QUESTION 4

How should I diagnose dental fluorosis?

Background

Ingestion of excess fluoride, especially in early childhood, increases the risk of dental fluorosis.[1] In most areas of Canada, the concentration of fluoride in untreated drinking water is below 0.3 mg/L (equivalent to 0.3 parts per million or ppm), but in some areas the water exceeds the maximum level, set by Health Canada, of 1.5 ppm. In the past, children living in areas of low fluoride exposure were given fluoride supplements, but this practice increased the risk of dental fluorosis. Similarly, more than half of Canadian communities have been fluoridating their drinking water for years; however, there has been a steady rise in the prevalence and severity of dental fluorosis in such communities.[2,3] Overall, 12.5% of children in communities with fluoridated water have objectionable dental fluorosis, which is often treated cosmetically.[4]

Diagnosis

When fluoride exposure occurs early in life (at 1–3 years of age) and then falls to a low level, only the anterior incisors and first molars are affected. Excess exposure occurring later (after mineralization of the incisors is complete) causes dental fluorosis only on the canines, premolars and second molars.[5] Increasing the fluoride level in water from 0.4 ppm to the typical level used for fluoridation (1.0 ppm) "would lead to one extra person with dental fluorosis for every 6 people."[4] Among susceptible children, continuous intake of fluoride at this level, from birth, results in fluorosis of all teeth (**Table 1**). Severe fluorosis, characterized by deep pitting and substantial loss of enamel tissue, rarely occurs in Canada but might be present in immigrants who previously lived in areas where fluorosis is endemic (e.g., India, Africa, China and the Middle East).

A medical history, including questioning about whether there has been excess fluoride exposure, should corroborate the appearance of the teeth. Dental fluorosis is a symmetric, systemic condition, occurring on pairs of teeth that develop at the same time. Depending on the timing of exposure, it can appear on the cusp tips only, on the incisal third of the teeth or on the entire surface

Figure 1: Six typical cases of mild to moderate dental fluorosis. The condition presents as various forms of white chalky spots and streaks, sometimes covering the entire tooth surface. In very mild cases (top left), these spots are barely noticeable. In moderate cases, areas of brown discolouration may occur. Among the patients depicted here, all but the patient at top left requested some form of treatment. All of the patients had nominal exposure to systemic fluoride (through fluoridated water, fluoride supplements or fluoridated toothpaste).

Table 1 Effects of the timing of fluoride exposure on the pattern of dental fluorosis

Daily fluoride intake[a] (mg/kg) and age at exposure	Severity of dental fluorosis	% prevalence[b] (95% CI)	Potential sources of excess fluoride	Permanent teeth usually affected
Low (< 0.05)	Mild	< 15 (10–22)		
0–3 years			Fluoridated tap water used for infant formula Early use of fluoridated toothpaste	Maxillary incisors, all first molars
3–6 years			Fluoridated water Minor ingestion of fluoridated toothpaste	Premolars, canines, second molars
0–6 years			Any combination of the above	All teeth
Medium (0.05–0.15)	Moderate	12.5 (7.0–21.5)		
0–3 years			Fluoridated tap water used for infant formula Early fluoridated toothpaste use General anesthetics Fluoride tablets Fluoridated water	Incisors, first molars and tips of canines and premolars
3–6 years			Fluoridated water Intentional fluoridated toothpaste ingestion General anesthetics Fluoride tablets	Cervical third of incisors, first molars and tips of canines and premolars
0–6 years			Any combination of the above	All teeth
High (> 0.15)	Moderate–severe	1–26[c]		
0–3 years			Early fluoridated toothpaste use Elevated fluoride in the drinking water (> 4 ppm fluoride) Pollution	All teeth
3–6 years			Pollution Elevated fluoride in drinking water Intentional toothpaste ingestion	All teeth
0–6 years			Any combination of the above May also be complicated by increased retention (e.g., kidney problems)	All teeth

CI = confidence interval
[a]Adapted from data published by the Committee on Fluoride in Drinking Water (U.S. National Research Council).[1]
[b]Prevalence estimates according to McDonagh and others.[4]
[c]Statistical analysis was not conducted for data from patients with severe fluorosis (U.S. National Research Council)[1]

