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고분자접착테잎(F-PVA)의 상아질 지각과민증 감소효과에 관한 임상적 평가

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Clinical evaluation of polymer adhesive tape containing 5% NaF(F-PVA) on dentin hypersensitivity reduction

2013년 2월 25일

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지도교수 이 상 호

이 논문을 치의학 박사학위신청 논문으로 제출함

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조선대학교 대학원

치 의 학 과

장 향 길

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위 원 조선대학교 교 수 이 상 호 인

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조선대학교 대학원

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고분자접착테잎(F-PVA)의 상아질 지각과민증 감소효과에 관한 임상적 평가

장 향 길
지도교수 : 치의학 박사 이 상 호
치의학과
조선대학교 대학원

본 연구는 불소 함유 폴리비닐알콜(fluoride polyvinyl alcohol , F-PVA) 테잎의 상아질 지각과민증 완화효과를 기존의 불소제제(Varnish™ white varnish, ClinPro™XT varnish) 및 위약과 비교한 연구이다. 상아질 지각과민증을 지닌 30명의 건강한 성인(79개 치아)을 대상으로 평가하였다. 대상자들은 3개의 실험군과 1개의 대조군으로 4개의 그룹으로 분류하여 실험하였다. 불소 제제는 제조사의 지시에 따라 도포하였다. 대상치아에 불소 제제 도포 전과 3일 후, 4주 후, 8주 후, 12주 후 압축공기와 얼음막대로 자극을 주어 통증의 정도를 visual analog scale(VAS)를 통해 측정하였다.

압축공기자극에서 VAS score의 변화는 12주째에서 Varnish™ white varnish와 ClinPro™ XT varnish, F-PVA에서 각각 -28.75(SD=22.69), -25.15(SD=14.95), -22.10(SD=9.63) 이었고 대조군에서 -14.42(SD=14.06)로 나타나 통계학적으로 유의한 차이를 보였다($P < 0.05$).

얼음막대자극에서 VAS score의 변화는 12주째에서 F-PVA는 -34.00(SD=21.43), 대조군에서 -24.36(SD=13.11)로 통계학적으로 유의한 차이를 보였다($P < 0.05$).

F-PVA의 상아질 지각과민증 치료효과는 기존의 불소 바니쉬와 유사한 효과를 보였으며, 임상에서 F-PVA 적용이 가능할 것으로 보여 진다.

I. Introduction

Dentin hypersensitivity is a common condition characterized by short and strong pain associated with external stimuli, such as heat, evaporation, touch, osmotic pressure, and chemical stimulation.[1] The condition is caused mainly by chronic trauma from tooth brushing, acid corrosion from acid reflux, anatomical factors, periodontal disease and gingival recession due to periodontal surgery.[2-6] Recently, the procedure of tooth whitening is also considered as a cause of dentin hypersensitivity.[7]

It has been reported that dentin hypersensitivity has been observed in 14-30%[8-14] of the population and occur frequently in adults and in more women than in men. The canines and premolars are the most frequent regions suffering from this condition.[15, 16]

Although mechanisms which develop the dentin hypersensitivity have not yet been explained well, the hydrodynamic theory proposed by Brannstom and others is the most widely accepted.[17] The Hydrodynamic theory is based on the fluid flow in dentinal tubules which can trigger nerve endings in the dental pulp and cause pain.

On the base of the above mechanism, a treatment option for dentin hypersensitivity would be to seal the exposed dentinal tubule to suppress fluid movement and to reduce dentin permeability.

Many agents have been proposed to alleviate the discomfort from dentin hypersensitivity including corticosteroids, silver nitrate, zinc and strontium chloride, formaldehyde, glutaraldehyde, sodium citrate, potassium oxalate, resin adhesives and fluorides.[18, 19] Laser irradiation and restorative materials such as composite resin and glass ionomer have also been used for physical obstruction of dentinal tubules.

Fluoride varnish is considered an effective method for treating dentin hypersensitivity because of it has the characteristic of adhesion to the

tooth surface that results in continuous release of fluoride. The mechanism of action is the deposition of calcium fluoride (CaF_2) on the tooth surface that acts as a fluoride reservoir to supply fluoride over a period of time to form the fluorapatite.

On the other hand, fluoride varnish has disadvantages that include being easily washed away by saliva, temporary discoloration of teeth, unpleasant taste and a sticky texture. Considerable effort has been made to identify a new media such as bioactive glasses, shellac, and resin-based materials to supply fluoride more effectively to the tooth surface.[20-22)]

As a method to overcome the disadvantages of fluoride varnish, we have developed a fluoride-polyvinyl alcohol (F-PVA) tape as an experimental fluoride delivery material. PVA has been widely used in fabric and paper sizing, adhesives, packing film, and fiber coating. It has also has been used in manufacturing medical materials such as human organ replacement hydrogel, drug delivery systems, bio-sensors, bio-reactors, and hemostatics. The F-PVA tape is colorless, tasteless, biocompatible, and is a self-dissoluble polymer that has adhesive characteristics if it is contacted with moisture.

Recently, the inhibition effect of F-PVA tape on enamel demineralization has been demonstrated in an *in vitro* study.[23)] This result has strengthened the rationale for clinical application of F-PVA tape as a desensitizing agent.

The objective of this study was to evaluate the efficiency of F-PVA tape in reducing dentin hypersensitivity.

II. Materials and Methods

This study protocol was approved (#123-456) by the Institutional Review Board (IRB) Chosun University Dental Hospital, Gwangju, Korea. The written informed consents were obtained from all participants prior to study enrolment and process of the study were informed to participants. The study design is shown in Fig. 1.

