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A randomized clinical study to assess ingestion of dentifrice by children

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ABSTRACT

This study investigated whether there was a difference in amounts of dentifrice ingested by children based on age using pea-sized instructions. The study had a randomized, single-blinded, 3-period, crossover design modelled after Barnhart et al. (1974) with one regular-flavored and two specially-flavored dentifrices used *ad libitum*. Subjects were enrolled in three groups: 2–4, 5–7, and 8–12 years. They were instructed to brush at home as they would normally with each dentifrice for 3 weeks (9 weeks total). On weekly study-site visits, subjects brushed with the assigned dentifrice containing a lithium marker to measure the amount of dentifrice ingested and used. Averaging across dentifrices, amounts ingested were: 0.205 g (2–4 yr), 0.125 g (5–7 yr) and 0.135 g (8–12 yr), demonstrating 2–4 year-olds ingested significantly more than older children ($p \leq 0.002$). Averaging across dentifrices, amounts used were: 0.524 g (2–4 yr), 0.741 g (5–7 yr) and 0.978 g (8–12 yr) suggesting an age-related effect ($p < 0.01$). Findings also showed that ingestion amount for specially-flavored dentifrices may increase relative to regular-flavored dentifrice for children 2–7 years-old. This research demonstrated that dentifrice ingestion amount decreased significantly with age while usage amount increased with age. Importantly, ingestion and usage levels in younger children reflect "pea-sized" direction and were numerically lower than historical levels reported prior to this direction.

1. Introduction

A link between naturally fluoridated water and lower rates of tooth decay was established in the 1930s. Specifically, topical fluoride plays a dominant role in caries prevention. Benefits of fluoridated dentifrice for caries prevention have been confirmed by numerous reviews. Standard fluoride dentifrices, containing 1000–1500 ppm fluoride, reduce 24–29% of caries in permanent teeth when compared to placebo (Marinho et al., 2003, 2004a, 2004b; Marinho, 2009; Twetman, 2009; Walsh et al., 2010).

A concern associated with use of fluoride dentifrice in children is the potential for unintentional ingestion of dentifrice as the swallowing reflex develops (Nacacche et al., 1992). Furthermore, the first 6–8 years of life appear to be the most critical for enamel formation and maturation and thus these years are likely when children are most susceptible to dental fluorosis (National Research Council, 2006). Dental fluorosis presents as changes in tooth enamel appearance. Milder forms of dental fluorosis are considered cosmetic as the outer enamel surface remains well mineralized; however, enamel surface breakdown can occur in more severe cases. Occurrence of dental fluorosis depends on factors including environmental fluoride level, and timing and duration of systemic and topical fluoride exposure (Aoba and Fejerskov, 2002). While fluoride dentifrice use is not generally identified as a singular causal agent for dental fluorosis in children, inadvertent swallowing has been identified as a risk factor. Dental fluorosis reported from studies associated with the use of fluoridated dentifrice has generally been classified as very mild (National Research Council, 1993).

An investigation of dentifrice usage and ingestion in children (2–4 years, 5–7 years, 11–13 years) and adults (20–35 years) was performed by Barnhart et al. (1974). Amount ingested was determined by recovering the dentifrice after brushing and calculating the difference from the amount initially applied to the brush utilizing a lithium chloride tracer added to the dentifrice. Barnhart et al. (1974) called this method of measurement the "difference

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technique" and noted that it may be considered conservative due to the assumption that any dentifrice not recovered would be considered ingested. The study illustrated that children ingested more dentifrice than adults and that ingestion decreased as age increased. Results also indicated that the average amount of dentifrice used at each brushing did not differ significantly between groups.

In 1991, the American Dental Association (ADA) made a policy change with the goal of reducing inadvertent ingestion of fluoride via dentifrice; thereby decreasing the risk of mild dental fluorosis in young children while maintaining decay prevention benefits. The statement "Do not swallow. Use only a pea-sized amount for children under six. To prevent swallowing, children under six years of age should be supervised in the use of toothpaste" was required on all dentifrice labels carrying the ADA Seal of Approval. More recently, the ADA issued an updated recommendation following a review of data addressing efficacy and safety of fluoridated toothpaste use in children under 6 years (Wright et al., 2014; American Dental Association, 2014). The resulting recommendation specifies that children ages 3–6 years should use a pea-sized amount of fluoridated dentifrice while children under 3 years with erupted teeth should use no more than a smear, or size of a grain of rice, of fluoridated toothpaste for effective caries prevention while minimizing mild fluorosis.

