Original Article

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EFFECTIVENESS OF TOPICAL APPLICATION OF AMMONIUM FLUORIDE - AMMONIUM MOLYBDATE (3%F^-) IN SCHOOLCHILDREN: A 3-YEAR FOLLOW-UP STUDY

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ABSTRACT:

Objectives: The aim of this study is to assess the effectiveness of semiannual topical application of ammonium fluoride - ammonium molybdate solution in schoolchildren for 3 years.

Material and Methods:709 schoolchildren (6 to 7 years of age) of 3 primary schools (randomly selected) in Pyongyang city, DPRK participated in this double blind clinical trials. 1418 lower first permanent molars erupted completely were studied. We manufactured "ammonium fluoride - ammonium molybdate anticaries solution (FMS)". Of 1418 teeth, 798 teeth were included in FMS group and 620 teeth in control group. Through 3 years of follow-up study, we assessed the effectiveness (prevalence reduction, development reduction of new caries lesions) of topical application of this solution.

Results: The prevalence of caries at baseline was similar in FMS and control group (27.82%, 28.87%). However, there was great difference in caries prevalence in both groups 3 years later (32.08%, 74.03% respectively.). And at every semiannual observation, caries development reduction of this solution was more than 74%.

Conclusion:FMS can be used as an effective anticaries agent.

Keywords: caries development, caries prevalence, ammonium fluoride, ammonium molybdate

INTRODUCTION:

Fluoride is the primary agent available for caries prevention. In past decades a number of studies have reported a reduction in dental caries prevalence, possibly due to the preventive effects of fluorides. (Hugoson et al., 2005; Divaris et al., 2012; ten Cate, 2004,Bratthall D, et al. 1996) Fluorides have their largest effects on reducing demineralization, promoting remineralization of non-cavitated lesions, and can affect other biological activities of cariogenic microorganisms.

Numerous epidemiological data and common clinical experience have repeatedly shown that occlusal surfaces of posterior teeth are the most vulnerable sites for dental caries. Conventionally, the high incidence of caries on these surfaces has been

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directly related to the narrow and inaccessible pits and fissures on occlusal surfaces, and for that reason it has been natural in the past simply to refer to occlusal caries as 'fissure caries'. (Carvalho *et al*.1992, Extrand et al. 1991)

Some researchers assessed effect of professional application of 1.23% APF gel semiannually on the caries reduction in permanent first molars in 6-7-year-old children for 2 years. (Jiang H et al., 2006). Curnow and coworkers (Curnow et al., 2002) designed an investigation to determine the reduction in 2-year caries increment that can be achieved by daily supervised toothbrushing on school days with a toothpaste containing 1000 ppm F^-(Sodium monofluorophosphate), combined with recommended daily home use. Their results indicated significantly less caries developed in first permanent molars in the intervention group at both D_1, D_3 levels.

Through the several epidemiological investigations and numerous animal studies, it has been reported that Mo is an element which has cariostatic property (Adler et al., Ludwig et al., Anderson et al.,) In 1984, Oziai[22] studied the effect of $(NH_4)_2MoO_2F_4$ on enamel surface. He reported that enamel surface was more resistant to acid by formation of CaF_2 and placement of Mo within enamel crystal when $(NH_4)_2MoO_2F_4$ solution was applied. The study showed that this compound had higher anticaries property than other fluorides. He clarified the effect of Mo on F-HA reactive system and its mechanism of action.

However, the optimal concentration of molybdenum which raises the reactivity of F^-, the effect of F^- and molybdenum on β-TCP, $Ca(HPO_4)^-$ which are known as "caries crystal" weren't studied. Furthermore, the anticaries effect of $(NH_4)_2MoO_2F_4$ was studied in only 50 teeth.[20]

We manufactured "F-Mo anticaries Solution (FMS)" by mixing of F^- (ammonium fluoride) and Mo (ammonium molybdate), not by synthesizing $(NH_4)_2MoO_2F_4$ and studied anticaries effect of the solution. The concentration of F^-, Mo can be randomly controlled in the solution. We determined the appropriate concentration of Mo in FMS and clarified the anticaries mechanism of action of FMS.

Based on this, we assessed clinical anticaries effect of FMS. This study aimed to assessed the effectiveness (prevalence reduction, development reduction of new caries lesions) of topical application of this solution.

MATERIAL AND METHODS

The participants of this study were all schoolchildren (n=709) aged from 6 to 7 of 3 primary schools (Ryonhwa primary school, Ryusong primary school, Tonghung primary school) randomly selected in Central district, Pyongyang city in period of 2001 to 2004. The F^- concentration of drinking water in this area was less than 0.25ppmF.