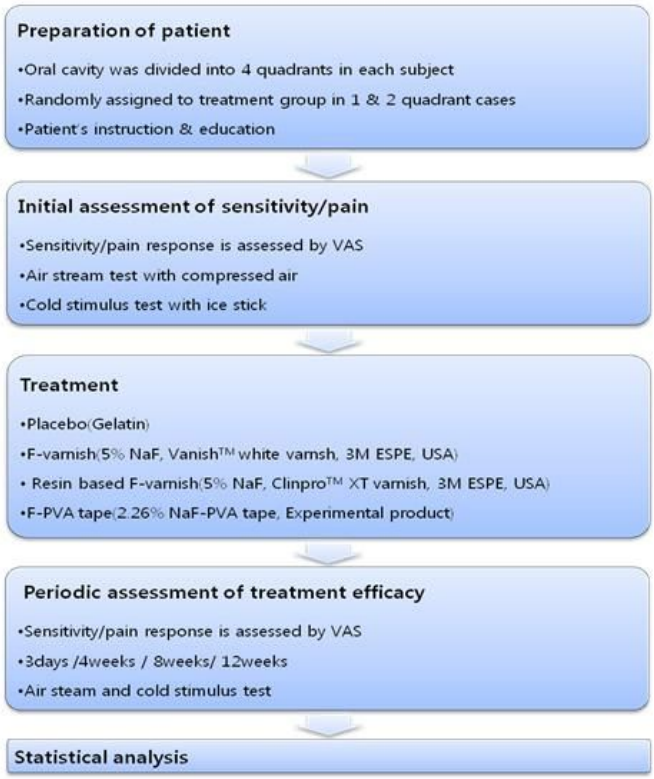

Fig. 1. Illustration of the study design.

1) Preparation of F-PVA tape

PVA (10 g) and polyacrylic acid (5 g) were added to 85 g of distilled water and the mixture was stirred for 2 hours at 85℃. Polyethylene glycol (3 g) as a plasticizer and NaF (0.95 g) were added progressively

and stirred for 2 hours at 85℃. Then, the mixture was poured onto a glass plate, and spread to a uniform width (20 μm) using an applicator and then dried for 24 hours at 60℃ (Fig. 2). The thickness of F-PVA tape was set to 20μm through a pre-test, which had adequate tensile strength and elasticity so adhesion to the tooth did not decrease. In addition, methyl cellulose (MC) was added to the PVA to limit the degradation time by saliva within 60 min after attachment. The F-PVA tape is shown in Fig. 3

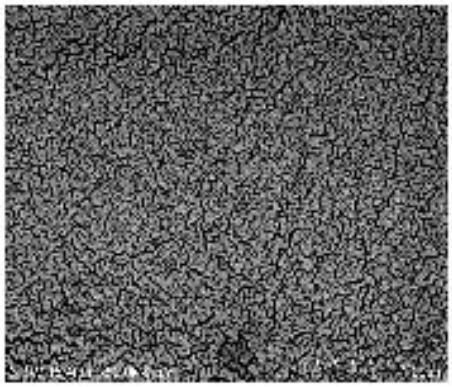

Fig. 2. The mixture was poured onto a glass plate.

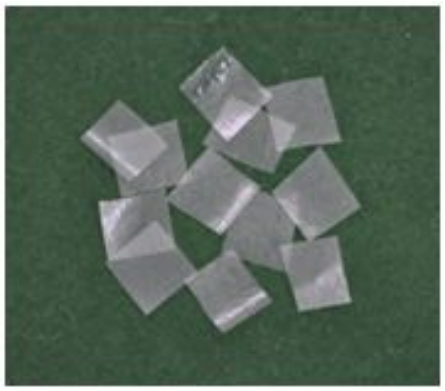

Fig. 3. The F-PVA tape.

2) Selection of subjects

Subjects were selected from patients presenting dentin hypersensitivity who came to the Chosun University Dental Hospital, Gwangju, Korea. Thirty men and women among healthy young patients with dentin hypersensitivity were enrolled in this study.

Excluded subjects and teeth were determined according to the standards provided by Holland et al[24], which included: a person who recently went to the dentist for the treatment of hypersensitivity, had used a hypersensitivity treatment agent within recent 6 weeks, had taken anti-inflammatory analgesic drug for a long time, had feeding and eating

disorders, a systemic disease, those exposed to excess amounts of acid due to food or environment, and those who received orthodontic treatment or periodontal surgery within the last 3 months. In addition, the following teeth were excluded: teeth with defects on the subject teeth or surrounding tissue, teeth that were restored within the last 3 months, abutment teeth of fixed or removable prosthesis, teeth that had been restored for complete coating metal crown, widely restored teeth, teeth that were restored to the testing area, and teeth with caries.

Seventy nine teeth from 30 patients with a mean age of 31.07 were included in this study (Table 1 and 2). Split mouth assessment design was adopted in this study because it has advantages for statistical analysis by standardizing the oral environment and pain perception of subjects. The oral cavity of each subject was divided into four quadrants that were considered to be an assessment unit and randomly assigned to test groups in accordance with following application agents (Fig. 4):

- Subject with sensitive teeth in four quadrants: fluoride varnish, resin-based fluoride varnish, F-PVA, and placebo in each quadrant.
- Subject with sensitive teeth in three quadrants: Fluoride varnish, resin-based fluoride varnish, and F-PVA in each quadrant.
- Subject with sensitive teeth in two quadrants: placebo in one quadrant and one of three agents (fluoride varnish, resin-based fluoride varnish, F-PVA) in the other quadrant.
- Subject with sensitive teeth in one quadrant: one of four agents (placebo, fluoride varnish, resin-based fluoride varnish, F-PVA)

