

Fluoride ingestion from toothpaste by young children

E. M. Bentley,¹ R. P. Ellwood,² and R. M. Davies,³

Objective To investigate the reported and observed brushing habits of young children and their ingestion of fluoride from toothpaste.

Design In 1997, a random sample of 50 children, aged 30 months, from three districts in the North West region of England, were visited at home.

Methods The reported and observed toothbrushing behaviour was determined and the weight of toothpaste applied to the toothbrush was measured. The amount of fluoride retained in the mouth after brushing with either a 400 ppm F or 1,450 ppm F toothpaste was determined.

Results All parents claimed that their children's teeth were being brushed with a fluoride toothpaste at least once daily. The mean amount of toothpaste applied on the brush was 0.36 g of which 0.27 g (72%) was retained in the mouth. The mean amount of fluoride ingested per brushing was 0.42 mg when using the 1,450 ppm F toothpaste and 0.10 mg when using the 400 ppm F toothpaste. Although most parents applied a small amount of toothpaste a small minority applied a large amount. If using the 400 ppm F toothpaste twice daily no children of average weight would have exceeded ingestion of 0.05 mgF/kg body weight whereas 14 average weight children would have exceeded this value if using the 1450 ppm F toothpaste.

Conclusions It is essential that parents of children aged less than 7 years apply a small (pea-sized) amount of fluoride toothpaste on the toothbrush and discourage swallowing.

The appropriate use of fluoride has always necessitated an assessment of the relative benefits and risks. It is generally accepted that the use of fluoride-containing toothpastes has been the most important factor in the decline in dental caries.¹ However, the early use of fluoride toothpaste is one of many factors that may be associated with an increased risk of fluorosis in both fluoridated and non-fluoridated communities.²⁻⁶ The permanent dentition is at risk of fluorosis during the first 7 years of life⁷ but there is evidence that the aesthetically important permanent maxillary incisors are most susceptible before 2 years of age.^{8,9}

Since 1990, manufacturers of toothpaste in the UK have labelled their products with instructions that children under 7 years of age should be supervised when brushing and use only a pea-sized amount of toothpaste. Despite this advice a recent survey in Great Britain indicated that around 10% of all children, aged 1fi to 4fi years, had never had their teeth brushed by an adult and 27% of 1fi to 2fi-year-olds brushed themselves.¹⁰ In addition, 58% of 1fi to 2fi-year-olds were reported to cover a small part of the toothbrush with paste while 37% covered half, or more.

The aim of this study was to investigate the reported and observed brushing habits of children aged 30 months and determine the amount of fluoride retained and ingested after brushing with a fluoride toothpaste.

Method

In 1997, 50 children, aged 30 months, who were participating in a community dental health programme, were randomly selected from three districts in the North West Region of England. The homes were visited and parents were first asked about their child's brushing habits. Each child was weighed clothed, but without shoes, on household scales. Parents were then provided with a new, child-size brush (Colgate My First) and a weighed tube of toothpaste and asked to brush their child's teeth in the usual manner. Half the children used a children's toothpaste containing 400 ppm F (Colgate 0-6 Gel) and half used a family toothpaste containing 1,450 ppm F (Colgate Great Regular Flavour). The orifice of both tubes was 8 mm but that of Colgate 0-6 Gel had a star-shaped nozzle. The weight of toothpaste applied per brushing was measured and the method of brushing was observed and recorded.

In order to determine the amount of toothpaste and fluoride retained in the mouth after brushing, the amount of toothpaste retained on the brush and collected in rinsing fluids was measured. Care was taken to ensure that toothpaste was not retained on the lips, face and hands of subjects. If this occurred the data for the subject were to be discarded. All waste toothpaste and fluids were stored and placed in a secure container together with the toothbrush. The amount of fluoride from toothpaste remaining on the toothbrush and in the waste fluids was then determined by gas chromatography.¹¹ The difference between the amount of toothpaste applied to the brush and that recovered after brushing was estimated to be the amount of toothpaste ingested.

Results

Reported and observed toothbrushing behaviour

When interviewed, 48 mothers reported that they always put the toothpaste on the child's brush and only two said that their child usually did so. However, five children were observed to dispense their own toothpaste.

Thirty-four mothers reported that toothbrushing usually involved both the parent and child, 12 stated that they always brushed their child's teeth and four said that their child brushed their own teeth. However, it was observed that in 21 instances toothbrushing involved both parent and child, 17 parents brushed their child's teeth and 12 children brushed without help.