This study was approved ethically by the public health office of Pyongyang People's committee. The parents were informed about national public health policy and additional free of charge preventive dental program at school which comprises dental hygiene education and fluoride application and consent from them was collected. All schoolchildren were entitled to the program. And parents were asked to fill out a questionnaire on use of toothpaste containing fluoride, past and current preventive treatment by fluoride. No data on any fluoride exposure in all children were recorded.

Since caries prevalence and incidence in the lower first permanent molars is the highest, only occlusal surfaces of the lower first permanent molars were examined in this study. Of 1418 first lower permanent teeth erupted completely, 798 teeth were included in FMS group and 620 teeth in control group.

1) examination

The examination was performed by one calibrated dental hygienist using the plane mouth mirror and sickle probe under the natural illumination. According to a literature (Table 2, Pitts & Fyffe, 1988), caries was classified and diagnosed. From second examination, data obtained from previous examination were referred.

Local symptoms such as discoloration in teeth, changes in oral mucous membrane, abnormal sensation of tongue and general manifestations were also recorded.

2) Fluoride application

The tooth was dried and FMS was applied to the surfaces using the swab for 3 minutes. After application of solution, children had to avoid drinking and eating food for 40 min.

3) Statistics

Data of 3 years' observation on teeth diagnosed "healthy" at baseline were collected separately for calculation of development reduction of new carious lesions. Caries development reduction and caries progression reduction were calculated by following formulas (Ellwood R., et al. 2008).

$$\textit{Caries development reduction (\%)} = \frac{DMFT\ of\ Control\ group - DMFT\ of\ Test\ group}{DMFT\ of\ Control\ group} \times 100$$

Caries prevalence and caries development reduction was analyzed by t-test.

RESULT

1) Caries prevalence in FMS and control group over time

Table 3 presented the change in caries prevalence over time.

As shown in table 3 and Fig. 1, 2, the prevalence in FMS and control group at baseline were similar (27.82% in FMS group and 28.87% in control group). However, there were significant differences in prevalence between FMS

group and control group in the period of 1 year to 3 years of observation(P value less than 0.01). And 3 years later after beginning of study, there was significant decrease in the Proportions of D_3(dentin caries), D_4(pulp involvement), filled teeth in FMS group compared with that of control group (4.01%, 0.75%, 4.14% in FMS, 7.74%, 5.00%, 11.13% in control group, respectively).

2) Caries development inhibiting effect of FMS

The development of new caries lesions in both FMS and control group was presented in table 4, 5, Fig.3.

As shown in table 4, 5, DFT score per 100 teeth in FMS group was 5.03 at 6 month, 9.25 at 1 year, 11.81 at 1.5 year, 14.76 at 2 year, 15.10 at 2.5 year and 15.97 at 3 year. And DFT score per 100 teeth in control group was 20.63 at 6 month, 40.36 at 1 year, 45.58 at 1.5 year, 57.37 at 2 year, 60.54 at 2.5 year, 64.17 at 3 year.

There were significant differences in DFT score between FMS group and control group in the period of 6 months to 3 years (P value less than 0.01). And more than 74% of development reduction of new carious lesions was recorded during the observation period in FMS group.

DISCUSSION

Fluoride was introduced in dental practice as a powerful anticaries agent in the early 20th century. Various kinds of fluorides such as 2% NaF, 2~10% SnF_2, APF (Acidulated Phosphate Fluoride), 38% $Ag(NH_3)_2F$ have developed and been used as efficient anticaries agents(Ellwood R et al., 2008).

In 1984, an attempt to use 10% $(NH_4)_2MoO_2F_4$ as an anticaries agent was done by Oziai. [22] He assessed the effect of Mo on F-HA reactive system. However, though the anticarious mechanism of $(NH_4)_2MoO_2F_4$ became clear, the optimal concentration of molybdenum which raises the reactivity of F^-, the effect of F^- and molybdenum on β-TCP, $CaHPO_4$ which are known as "caries crystal" weren't studied. A clinical study assessed anticaries effect of 10% $(NH_4)_2MoO_2F_4$ solution. But only 50 teeth were objected in this study. [20]

Therefore, we manufactured Fluoride solution containing Mo and assessed anticaries effect of this solution. This solution can be made easily using the material rich in our country. We manufactured this solution by mixing of F^-(ammonium fluoride) and Mo (ammonium molybdate), not by synthesizing $(NH_4)_2MoO_2F_4$. And we named this solution as "Fluoride-Mo Solution (FMS)". We clarified its mechanism and assessed the clinical effectiveness of the solution.