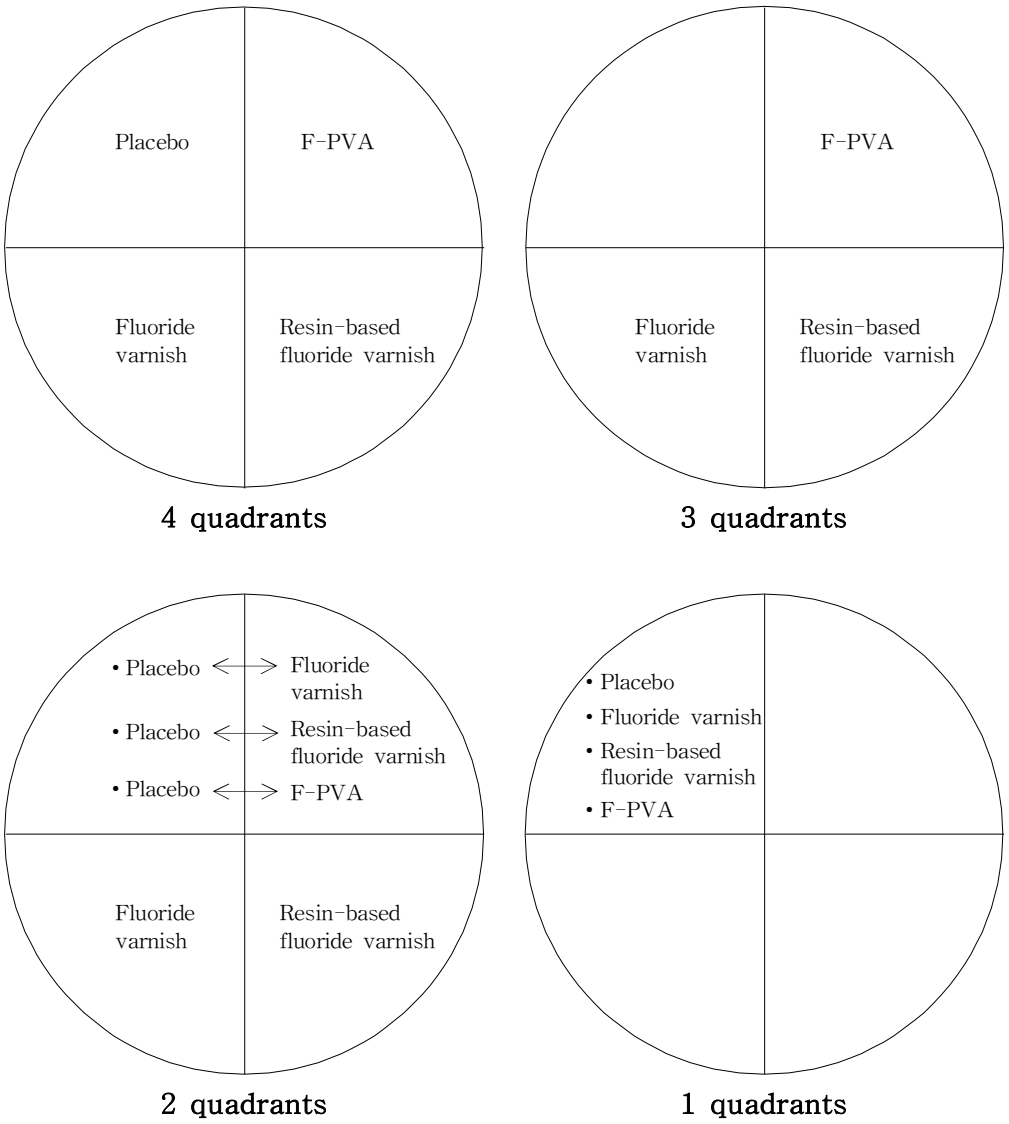

Fig. 4. Oral cavity of each subject was divided into four quadrants.

3) Clinical assessment of hypersensitivity

Instead of a double-blind test, a subject-blind test was designed in which only the subject was not aware of the agent's name since the investigator could perceive the agents during the procedure due to the different application methods. To avoid the preconception of investigator,

two trained dentists participated in this procedure as investigators. One was responsible for applying agents and the other was responsible for testing the subject's response to stimuli.

The teeth to be evaluated were isolated with a cotton roll, the area stimulated was wiped with a cotton pellet, and the moist condition was maintained until the next stimulus was given.

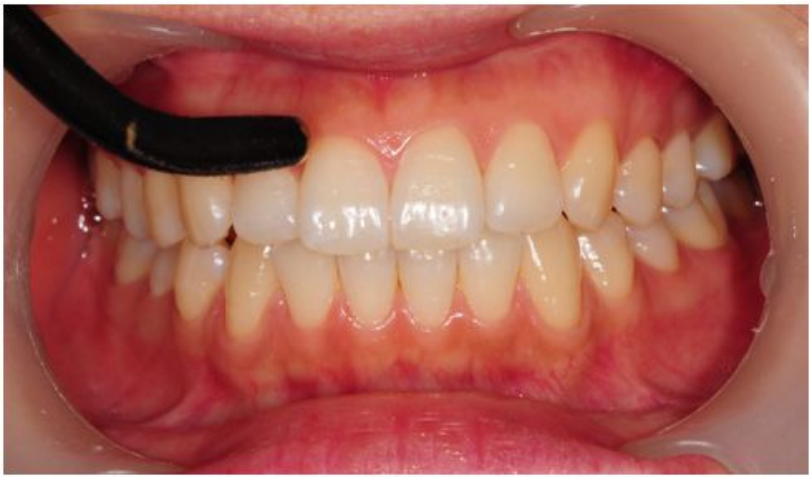

Fig. 5. Air stream test using a dental air/water syringe.

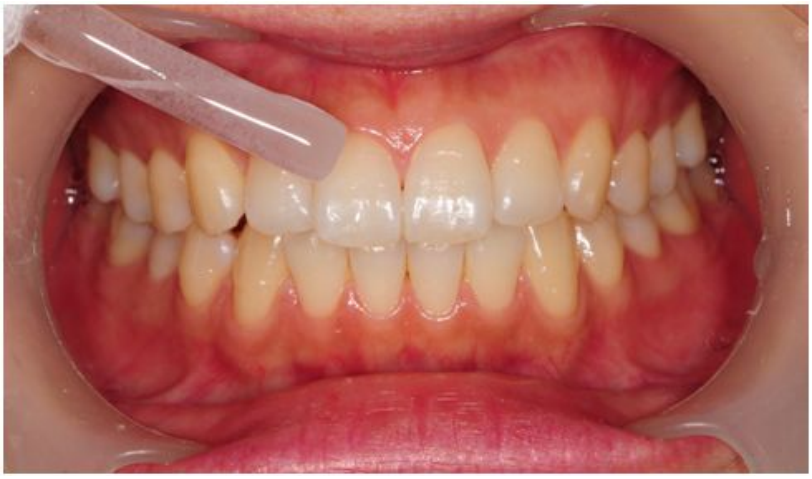

Fig. 6. Cold stimulus test with an ice stick.

Two stimulation methods were used: one with blowing strong compressed air 10 mm away from the tooth surface for 2 sec using a three way syringe attached to the dental unit and chair, and the other by touching the tooth surface with an ice stick for 2 sec.

Two stimuli were performed at more than 5 min intervals to avoid overlap of each stimulus.

The degree of hypersensitivity was recorded directly by the patients using a visual analog scale (VAS) indicating the degree of pain using consecutive bars from 0 to 100.[25] The patients were asked to report the degree of pain from 0, if they did not feel any pain, to 100, if they suffered very severe pain with a grimacing face.

Assessment of hypersensitivity was performed before treatment and at 4, 8, and 12 weeks after treatment by one trained dentist. The subject's response before treatment was considered as a baseline measurement.