The mothers of 17 children reported that their child spat out toothpaste, although only five were observed to do so. When observed 38 children washed the brush under a running tap and then sucked and swallowed the water from the brush. Although 15 children were reported to use a cup of water, only three did so when observed and these children then spat the water out. Spitting ability was reported by the parents to be a recent phenomenon. Twenty-

¹Research Associate, ²Technology Manager, ³Director, Dental Health Unit, Manchester Science Park, Lloyd Street North, Manchester M15 6SH

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Table 1 The amount of toothpaste (g) applied and ingested per brushing and the percentage toothpaste ingested

Toothpaste	N	Amount toothpaste (g) applied per brushing		Amount toothpaste (g) ingested per brushing		% toothpaste ingested per brushing	
		mean (SD)	range	mean (SD)	range	mean (SD)	range
Family (1,450 ppm F)	25	0.37 (0.20)	0.09 – 1.00	0.29 (0.16)	0.04 – 0.71	77 (16)	32 – 96
Children's (400 ppm F)	24	0.34 (0.22)	0.10 – 0.92	0.25 (0.20)	0.04 – 0.83	69 (17)	27 – 91
All	49	0.36 (0.21)	0.09 – 1.00	0.27 (0.18)	0.04 – 0.83	72 (17)	27 – 96

two children were reported to brush once a day, 26 twice a day and two more than twice a day.

Amount of toothpaste used

Data on toothpaste usage was available for 49 children; one subject was uncooperative and the sample was discarded. The mean amount of toothpaste applied on the brush was 0.36 g (SD 0.21) with a range of 0.09 g to 1.00 g (Table 1). The 90th percentile was 0.64 g. Those using the family toothpaste applied a mean of 0.37 g, those using the children's toothpaste 0.34 g. This difference was not statistically significant.

Toothpaste ingested

The mean amount of toothpaste ingested per brushing was 0.27 g (SD 0.18) range 0.04 to 0.83 g (Table 1). For those using the family toothpaste the mean was 0.29 g (SD 0.16), range 0.04 to 0.71 g and for those using children's toothpaste the corresponding amounts were 0.25 g (SD 0.20), range 0.04 to 0.83 g. The proportion of toothpaste ingested ranged from 27 to 96% (Table 1) with a mean of 77% for the family toothpaste and 69% for the children's toothpaste. This difference was not statistically significant.

Amount of fluoride ingested

The children's and the family toothpaste contained 400 ppm and 1450 ppm F respectively and this difference in concentration was reflected in the amount of fluoride ingested (Table 2). The mean amount of fluoride ingested per brushing by those children using the family toothpaste was 0.42 mg (range 0.05 to 1.02 mg) compared with a mean of 0.10 mg (range 0.02 to 0.33 mg) for those using children's toothpaste.

The potential daily dose of fluoride ingested was calculated using the mean weight of the children, 14.2 kg (range 10.8 to 18.0 kg) and assuming that toothbrushing occurred twice daily. For those using

the family toothpaste the mean mgF/kg/day was 0.06 (range 0.007 to 0.14) compared with 0.01 mgF/kg/day (range 0.002 to 0.05) for those using the children's toothpaste (Table 2). These differences were statistically significant ($P < 0.001$).

Discussion

In the present study all the mothers claimed that their children's teeth were being brushed at least once a day with a fluoride toothpaste. This finding supports a recent report that in Great Britain toothbrushing had commenced before 2 years of age in 95% of children aged 1fi to 2fi years and 92% used a fluoride toothpaste.¹⁰

The risk of fluorosis is related to the dose of fluoride ingested and is a function of both the amount of toothpaste ingested and its fluoride concentration. In the present study the mean amount of toothpaste applied (0.36 g) was comparable to the 0.30 g used when parents were asked specifically to apply a pea-sized amount.¹² Other studies have reported higher values for children of a similar age ranging from 0.46 g¹³ to 0.62 g.¹⁴ In order to identify those subjects using the most toothpaste, the range of values was quoted in this paper. Some care must be taken when interpreting data based on ranges as these are particularly sensitive to the sample size. However, more importantly, it is unclear how accurate a single measure of toothpaste predicts the average amount used over a longer period. If the amounts applied are quite variable there could be a tendency for the mean amount applied to decrease over a longer period due to regression towards the mean. The variability of the amounts applied over an extended sampling period are unknown. Nevertheless, the present data suggest that most parents were following the advice of manufacturers and used a small amount of toothpaste, a relatively small minority were applying large amounts.

In this study an average of 72% of the toothpaste applied to the brush was retained in the mouth and presumably ingested. In previous studies children of a comparable age swallowed 59%¹³ and

Table 2 The amount of fluoride (mg) ingested per brushing and the ingested dosage per day (mg/kg/day) assuming that the child brushes twice daily and weighs 14.2 kg

Toothpaste	N	Amount F (mg) ingested per brushing		Ingested dose per day (mgF/kg) Using mean weight of children (14.2 kg) and brushing twice daily	
		mean (SD)	range	mean (SD)	range
Family (1,450 ppm F)	25	0.42 (0.24)	0.05 – 1.02	0.06 (0.03)	0.007 – 0.14
Children's (400 ppm F)	24	0.10 (0.08)	0.02 – 0.33	0.01 (0.01)	0.002 – 0.05
All	49	0.26 (0.24)	0.02 – 1.02	0.04 (0.03)	0.002 – 0.14

65%.¹⁴ The threshold level of fluoride ingested beyond which fluorosis may occur is not known accurately.¹⁵ It has been suggested that children should consume no more than 0.10 mgF/kg body weight if an undesirable degree of fluorosis is to be avoided. However, a lower threshold of 0.05–0.07 mgF/kg body weight has also been suggested.¹⁶ In the present study no children of average weight (14.2 kg) would have exceeded the value of 0.05 mgF/kg body weight using the children's toothpaste (400 ppm F) twice a day. In contrast, if using the family toothpaste (1,450 ppm F) twice per day, 14 children of average weight would have ingested more than 0.05 mgF/kg body weight, seven would have exceeded 0.07 mgF/kg body weight and four would have exceeded 0.10 mgF/kg body weight.