Numerous epidemiological data and common clinical experience have repeatedly shown that occlusal surfaces of posterior teeth are the most vulnerable sites for dental caries. Conventionally, the high incidence of caries on these surfaces has been directly related to the narrow and inaccessible pits and fissures on occlusal

surfaces. (Carvalho *et al*.1992) Since the lower first permanent molars of 6~7 year children are highly susceptible to caries, only lower first permanent molars were selected as objects of our study and we assessed the anticaries effect of FMS in these teeth.

Through a 3-year follow-up study, we observed the change in anticaries effect over time when FMS was applied semiannually.

Change in caries prevalence over time

Several researchers studied the effect of semiannual application of various fluorides (such as APF, NaF, silver amine fluoride) in first permanent molar of schoolchildren. (Westwater K. et al. 1974, Holm GB, et al. 1979, Carvalho JC et al. 1992, Bravo M et al. 1997,Flório FM, et al. 2001, Llodra JC et al. 2005, Jiang H et al. 2005, Cristian H. Splieth et al. 2011, Divaris K, et al. 2012) All results showed reduction in caries prevalence by fluoride application semiannually. We assessed the change in caries prevalence in first permanent molars by application of Fluoride-Mo solution (FMS) over time. According to our result (table 3), though caries prevalence in both group were almost similar at baseline, there was significant difference in caries prevalence between FMS group and control group at the end of study (32.08% in FMS group, 74.03% in control group) (P value less than 0.01). And caries prevalence at D_3, D_4 caries level in FMS group was significantly lower than that in control group at the end of study. This means that FMS can be used effectively for the caries prevention, and that caries progression is efficiently inhibited by application of FMS.

Caries Development Inhibiting Effect of FMS

Caries incidence after topical application of fluorides was assessed in several literatures. (Obersztyn A et al 1979, Haugejorden O. et al. 1991, Mejàre I, et al.2004) We assessed caries development inhibiting effect of FMS. The development of new caries lesions in both FMS and control group was compared (table 4, 5). There were significant differences in DFT score between FMS group and control group in the period of 6 month to 3 year (P value less than 0.01). And more than 74% of development reduction of new carious lesions was recorded during the observation period in FMS group.

And any symptom such as discoloration of teeth and the change in oral mucous membrane, and general symptoms was not recorded. Only acidic taste was complained by children during application of solution.

CONCLUSION

Regular application of FMS (semiannually) can effectively reduce the caries incidence and prevalence.

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TABLES:

Table 1 Objects of Study

group	The number of teeth				
	healthy	D_1	D_2	D_3	Total
FMS group	576	148	66	8	798
Control group	441	102	68	9	620
Total	1017	250	134	17	1418

Table 2 caries classification and criteria for diagnosis (Pitts & Fyffe, 1988)

classification	Abbreviation	Criteria for diagnosis
Surface sound	0	No evidence of treated or untreated clinical caries
Initial caries	D_1	No clinically detectable loss of substance. For pits and fissures, there may be significant staining, discoloration or rough spots in the enamel that do not catch the explorer, but loss of substance cannot be positively diagnosed. For smooth surfaces, these may be white, opaque areas with loss of luster
Enamel caries	D_2	Demonstrable loss of tooth substance in pits or fissures, or on smooth surfaces, but no softened floor or wall or undermined enamel. The texture of the material within the cavity may be chalky or crumbly, but there is no evidence that cavitation has penetrated the dentin
Caries of dentin	D_3	Detectably softened floor, undermined enamel or a softened wall, or the tooth has a temporary filling. On approximal surfaces, the explorer point must enter a lesion with certainty.
Pulpal involvement	D_4	Deep cavity with probable pulpal involvement. Pulp should not be probed.