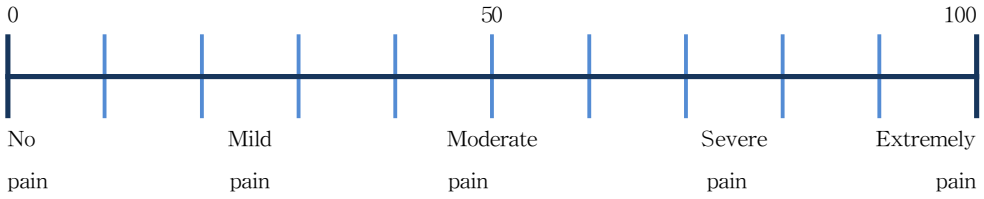

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Fig. 7. Visual analog scale (VAS).

4) Treatment

Thin gelatin was used as a placebo. Two commercially available fluoride varnishes, Varnish™ (3M ESPE, USA) and ClinPro™ XT varnish, were used to compare the treatment efficacy with F-PVA tape (experimental product)(Table 1, 2).

Table 1. Characteristics of the subjects

Subject	Number	Mean age	Quadrant			
			One	Two	Three	Four
Male	19	31.68	9	9	1	0
Female	11	30	4	6	0	1
Total	30	31.07	13	15	1	1

Table 2. Characteristics of the teeth

Teeth	Placebo	Varnish™	CinPro™ XT varnish	F-PVA tape
Arch				
Maxilla	10	9	3	10
Mandible	9	11	17	10
Quadrant				
One	0	8	7	9
Two	18	9	10	9
Three	0	2	2	1
Four	1	1	1	1
Tooth type				
Incisor	3	6	10	7
Canine	2	5	3	5
Premolar	14	9	7	8

Prior to the topical application of desensitizing agents, teeth received oral prophylaxis with pumice and were isolated with cotton rolls.

Placebo

Thin Gelatin™ was applied to the labial/buccal surface of the teeth

including cervical area using an application brush.

Table 3. Fluoride products tested in this clinical trial

Product	Composition	Manufacturer
Gelatin™	Amino acid	GelTec, Korea
Varnish™ white varnish	5% sodium fluoride	3M ESPE, USA
ClinPro™ XT varnish	5% sodium fluoride	3M ESPE, USA
F-PVA	5% sodium fluoride	Experimental product, Korea

Varnish™ white varnish

Entire content of varnish was dispensed from the unit package on to the mixing pad and mixed thoroughly with the brush provided. Varnish was applied evenly in a thin layer over the treatment area with a brush.

ClinPro™ XT varnish

Varnish was dispensed onto the mixing pad from the Clicker™ dispenser and mixed for 15 sec and then applied in a thin layer to tooth surface using an applicator. The coated layer was lightly cured for 20 seconds. The oxygen-inhibited layer was wiped away with a moist cotton applicator.

F-PVA

A 10 mm × 5 mm fluoride adhesive film was attached to the labial/buccal surface of the teeth including the cervical area using a cotton ball without drying the saliva. For close attachment, the smooth labial/buccal surface was tapped lightly with a cotton swab and the

interdentally space was pressed using a plastic stick so the film could go through the space.

All subjects were instructed not to take any food including water for 1 hour after application of agents, and not to brush their teeth for 6 hours post application. The subjects were allowed to eat and brush their teeth naturally from the next day. The total number of brushing was 4 times per day (after each meal and before bed). They were not allowed to take other hypersensitivity drugs and were asked to use the toothpaste without fluoride.

5) Statistical analysis

All data were processed by SPSS 17.0 (IBM, Chicago, USA) software. The descriptive statistics were performed for gender, age, intra-oral site, and type of teeth. The VAS scores were compared at the different time intervals for each agent with the paired t-test at a significance level of 0.05 (P value $<$ 0.05). The effect of agents on the reduction of hypersensitivity shown in the VAS score at each measurement time were analyzed using one-way ANOVA and followed by Tukey test as a post-hoc test at a significance level of 0.05 (P value $<$ 0.05)

III. Result

In the streamed air test, VAS scores decreased after applying each medication (Fig. 8). A significant decreased in the VAS score was observed after 3 days, 4 weeks, 8 weeks, and 12 weeks from baseline in placebo, Varnish™ white varnish, ClinPro™ XT varnish, and F-PVA by student t-test (P <0.05) (Table 4).

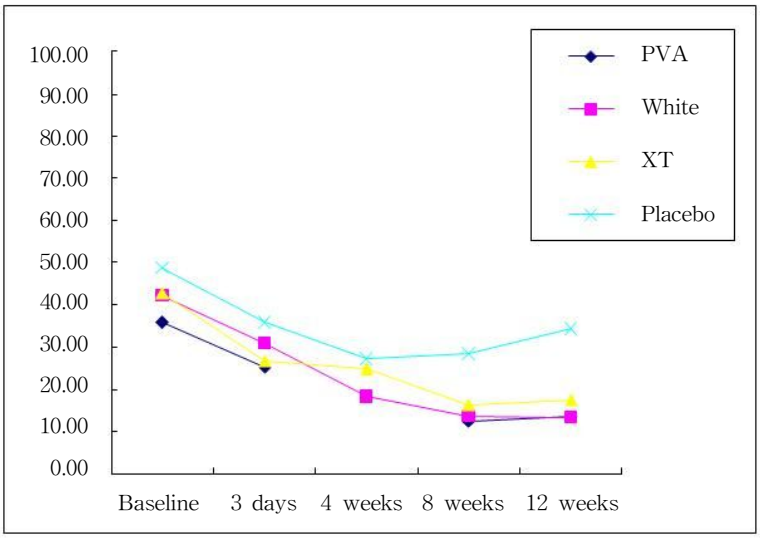

Fig. 8. Change in VAS scores over time in the air steam test.

Table 4. VAS scores change by air stream test

group	day3-base	week4-base	week8-base	week12-base
Placebo	-12.95±13.44	-21.53±23.00	-20.37±20.20	-14.42±14.06
Varnish	-11.30±11.76	-23.90±18.46	-28.40±19.47	-28.75±22.70
Clinpro XT	-15.90±14.75	-17.90±18.27	-26.30±15.50	-25.15±14.95
F-PVA	-10.50±12.01	-22.30±16.51	-23.35±17.64	-22.10±19.64
p-value	0.301	0.037	0.005	0.000

In the ice stick test, the VAS scores decreased after application of each medication (Fig. 9). A significant decreased in the VAS score was observed after 3 days, 4 weeks, 8 weeks, and 12 weeks from baseline in placebo, Varnish^{TM} white varnish, ClinPro^{TM} XT varnish, and F-PVA by student t-test(P <0.05) (Table 5).