A primary aim of the present study was to determine whether the amounts of dentifrice used and ingested by young children has decreased since the implementation of the ADA usage recommendations. The present study was largely modeled after the Barnhart et al. (1974) study with the goal to produce updated data for young children to reflect current tooth brushing directions. Both studies were conducted to provide essential data regarding consumers' normal habits and practices and therefore shared many methodological features, including simulated home-use conditions and use of a spectrophotometric method with a lithium chloride tracer added to the dentifrice and use of the "difference technique".

2. Materials & methods

2.1. Subjects

The study was conducted at Hill Top Research, Inc., Miamiville, Ohio, USA and approved by Hill Top Research, Inc. Institutional Review Board. Ninety children aged 2–12 years were recruited; parents or guardians completed written consent forms. Additionally for inclusion, subjects were required to be in good health and to have practiced daily tooth brushing for at least three months prior to the start of the study.

2.2. Study treatments

The three treatment dentifrices containing 0.243% sodium fluoride included a regular-flavored control (Crest Cavity Protection) and two specially-flavored dentifrices (Crest for Kids Hawaiian Punch [HP] and Crest for Kids Bubblegum [BG]); all dentifrices were supplied by The Procter & Gamble Co., Cincinnati, OH, USA. Treatment dentifrices had on-site counterparts supplemented with 0.05% lithium chloride.

The acclimation dentifrice (Gleem; 0.243% sodium fluoride) was provided in commercial packaging. All treatment dentifrices were dispensed in standard commercially-marketed tubes. Each tube was labeled with the subject number and range of weeks (Weeks 2–4, 5–7, or 8–10) indicating when the subject was to use the product. Labels listed sodium fluoride as the active ingredient and instructed the subject to brush as they would normally and to report any unusual experience.

Lithium-supplemented dentifrices were used once-weekly at the study center. Lithium-supplemented dentifrice tubes were labeled with the same information as treatment dentifrice tubes with the addition of an "L" following the range of week denotation indicating the tube contained lithium-supplemented product. Additionally, lithium-supplemented product labels were colored for further distinction.

2.3. Study design

This was a randomized, single-blinded, 3-period, 3-treatment, crossover trial. There was a 1-week acclimation period followed by three, 3-week treatment periods in which subjects brushed with each assigned dentifrice for 3 weeks (weeks 2–4 = period 1, weeks 5–7 = period 2, weeks 8–10 = period 3). Once weekly, subjects brushed at the study center with the lithium-supplemented dentifrice. Subjects crossed to another dentifrice after each 3-week treatment period for a total of 9 weeks.

To begin, subjects were given the acclimation product to use at home twice-daily for 1 week. At the end of the acclimation period, subjects returned to the study center and were stratified by age (2–4 years, 5–7 years, and 8–12 years). Within age strata, subjects were randomly assigned treatment order by random number in block sizes of 6 providing six unique sequences: ABC, BCA, CAB, CBA, ACB, BAC (A, B and C represent the treatment dentifrices). The randomization list was computer generated at the study center. At the start of each treatment period, study site personnel provided subjects with the assigned dentifrice to use (by self or with aid of a care-taker) at home for 3 weeks. Dentifrice tubes were pre-weighed at the start of each period. At the end of each week of use, tubes were collected, weighed and returned to subjects as appropriate. Use of other non-study dentifrices was prohibited. Subjects were instructed to "brush as you normally do" with the acclimation, treatment, and lithium-supplemented products.

At the end of each week, subjects returned to the study center and brushed with the lithium-supplemented dentifrice matching that week's treatment (AL, BL or CL). Each subject was provided with a brush (weighed to the nearest 0.1 g) similar to the one they were currently using at home. Subjects brushed in the same manner as they would at home.

Treatment and lithium-supplemented dentifrices were supplied in see-through tubes; therefore, product use was not blinded. However, examiners and laboratory personnel were blinded to treatment.

2.4. Study assessments

Dentifrice amount used and ingested was calculated based on study center product use. Brushing was performed at a sink in a bathroom setting. A container was weighed to the nearest 0.1 g and placed under the sink to collect all fluid (expectorated product, water, sink effluent). A cup was available and the tap water was lithium-free. Brushing was monitored from behind a two-way mirror. If an observable amount of dentifrice was spilled where it could not be collected, that specific sample was excluded from analysis. Tubes were weighed (nearest 0.001 g) before and after brushing. After brushing, all items used were left in the sink.

After use, the toothbrush, cup, and sink were rinsed with water and all rinse was added to the container. The sink and sink area were dried with a pre-weighed lithium-free wipe, which was added to the container. Glutaraldehyde was added to the container as a preservative; the amount added was recorded. The container and contents were weighed; the weight of the container, toothbrush, and wipe were subtracted to give liquid weight.

The used container was labeled with the subject number and