Table 3 The Change in caries prevalence over time

Observation period	FMS group(n=798)							Control group(n=620)						
	The number of teeth (%)						Prevalence (%)	The number of teeth (%)						Prevalence (%)
	Healthy	D				F		Healthy	D				F	
		D_1	D_2	D_3	D_4				D_1	D_2	D_3	D_4		
Baseline	576 (72.18)	148 (18.55)	66 (8.27)	8 (1.00)	-		27.82	441 (71.13)	102 (16.45)	68 (10.97)	9 (1.45)	-		28.87
6 month	558 (69.92)	153 (19.17)	79 (9.90)	8 (1.00)	-		30.07	350* (56.45)	155* (25.00)	102* (16.45)	12 (1.94)	-	1 (0.16)	43.55*
1 year	539 (67.54)	156 (19.55)	81 (10.15)	19 (2.38)	-	3 (0.38)	32.46	264* (42.58)	173* (27.90)	143* (23.06)	28* (4.52)	1 (0.16)	11 (1.77)	57.41*
1.5 year	538 (67.42)	140 (17.54)	91 (11.40)	18 (2.26)	2 (0.25)	9 (1.13)	32.58	241* (38.87)	75 (12.10)	246* (39.68)	29* (4.68)	3 (0.48)	26* (4.19)	61.13*
2 year	531 (66.54)	134 (16.79)	93 (11.65)	19 (2.38)	5 (0.63)	16 (2.01)	33.46	191* (30.81)	82 (13.23)	263* (42.42)	36* (5.81)	8 (1.29)	40* (6.45)	69.19*
2.5 year	541 (67.79)	114 (14.29)	93 (11.65)	22 (2.76)	4 (0.50)	24 (3.01)	32.21	176* (28.39)	89 (14.35)	245* (39.52)	37* (5.97)	14* (2.26)	59* (9.52)	71.61*
3 year	542 (67.92)	96 (12.03)	89 (11.15)	32 (4.01)	6 (0.75)	33 (4.14)	32.08	161* (25.96)	96 (15.48)	215* (34.68)	48* (7.74)	31* (5.00)	69* (11.13)	74.03*

*; P<0.01

Table 4 Caries Development of both FMS and Control group over time

period(times of application)	FMS group (n=576)		Control group (n=441)	
	D	F	D	F
6 months(1)	29	-	91	-
1 year(2)	55	-	178	-
1 year and 6 months(3)	68	-	199	2
2 years(4)	83	2	240	13
2 years and 6 months(5)	84	3	243	24
3 years(6)	86	6	240	43

Table 5 Caries development inhibiting effect of FMS over time

period(times of application)	DF Score/100 teeth		Caries development reduction (%)
	FMS group (n=576)	Control group (n=441)	
6 months(1)	5.03	20.63*	75.62
1 year(2)	9.25	40.36*	77.08
1 year and 6 months(3)	11.81	45.58*	74.09
2 years(4)	14.76	57.37*	74.27
2 years and 6 months(5)	15.10	60.54*	75.06
3 years(6)	15.97	64.17*	75.11

*; P value<0.01(intergroup)

FIGURES:

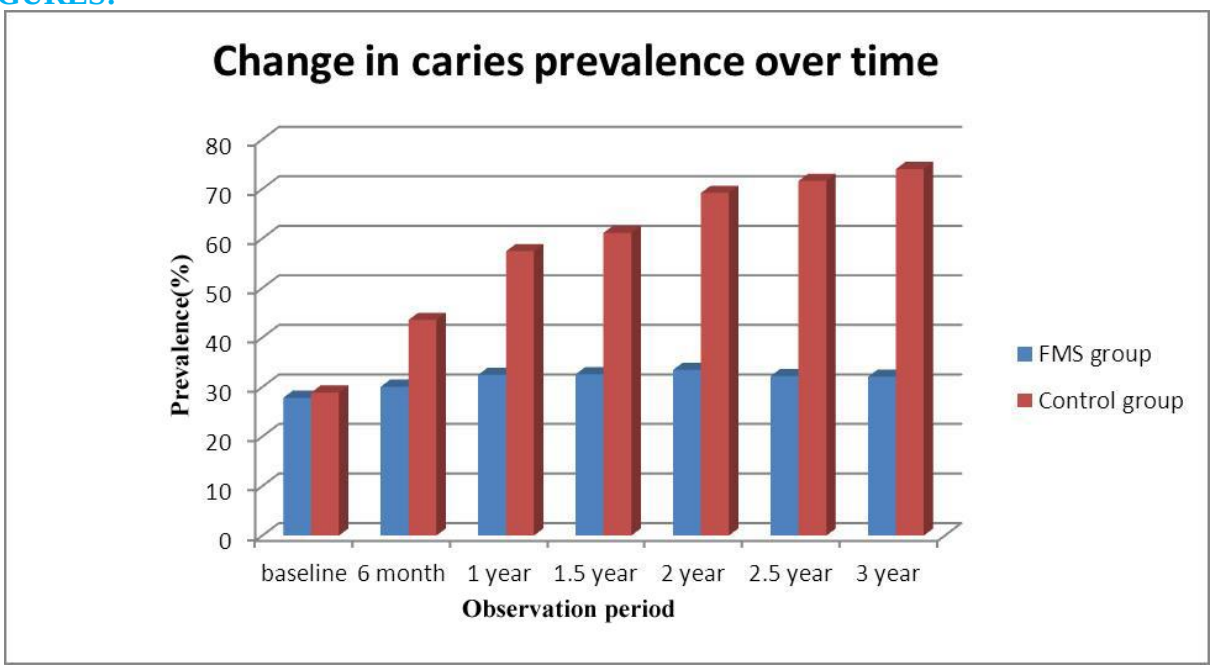

Fig 1. Change in caries prevalence over time

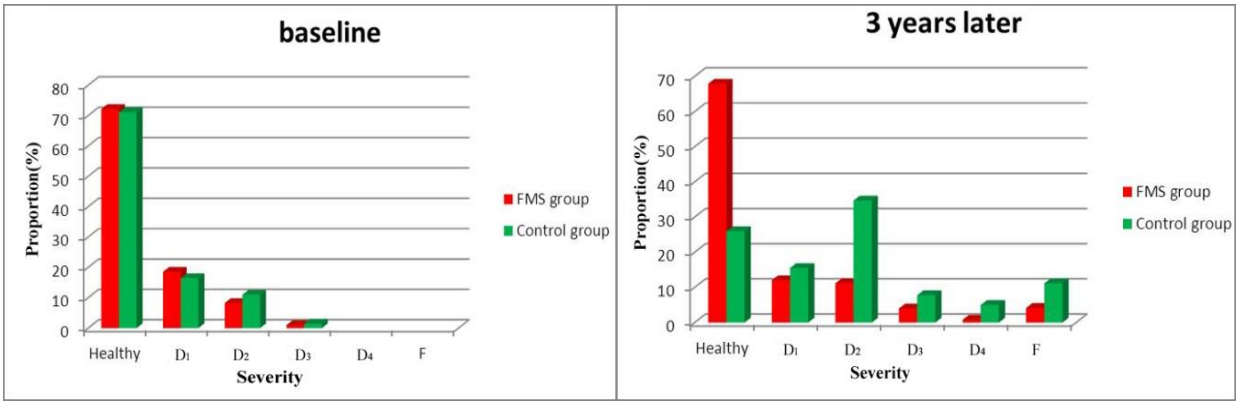

Fig 2. The proportion of caries lesions at baseline and 3 years later

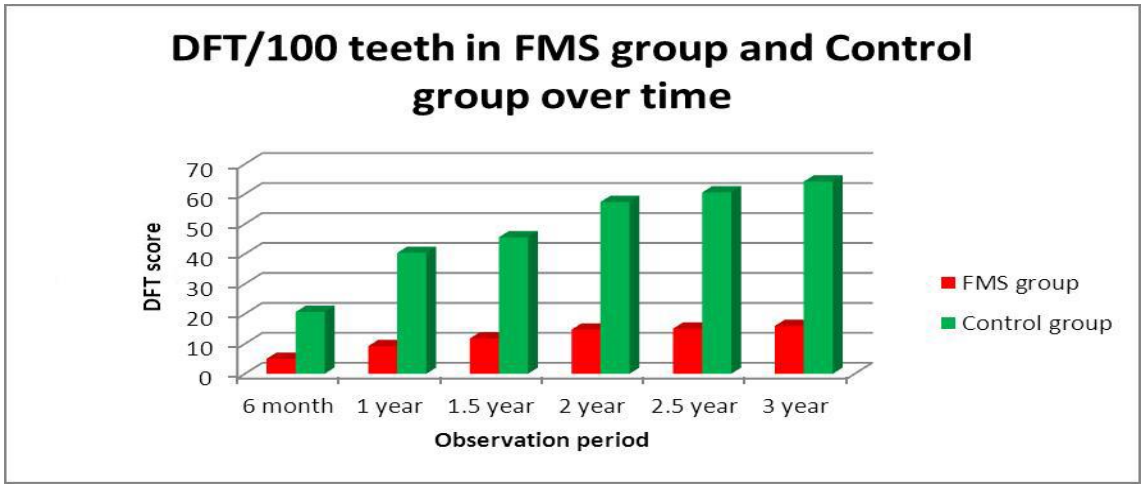

Fig 3. DFT/100 teeth in FMS group and Control group over time