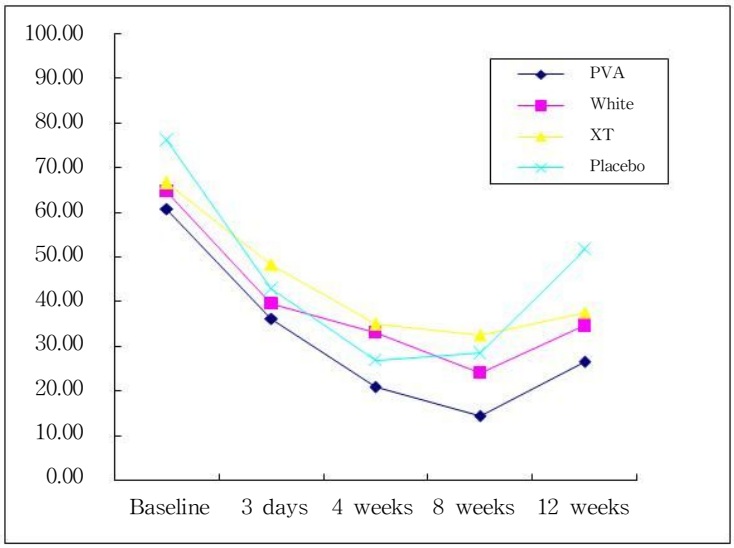

Fig. 9. Change in VAS scores over time in the ice stick test.

Table 5. VAS scores change by ice stick test

group	day3-base	week4-base	week8-base	week12-base
Placebo	-33.32±29.60	-49.21±34.75	-47.74±33.66	-24.37±13.12
Varnish	-21.83±32.92	-30.67±34.99	-39.17±30.73	-28.94±30.68
Clinpro XT	-18.25±16.54	-31.70±22.74	-34.05±21.81	-28.90±22.37
F-PVA	-24.50±28.92	-39.75±22.91	-46.30±19.04	-34.00±21.44
p-value	0.487	0.215	0.060	0.014

One-way ANOVA was performed to test the significance of the results. In the streamed air test at 4 weeks(P = 0.037), 8 weeks(P = 0.005), and

12 weeks(P 〈 0.001), there were significantly different hourly drugs mean VAS scores. In the 4th week, the difference between placebo and F-PVA had a significant difference. Similarily, the difference at 8th week between placebo and between F-PVA, Varnish^{TM} white varnish was significant. However at 12th week placebo between all another drugs was a not significant difference as followed by Tukey test (Table 6).

Table 6. Comparison of the VAS scores in the air stream test followed by Tukey test

TukeyHSD

Multiple Comparisons

Dpendent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Base	PVA	White	-6.400	6.591	.766	-23.72	10.92
		XT	-6.950	6.591	.718	-24.27	10.37
		Placebo	-12.992	6.677	.218	-30.54	4.55
	White	PVA	6.400	6.591	.766	-10.92	23.72
		XT	-.550	6.591	1.000	-17.87	16.77
		Placebo	-6.592	6.677	.757	-24.14	10.95
	XT	PVA	6.950	6.591	.718	-10.37	24.27
		White	.550	6.591	1.000	-16.77	17.87
		Placebo	-6.042	6.677	.802	-23.59	11.50
	Placebo	PVA	12.992	6.677	.218	-4.55	30.54
		White	6.592	6.677	.757	-10.95	24.14
		XT	6.042	6.677	.802	-11.50	23.59
day3	PVA	White	-5.600	5.901	.779	-21.11	9.91
		XT	-1.550	5.901	.994	-17.06	13.96
		Placebo	-10.545	5.978	.299	-26.25	5.16
	White	PVA	5.600	5.901	.779	-9.91	21.11
		XT	4.050	5.901	.902	-11.46	19.56
		Placebo	-4.945	5.978	.841	-20.65	10.76
	XT	PVA	1.550	5.901	.994	-13.96	17.06
		White	-4.050	5.901	.902	-19.56	11.46
		Placebo	-8.995	5.978	.440	-24.70	6.71
	Placebo	PVA	10.545	5.978	.299	-5.16	26.25
		White	4.945	5.978	.841	-10.76	20.65
		XT	8.995	5.978	.440	-6.71	24.70
week4	PVA	White	-4.800	5.100	.783	-18.20	8.60
		XT	-11.350	5.100	.126	-24.75	2.05
		Placebo	-13.766*	5.166	.046	-27.34	-.19
	White	PVA	4.800	5.100	.783	-8.60	18.20
		XT	-6.550	5.100	.576	-19.95	6.85
		Placebo	-8.966	5.166	.313	-22.54	4.61
	XT	PVA	11.350	5.100	.126	-2.05	24.75
		White	6.550	5.100	.576	-6.85	19.95
		Placebo	-2.416	5.166	.966	-15.99	11.16
	Placebo	PVA	13.766*	5.166	.046	.19	27.34
		White	8.966	5.166	.313	-4.61	22.54
		XT	2.416	5.166	.966	-11.16	15.99
week8	PVA	White	-1.350	4.727	.992	-13.77	11.07
		XT	-4.000	4.727	.832	-16.42	8.42
		Placebo	-15.974*	4.789	.007	-28.56	-3.39
	White	PVA	1.350	4.727	.992	-11.07	13.77
		XT	-2.650	4.727	.943	-15.07	9.77
		Placebo	-14.624*	4.789	.016	-27.21	-2.04
	XT	PVA	4.000	4.727	.832	-8.42	16.42
		White	2.650	4.727	.943	-9.77	15.07
		Placebo	-11.974	4.789	.068	-24.56	.61
	Placebo	PVA	15.974*	4.789	.007	3.39	28.56
		White	14.624*	4.789	.016	2.04	27.21
		XT	11.974	4.789	.068	-.61	24.56
week12	PVA	White	.250	4.575	1.000	-11.77	12.27
		XT	-3.900	4.575	.829	-15.92	8.12
		Placebo	-20.671*	4.635	.000	-32.85	-8.49
	White	PVA	-.250	4.575	1.000	-12.27	11.77
		XT	-4.150	4.575	.801	-16.17	7.87
		Placebo	-20.921*	4.635	.000	-33.10	-8.74
	XT	PVA	3.900	4.575	.829	-8.12	15.92
		White	4.150	4.575	.801	-7.87	16.17
		Placebo	-16.771*	4.635	.003	-28.95	-4.59
	Placebo	PVA	20.671*	4.635	.000	8.49	32.85
		White	20.921*	4.635	.000	8.74	33.10
		XT	16.771*	4.635	.003	4.59	28.95

* The mean difference is significant at the 0.05 level

The results from the ice stick test were analyzed by one-way ANOVA test between the measured hourly drugs VAS scores mean. Only in the 12th weeks was there a significant difference (P = 0.014)(Table 8). At 12th weeks there was a significant difference between placebo and F-PVA followed by Tukey test (Table 7).

