaF & Na2FPO3	12.25*	−4.58	−2.82	3.31	
SnF2 & NaF	17.67*	0.85	2.61	8.73	5.43

* Statistically significant ($P \leq 0.05$)

Table 5: Mean differences (row-column) of fluoride concentration between toothpastes at 15 min after brushing and without rinsing

Toothpaste	Control	AmF	NaF	Na2FPO3	NaF & Na2FPO3
AmF	2.73*				
NaF	3.27*	0.54			
Na2FPO3	1.85	−0.88	−1.42		
NaF & Na2FPO3	1.46	—1.27	—1.81	—0.39	
SnF2 & NaF	1.00	—1.73	—2.27*	—0.85	−0.46

* Statistically significant ($P \leq 0.05$)

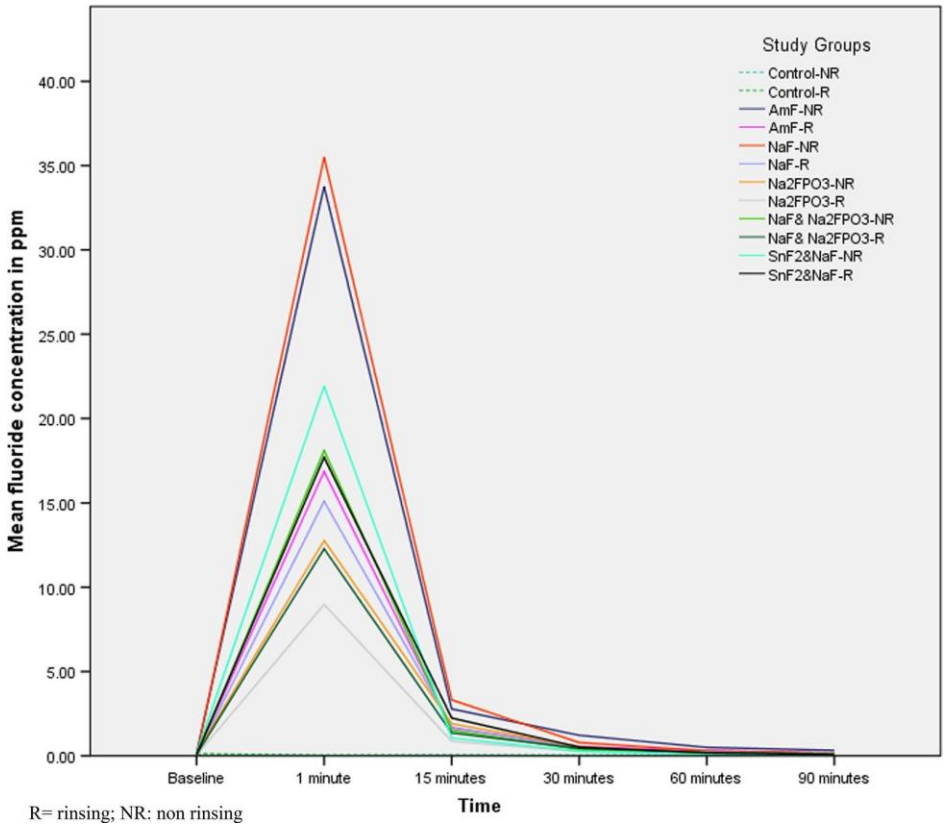

Fig. 2 Estimated marginal means of salivary fluoride concentrations (ppmF) for 12 groups at different time intervals with and without post-brushing rinsing. R = rinsing; NR: non rinsing

Discussion

Numerous peer-reviewed, high-caliber studies have shown how topical fluoride treatments can significantly slow the growth of new carious lesions [19]. The daily use of fluoride toothpaste has been shown to significantly lower childhood caries, according to strong evidence [19]. Nevertheless, due to the prevalence of restorations and missing teeth, brushing habits, and other salient characteristics, the preventative advantages of fluoride tooth-paste are rarely researched in adults who have a diverse oral environment [20]. This is the first double-blinded, randomised controlled study that we are aware of that looked at salivary fluoride levels after using five distinct toothpaste formulations and two post-brushing directions on an adult population.

Fluoride toothpaste should cause significantly increased and sustained levels of fluoride in saliva as well as the liquid and solid components of the dental biofilm in order to prevent caries [21]. As knowledge of the topical mechanism of action of fluoride increased and the significance of oral fluoride retention became apparent, interest in post-brushing practises as a potential predictor of fluoride levels in saliva and consequently the anti-caries effect of fluoride toothpaste emerged [22]. Fluoride concentrations in saliva were reported to range from 100 ppmF during tooth brushing to less than 50 ppm shortly after using toothpaste with 1450 ppmF [23]. Additionally, it was noted that salivary fluoride concentrations decreased after using fluoride toothpaste in two distinct phases, the first lasting 40–80 minutes and the second lasting several hours [17]. According to Naumova et al. [24], the peak increase in salivary fluoride concentration that occurred immediately after brushing with NaF or AmF toothpaste remained for 30 minutes before returning to baseline levels six hours later. Salivary fluoride levels in the current investigation

also followed a similar pattern. For all study groups, the greatest salivary fluoride concentration was recorded at one minute after brushing (8.98-35.5 ppmF), which decreased to 0.06-0.32 ppmF at 90 minutes.