The concentration of fluoride in a toothpaste is an important determinant of efficacy. Clinical trials indicate that within the range 1,000 to 2,500 ppm F an increase in fluoride of around 500 ppm results in an additional 6% reduction in dental caries.^{17,18} In the UK 41% of the parents of young children aged 1fi to 2fi years claim to use a toothpaste containing less than 600 ppm F.¹⁰ Toothpastes containing higher concentrations of fluoride confer greater protection against dental caries but increase the risk of fluorosis. In contrast, low fluoride toothpastes provide less protection against dental caries but reduce the risk of fluorosis. They may therefore be appropriate for young children if considered to be at low caries risk.¹⁹ When any toothpaste is used by children less than 7 years of age it is essential that parents apply a small (pea-sized) amount on the toothbrush and discourage swallowing.

- 1 Bratthall D, Hansel-Petersson G, Sundberg H. Reasons for the caries decline: what do the experts think? *Eur J Oral Sci* 1996; **104**: 416-412.
- 2 Osuji O D, Leake J L, Chipman M L, Nikiforuk G, Locker D, Levine N. Risk factors for dental fluorosis in a fluoridated community. *J Dent Res* 1988; **67**: 1488-1492.
- 3 Milsom K, Mitropoulos C M. Enamel defects in 8 year old children in fluoridated and non-fluoridated parts of Cheshire. *Caries Res* 1990; **24**: 286-289.
- 4 Lalumandier J A, Rozier R G. The prevalence and risk factors of fluorosis among patients in a paediatric dental practice. *Paediatr Dent* 1995; **17**: 19-25.
- 5 Ellwood R P, O'Mullane D M. Dental enamel opacities in the groups with varying levels of fluoride in their drinking water. *Caries Res* 1995; **29**: 137-142.
- 6 Rock W P, Sabieha A M. The relationship between reported toothpaste usage in infancy and fluorosis of permanent incisors. *Br Dent J* 1997; **183**: 165-170.
- 7 Ishii J, Suckling G. The severity of dental fluorosis in children exposed to water with a high fluoride content for various periods of time. *J Dent Res* 1991; **70**: 952-956.
- 8 Evans R W, Stamm J W. An epidemiological estimate of the critical period during which human maxillary central incisors are most susceptible to fluorosis. *J Public Health Dent* 1991; **51**: 251-259.
- 9 van Palenstein Helder W H, Mabeya, van't Hof M A, Konig K G. Two types of intraoral distribution of fluorotic enamel. *Community Dent Oral Epidemiol* 1997; **25**: 251-255.
- 10 Hinds K, Gregory J R. *National diet and nutrition survey: children aged 1fi to 4fi years*. Volume 2: Report of the Dental Survey. London: HMSO, 1995.
- 11 Fresen J A, Cox F H, Witter M J. The determination of fluoride in biological materials by means of gas chromatography. *Pharm Weekblad* 1968; **103**: 909-914.
- 12 Bentley E M, Ellwood R P, Davies R M. Factors influencing the amount of fluoride toothpaste applied by the mothers of young children. *Br Dent J* 1997; **183**: 412-414.
- 13 Simard P L, Lachapelle D, Trahan L, Naccache H, Demers M, Brodeur J M. The ingestion of fluoride dentifrice by young children. *J Dent Child* 1989; **56**: 177-181.
- 14 Naccache H, Simard P L, Trahan L, Brodeur J M, Demers M, Lachapelle D, Bernhard P M. Factors affecting the ingestion of fluoride dentifrice by children. *J Public Health Dent* 1992; **52**: 222-226.
- 15 Levy S M, Kiritsy M C, Warren J J. Sources of fluoride intake in children. *J Public Health Dent* 1995; **55**: 39-52.
- 16 Burt B A. The changing patterns of systemic fluoride intake. *J Dent Res* 1992; **71**: 1228-1237.
- 17 Stephen K W, Creanor S L, Russell J I, Burchell C K, Huntington E, Downie C F A. A 3-year oral health response study of sodium monofluorophosphate dentifrice with and without zinc citrate: anticaries results. *Community Dent Oral Epidemiology* 1988; **16**: 321-325.
- 18 O'Mullane D M, Kavanagh D, Ellwood R P, et al. A three-year clinical trial of a combination of trimetaphosphate and sodium fluoride in silica toothpastes. *J Dent Res* 1997; **76**: 1776-1781.
- 19 Holt R D, Nunn J H, Rock W P, Page J. British Society of Paediatric Dentistry: A policy document on fluoride dietary supplements and fluoride toothpastes for children. *Int J Paediatr Dent* 1996; **6**: 139-142.