Table 7. Comparison of the VAS scores in the ice stick test followed by Tukey test

TukeyHSD

Multiple Comparisons

Dpendent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Base	PVA	White	-4.028	7.330	.946	-23.30	15.24
		XT	-5.900	7.135	.842	-24.66	12.86
		Placebo	-15.461	7.228	.151	-34.46	3.54
	White	PVA	4.028	7.330	.946	-15.24	23.30
		XT	-1.872	7.330	.994	-21.14	17.40
		Placebo	-11.433	7.421	.419	-30.94	8.08
	XT	PVA	5.900	7.135	.842	-12.86	24.66
		White	1.872	7.330	.994	-17.40	21.14
		Placebo	-9.561	7.228	.552	-28.56	9.44
	Placebo	PVA	15.461	7.228	.151	-3.54	34.46
		White	11.433	7.421	.419	-8.08	30.94
		XT	9.561	7.228	.552	-9.44	28.56
day3	PVA	White	-3.400	8.076	.975	-24.62	17.82
		XT	-12.150	8.076	.440	-33.37	9.07
		Placebo	-6.645	8.182	.849	-28.14	14.85
	White	PVA	3.400	8.076	.975	-17.82	24.62
		XT	-8.750	8.076	.701	.29.97	12.47
		Placebo	-3.245	8.182	.979	-24.74	18.25
	XT	PVA	12.150	8.076	.440	-9.07	33.37
		White	8.750	8.076	.701	-12.47	29.97
		Placebo	5.505	8.182	.907	-15.99	27.00
	Placebo	PVA	6.645	8.182	.849	-14.85	28.14
		White	3.245	8.182	.979	-18.25	24.74
		XT	-5.505	8.182	.907	-27.00	15.99
week4	PVA	White	-12.200	7.265	.342	-31.29	6.89
		XT	-13.950	7.265	.228	-33.04	5.14
		Placebo	-6.000	7.360	.847	-25.34	13.34
	White	PVA	12.200	7.265	.342	-6.89	31.29
		XT	-1.750	7.265	.995	-20.84	17.34
		Placebo	6.200	7.360	.834	-13.14	25.54
	XT	PVA	13.950	7.265	.228	-5.14	33.04
		White	1.750	7.265	.995	-17.34	20.84
		Placebo	7.950	7.360	.703	-11.39	27.29
	Placebo	PVA	6.000	7.360	.847	-13.34	25.34
		White	-6.200	7.360	.834	-25.54	13.14
		XT	-7.950	7.360	.703	-27.29	11.39
week8	PVA	White	-9.600	6.852	.503	-27.60	8.40
		XT	-18.150*	6.852	.047	-36.15	-.15
		Placebo	-14.024	6.941	.190	-32.26	4.21
	White	PVA	9.600	6.852	.503	-8.40	27.60
		XT	-8.550	6.852	.599	-26.55	9.45
		Placebo	-4.424	6.941	.920	-22.66	13.81
	XT	PVA	18.150*	6.852	.047	.15	36.15
		White	8.550	6.852	.599	-9.45	26.55
		Placebo	4.126	6.941	.933	-14.11	22.36
	Placebo	PVA	14.024	6.941	.190	-4.21	32.26
		White	4.424	6.941	.920	-13.81	22.66
		XT	-4.126	6.941	.933	-22.36	14.11
week12	PVA	White	-8.000	7.485	.709	-27.67	11.67
		XT	-11.000	7.485	.461	-30.67	8.67
		Placebo	-25.092*	7.583	.008	-45.02	-5.17
	White	PVA	8.000	7.485	.709	-11.67	27.67
		XT	-3.000	7.485	.978	-22.67	16.67
		Placebo	-17.092	7.583	.118	-37.02	2.83
	XT	PVA	11.000	7.485	.461	-8.67	30.67
		White	3.000	7.485	.978	-16.67	22.67
		Placebo	-14.092	7.583	.255	-34.02	5.83
	Placebo	PVA	25.092*	7.583	.008	5.17	45.02
		White	17.092	7.583	.118	-2.83	37.02
		XT	14.092	7.583	.255	-5.83	34.02

* The mean difference is significant at the 0.05 level

IV. Discussion

Fluoride application, as a dentin hypersensitivity treatment, reduces the dentin permeability by forming a barrier after depositing CaF_2 on the exposed dentin surface, which eventually reduces dentin hypersensitivity.[19, 26] The fluoride agents used for tooth hypersensitivity treatments are mainly varnish agents containing NaF. Other fluoride application methods, such as electrophoresis or tray, are difficult to operate inside the mouth and an excessive amount of fluoride intake may occur. Consequently, they are not used much in dentin hypersensitivity treatment methods.

The reduction effect of fluoride varnish in the prevalence of dental caries is higher than other methods and although its effect on dentin hypersensitivity has not been widely reported, it is known to have a reliable effect. On the other hand, because fluoride varnish is also washed away by saliva and food, it has the problem of not maintaining the optimal concentration in the mouth for a long time.

Therefore, new trials to increase the residence time of fluoride are being conducted. Curzon and Toumba[27] attempted to increase the fluoride residence time in the mouth by adding fluoride to a glass pellet that dissolves slowly. Similarily, Gabre et al[28] attempted to increase the residence time by adding fluoride to an adhesive paste for mucosa.

In the medical field, many studies have been performed to ensure and control the technology that regulates the diffusion rate of a drug to a target organ.[5, 29] In recent years in the field of dental treatments, various forms of mucousal adhesives have been studied and developed to increase the residence time of drugs in the gastrointestinal tract. Among them, a polymer with a good bio-affinity is considered to be the most appropriate medium. Among the polymers, Methyl cellulose (MC), which is a

hydrophilic low-calorie dietary fiber, is a leading basic agent for drug delivery media.