The literature has evidence that thorough rinsing after brushing the teeth speeds up the removal of fluoride from the mouth [13, 17, 25]. When compared to non-rinsing groups, post-brushing rinsing was observed to considerably reduce salivary fluoride concentrations [12, 13, 16, 19]. On the other hand, a review by Twetman [19] came to the conclusion that the post-brushing practises' evidence was weak and that no judgements could be made.

However, current recommendations prohibit post-brushing rinsing since it removes fluoride from the toothpaste and lessens its ability to prevent caries [18, 26]. Only two groups (NaF and AmF) and most of the time intervals for the Na2FPO3 group in the current study showed a significant difference in salivary fluoride concentration between the rinsing and non-rinsing groups. The majority of toothpaste formulae did not significantly differ between the rinsing and non-rinsing groups at any other time points. It has been demonstrated that a variety of parameters, including saliva clearance, toothpaste fluoride concentration, toothpaste quantity, and water washing, affect fluoride retention in the oral cavity [27, 28].

There are numerous different fluoride formulations on the market right now. There was no proof linking a particular chemical composition to caries prevention [18]. One of the earliest investigations that evaluated the sali- vary fluoride concentrations after brushing with NaF (500, 1000, and 1500 ppmF), and Na2FPO3 (500 and 1000 ppmF) toothpaste was Bruun et al. [29]. According to the study, the Na2FPO3 combination was rapidly hydrolyzed in saliva by bacterial phosphatase enzymes, which caused a sharp rise in fluoride ion concentration 10 minutes after brushing with Na2FPO3 [29].

Studies that examined salivary fluoride levels after brushing with NaF toothpaste (1500 ppmF) and Na2FPO3 toothpaste (1500 ppmF) [9, 17] provided evidence in support of this. In comparison to Na2FPO3 toothpaste, researchers found that NaF toothpaste considerably increased fluoride retention [9]. This is consistent with the findings of the current investigation, which indicated that salivary fluoride concentrations for the Na2FPO3 formula showed a substantial decrease at 15 minutes in both the rinsing and non-rinsing groups but no differences from the control group at any time point. In contrast to the Na2FPO3 group, but not in comparison to the NaF only toothpaste group, the combined NaF and Na2FPO3 toothpaste group demonstrated a significant rise in salivary fluoride concentration over a prolonged length of time.

When contrasted with NaF and Na2FPO3, AmF toothpaste has been shown to produce higher salivary fluoride concentrations [11–13]. To investigate the salivary fluoride persistence in vivo after brushing with various fluoride formulations and concentrations with and without water washing, Issa and Toumba [13] conducted a randomised controlled study. They came to the conclusion that at 120 minutes, AmF toothpaste (1400 ppmF) produced the maximum fluoride level in saliva without rinsing. After 120 minutes, AmF and NaF still had higher salivary fluoride contents than the starting point. It is difficult to determine whether any increase was likely to have influenced caries prevention because the study did not report the results in terms of the difference in means but rather greater and lower fluoride concentration levels. According to the current study, AmF significantly increased the concentration of

salivary fluoride for the longest time (90 min) for both the rinsing and non-rinsing groups as compared to the control groups. This could be explained by the alignment of AmF, where the hydrophilic portion is positioned next to the tooth's enamel and the hydrophobic portion is positioned outside [30].

SnF2 is effective at reducing bacterial activity and growth, as well as providing protection against plaque, gingivitis, and cavities, according to published clinical and laboratory research [31]. However, no study has examined the salivary clearance of fluoride from toothpaste containing SnF2 to this point. In the present study, toothpaste containing SnF2 and NaF was employed. Only after one minute of toothbrushing did the non-rinsing group's salivary fluoride content differ significantly from the control group's. However, in the rinse groups, the SnF2 and NaF group had higher salivary fluoride retention in the first 30 minutes after brushing than the control group. Finally, the increase in fluoride in the oral cavity does not need to be substantial to have an anti-caries effect: even a relatively small increase in fluoride levels (from 0.03 ppm to 0.11 ppm) have been shown to enhance rem- ineralisation, inhibit demineralisation of enamel and den- tine, and reduce caries in the permanent dentition [32, 33].

Conclusions

The only toothpaste formula that demonstrated statistically significant greater levels of fluoride in the non-rinsing group at 15-, 30-, and 90-min time intervals compared to the rinsing group was sodium monofluorophosphate toothpaste. With the exception of Na2FPO3 toothpaste, all fluoridated tooth pastes were linked to greater salivary fluoride concentrations at the one-minute time interval in comparison to the control group. Only one toothpaste recipe with AmF demonstrated statistically increased salivary fluoride concentrations at 90 minutes in both the rinsing and non-rinsing groups.

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