Therefore, we developed a fluoride-polyvinyl alcohol (F-PVA) by mixing 5% NaF with MC and PVA (polyvinyl alcohol), which are hydrophilic polymers with proven biocompatibility.

MC, the basic agent of an F-PVA, is generally known as cellulose gum. MC, which is a substitute polysaccharide, is made by a reaction of natural cellulose and monochloroacetate. The molecular weight varies according to the generation process but it is more than 350,000 daltons[30] and it is not metabolized.[31] In addition, MC is stable in heat and it is possible to sterilize it in boiling water for 5 min. An MC aqueous solution is transparent, semi-gluey and lubricities, and has a similar viscosity to synovial fluid.

F-PVA has many advantages such as: it attachs well to the tooth surface without drying, has no coloration, causes less discomfort (not sticky), and naturally degrades after a certain period time. The F-PVA we used degraded naturally in the mouth within 60 minutes. Adjusting the thickness of the film and the concentration of F-PVA can modulate the degradation of F-PVA. A film type of fluoride is considered suitable for home use, instead of needing professional application, because it is easy to attach to the tooth surface.

In this clinical trial, dentin hypersensitivity was reduced continuously for 8 weeks after application accept in the placebo group. According to Ritter et al[32], dentin hypersensitivity has been reduced continuously up to 24 weeks in the dentin hypersensitivity treatment using fluoride varnish.

In this study, the treatment effect of each fluoride preparation is expected to continue between 8 and 12 weeks. Therefore, an additional evaluation will be needed for longer time periods. The relatively long effects of the varnish with a single application are believed to be due to

the sealed effect of the dentinal tubules by the deposition of fluoride rather than transient blocking of stimulus by the formation of a membrane.[33)]

Calcium fluoride appears to be major reaction product on enamel after short exposure to concentrated fluoride agents. This may serve as a source of fluoride for the formation of fluorapatite.[34)] Another mechanism of slow releasing fluoride may be the precipitation of fluorapatite directly without formation of calcium fluoride.[35)]

A significant decrease in VAS scores for streamed air and ice stick test from 8 weeks after applying each fluoride was observed accept in the placebo group. But a slight increase in VAS scores for streamed air and ice stick test between 8 weeks to 12 weeks after applying each fluoride was observed. So, evaluation at 9 weeks, 10 weeks, and 11weeks after application should also be conducted.

In the air stream test, comparing between placebo and white fluoride varnish, the resin based fluoride varnish and F-PVA showed a significant difference in VAS scores at 12 weeks by Tukey test ($P < 0.05$). In the ice stick test, comparing between placebo and F-PVA showed a significant difference in VAS scores at 12 weeks by Tukey test ($P < 0.05$). So this means that the experimental F-PVA was similar in effect to white fluoride varnish and resin based fluoride varnish. This result indicated that film type of fluoride act as a mechanical barrier and it had the slow releasing characteristic of low concentrated fluoride, which precipitate it to fluorapatite directly to the tooth surface.

Varnish^{TM} white varnish, the fluoride varnish with Tri-Calcium Phosphate (TCP), contain 25mg (F=12.5mg) of fluoride in the form of NaF per 0.5ml (28 times dose). ClinPro^{TM} XT varnish varnish is a resin-modified glass ionomer material that releases fluoride, calcium and phosphate. It contains 0.5g (F=0.25g) of fluoride in the form of NaF per

10g (80 times dose). In contrast, F-PVA contains 0.14 ~ 0.225mg of fluoride in the form of NaF per 10 × 10 mm. Therefore, the amount of fluoride applied to an individual tooth was 7.9 to 12.7 times more in the other fluoride treatments than with F-PVA. From this we conclude that F-PVA showed a similar treatment effect with a smaller dose. Nevertheless, a future study will be needed to determine the most appropriate fluoride concentration for dentin hypersensitivity. In addition, a further study will be needed to evaluate the PVA content to determine the appropriate degradation time of fluoride film in the mouth.

Levin et al[36] and Overman[37] reported the placebo effect for dentin hypersensitivity with application of the distilled water to a tooth instead of a fluoride agent. Green et al[38] and Hernandez et al[39] found decreased dentin hypersensitivity in 20~45% of patients who received the placebo treatment or did not receive treatment. In this study, a placebo group showed a therapeutic effect in the initial period, and in the later time period, the effect was reduced when compared with other drugs group.

This study was designed to evaluate the efficiency of topical fluoride with a single application for dentin hypersensitivity. In the course of this study, up to 8 weeks the VAS scores decreased continuously, but at 12 weeks there was a slight increase. Further study is needed to evaluate the multiple applications of theses topical fluoride preparations across these time periods.

Varnish hardens quickly after opening was working time short. And Clinpro was needed additional photopolymerization process, inconvenience and high costs as a result. On the other hand, the F-PVA is adhesinve tape type, it applied in a manner easy to do. So it has a major advantage in that patients can apply it by themselves at home. Especially, the F-PVA are applied before I went to the bed, and are expected to be more effective for reduce dentin hypersensitivity.

V. Conclusion

On these results, the following conclusions were obtained.

1. F-PVA therapeutic effect was seen similar effects with other durgs, even smaller amounts of fluoride. It was demonstrated that F-PVA had significant effect in reducing dentin hypersensitivity.
2. Dentin hypersensitivity was reduced up to 8 weeks after application of all fluoride preparations. Therefore, we need VAS measure that broken down by 8-12 weeks after application . It is necessary to re-coating interval is determined.

VI. References

1. Canadian Advisory Board on Dentin Hypersensitivity. Consensus-based recommendations for the diagnosis and management of dentin hypersensitivity. J Can Dent Assoc, 69:221-6, 2003.
2. Dowell P, addy M & Dummer P : Dentin hypersensitivity: Aetiology, differential diagnosis and management. Br Dent J, 158:92-96, 1985.
3. Krauser JT : Hypersensitive teeth Part 1 : Etiology. J Prosthetic Dent, 56:153-156, 1986.
4. Irvine JH : Root surface sensitivity: A review of aetiology and management. J N Z Soc Periodontol, 66:15-17, 1988.
5. Addy M & Pearce N : Aetilolgical, predisposing and environmental factors in dentin hypersensitivity. Arch Oral Biol, 39:33-38, 1994.
6. Chabanski MB & Gillam DG : Aetiology, prevalence and clinical features of cervical dentin sensitivity. J Oral Rehabil, 24:15-19, 1997.
7. Jacobsen PL, Bruce G. Clinical dentin hypersensitivity: understanding the causes and prescribing a treatment. J Contemp Dent Pract, Feb 15:2(1):1-12, 2001.8. Abel I : Study of hypersensitive teeth and a new terapeutic aid. Oral Surg Oral Med Oral Pathol, 11:491-5, 1958.
9. Jensen AL : Hypersensitivity controlled by iontophoresis, double blind clinical investigation. J Am Dent Assoc, 68:216-25, 1964.
10. Graf H, Galasse R : Morbidity, prevalence and intraoral distribution of hypersensitive teeth. J Dent Res, 56:162, 1977.
11. Kanapka JA : Over-the counter dentifrices in the treatment of tooth hypersensitivity: review of clinical studies. Dent Clin North Am, 34:545-60, 1990.
12. Fischer C, Fischer RG, Wennberg A : Prevalence and distribution of cervical dentine hypersensitivity in a population in Rio de Janeiro, Brazil. J Dent, 20:272-6, 1992.

13. Murray LE, Roberts AJ : The prevalence of self-reported hypersensitive teeth. Arch Oral Biol, 39:129S,1994.
14. Chabanski MB, Gillam DG : Aetiology, prevalence and clinical features of cervical dentine sensitivity. J Oral Rehab, 24:15-9, 1997.
15. Orchardson R, Collins WJ : Clinical features of hypersensitive teeth. Br Dent J, 162:253-6, 1987.
16. Addy M, Mostafa P, Newcombe RG : Dentine hypersensitivity: the distribution of recession, sensitivity and plaque. J Dent, 15:242-8, 1987.
17. Brännström M, Aström A. The hydrodynamics of the dentine; its possible relationship to dentinal pain. Int Dent J, Jum;22(2):219-27, 1972.
18. Kaufman HW, Wolff MS, Winston AE, Triol CW : Clinical evaluation of the effect of a remineralizing toothpaste on dentinal sensitivity. J Clin Dent, 10:50-4, 1999.
19. Gangarosa LP Sr : Current strategies for dentist-applied treatment in the management of hypersensitive dentine. Arch Oral Biol, 39:101S-6S, 1994.
20. Lynch E, Brauer DS, Karpukhina N, Gillam DG, Hill RG. Multi-component bioactive glasses of varying fluoride content for treating dentin hypersensitivity. Dent Mater, Feb;28(2):168-78, 2012, Epub Dec 23, 2011.
21. Hoang-Dao BT, Hoang-Tu H, Tran-Thi NN, Koubi G, Camps J, About I. Clinical efficiency of a natural resin fluoride varnish (Shellac F) in reducing dentin hypersensitivity. J Oral Rehabil, Feb;36(2):124-31,2009.
22. Sohn S, Yi K, Son HH, Chang J. Caries-preventive activity of fluoride-containing resin-based desensitizers. Oper Dent, 37(3):306-315, 2012. Epub Feb 7, 2012.
23. Kim MJ, Lee SH, Lee NY, Lee IH. Evaluation of the effect of PVA

tape supplemented with 2.26% fluoride on enamel demineralization using microhardness assessment and scanning electromicroscopy: In vitro study. Arch Oral Biol. Jul 23, 2012.

24. Holland GR, Narhi MN, Addy A, Gangarosa L, Orchardson R : Guidelines for the design and conduct of clinical trials on dentine hypersensitivity. J Clin Periodontol, 24:808-13, 1997.
25. Price DD, McGrath PA, Rafii A, Buckingham B : The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain, 17:45-56, 1983.
26. Ehrlich J, Hochman H, Gedalia I, Tal M : Residual fluoride concentrations and scanning electron microscopic examination of root surfaces of human teeth after topical application of fluoride in vivo. J Dent Res, 54:897-900, 1975.
27. Curzon ME, Toumba KJ : In vitro and in vivo assessment of a glass slow fluoride releasing device: a pilot study. Br Dent J, 196:543-546, 2004.
28. Gabre P, Birkhed D, Gahnberg L : Fluoride retention of a mucosa adhesive paste compared with other home-care fluoride products. Caries Res, 42:240-246, 2008.
29. Etai Shpigel, Dana Elias : Production and Purification of a Recombinant Human hsp60 Epitope Using the Cellulose-Binding Domain in Escherichia coli. Protein Expression and Purification, 14:185-191, 1998.
30. Elkins TE, Bury RJ, Ritter JL, et al : Adhesion preventionby solutions of sodium carboxy methyl cellulose in the rat. I. Fertil Steril, 41(6):926-8, 1984.
31. Elkins TE, Ling FW, Ahokas RA, Abdella TN, Homsey CA, Malinak LR : Adhesion prevention by solutions of sodium carboxymethylcellulose in the rat. II. Fertil Steril, 41(6):929-32, 1984.

32. Ritter AV, de L Dias W, Miguez P, Caplan DJ, Swift EJ Jr : Treating cervical dentin hypersensitivity with fluoride varnish: a randomized clinical study. J Am Dent Assoc, 137:1013-20, 2006.
33. Parkinson CR, Willson RJ. : A comparative in vitro study investigating the occlusion and mineralization properties of commercial toothpastes in a four-day dentin disc model. J Clin Dent, 22(3):74-81, 2011.
34. Rølla G, Saxegaard E. : Critical evaluation of the composition and use of topical fluorides, with emphasis on the role of calcium fluoride in caries inhibition. J Dent Res, Feb; 69 Spec No: 780-785; discussion 820-823, 1990.
35. Retief DH, Bradley EL, Holbrook M, Switzer P. : Enamel fluoride uptake, distribution and retention from topical fluoride agents. Caries Res. 17(1):44-51, 1983.
36. Levin MP, Yearwood LL : The desensitizing effect of calcium hydroxide and magnesium hydroxide on hypersensitive dentine. Oral Surg, 35:741-746, 1973.
37. Overman PR : Calcium hypophosphate as a root desensitizing agent. Dent Hyg, 57:30-35, 1983.
38. Green BL, Green ML : calcium hydroxide and potassium nitrate as desensitizing agents for hypersensitive root surfaces. J Periodontol, 48:667-672, 1977.
39. Hernandez F, Mohammed C : Clinical study evaluating the desensitizing effect and duration of two commercially available dentifrices. J Periodontol, 43:367-372, 1972.