Figure 2: Family case studies of dental fluorosis. **Left:** Fraternal twins, 12 years of age, were exposed from birth to 1 ppm fluoride in drinking water. Regular use of fluoridated toothpaste from an early age resulted in extra fluoride ingestion in the girl (top left) because she was less efficient at expectorating the toothpaste than her brother, who had mild fluorosis (bottom left). **Right:** Siblings: 8-year-old girl (top right) and 12-year-old boy (bottom right). Both siblings had erosion of the enamel and white-spot mottling on all permanent teeth, accompanied by some staining. Both complained about the cosmetic appearance of their teeth. The patients and their parents stated that the problem had affected the children's self-image. The medical history was noncontributory. Several potential sources of excess fluoride were identified: general anesthetic used during caesarean birth, fluoridated tap water (although the mother breastfed each child for 6 months) and early (at 12 months of age) use of a "triple-swirl" of fluoridated toothpaste containing about 3 mg of fluoride.

of the tooth. The excess fluoride inhibits the final stages of tooth maturation. As a result, the surface enamel becomes hypercalcified while the subsurface layers are defective and hypocalcified, which makes bonding difficult. Mild fluorosis appears as chalky white spots or streaks, and moderate fluorosis may be associated with some structural loss of the surface enamel in thin layers, with or without accumulation of stain (**Fig. 1**). In more severe forms of fluorosis (such as those shown in **Fig. 2**), simple microabrasion (surface polishing) may be inadequate to remove the fluorotic enamel. More extensive treatment (involving composite resins, porcelain veneers and sometimes full-coverage restorations) is provided by most dentists.

Sources of Excess Systemic Fluoride

Foods and Beverages

Water containing fluoride at 1 ppm or higher (either naturally or artificially) and beverages made with fluoride-containing water contribute the most to daily fluoride intake. Because fluoride accumulates in bone, some foods (e.g. tinned salmon, mechanically separated chicken that contains ground bone) are rich in fluoride. Other foods also contain naturally high levels of fluoride. Dark tea,[6] for example, is rich in fluoride (3–6 ppm). Boiling water used for tea or cooking actually concentrates fluoride.

Fluoride Supplementation

Fluoride supplements are a major risk factor in dental fluorosis,[7] yet there is very little evidence that such supplements help to reduce dental caries.[8] The Canadian Dental Association (CDA), with input from various other health professionals, reached a consensus and modified its recommendations for the use of fluoride supplements in 1998.[9] The current protocol for fluoride supplement use was published in 2000.[10] If the current CDA guidelines (which state that total daily fluoride is not to exceed 0.05 mg/kg) are taken literally, physicians should abandon the prescription of supplemental fluoride altogether, since they are usually not prepared to estimate total fluoride intake from all sources. Fluoride works primarily by means of a topical effect,[11] so it may provide *some* benefit if given in lozenge form to patients at high risk for dental decay (i.e., those who have absolutely no topical exposure to fluoride and who are at high risk for caries because of their diet).

On the basis of average fluid intake and body weight, the daily fluoride intake of many infants exceeds 0.15 mg/kg.[1] To protect infants from ingesting too much fluoride, the American Dental Association now warns against using fluoridated tap water to make infant formula.[12]

Medicines

A large proportion of pharmaceuticals are fluorinated (e.g., Celebrex [celecoxib], Cipro [ciprofloxacin], Diflucan [fluconazole], Paxil [paroxetine], Dalmane [flurazepam], Lipitor [atorvastatin]). Furthermore, nearly all of the halogenated general anesthetics are fluorinated. Some

drugs, especially the general anesthetics, become defluorinated after administration and elevate serum levels of fluoride.[1]

Pollution

In the past, aluminum smelters produced a significant amount of fluoride pollution, but now the major fluoride polluters are phosphate fertilizer manufacturers and any industry that burns coal. Fluorosis associated with coal burning is well documented in China.[13]

THE AUTHOR

Dr. Hardy Limeback *is associate professor and head, preventive dentistry, University of Toronto, Toronto, Ontario. Email: Hardy.Limeback@dentistry.utoronto.ca.*

Dr. Limeback will be giving 3 presentations at the PDC: "New consumer products and fluorides," and "Cervical root hypersensitivity — ozone in dentistry," on Friday, March 7, and "New products, fluoride, root sensitivity and ozone," on Saturday, March 8.

References

1. Fluoride in drinking water: a scientific review of EPA's standards. Committee on Fluoride in Drinking Water, National Research Council, 2006. Available: www.nap.edu/catalog.php?record_id=11571.

2. Fomon SJ, Ekstrand J, Ziegler EE. Fluoride intake and prevalence of dental fluorosis: trends in fluoride intake with special attention to infants. *J Public Health Dent* 2000; 60(3):131–9.

3. Rozier RG. The prevalence and severity of enamel fluorosis in North American children. *J Public Health Dent* 1999; 59(4):239–46.

4. McDonagh MS, Whiting PF, Wilson PM, Sutton AJ, Chestnutt I, Cooper J, and others. Systematic review of water fluoridation. *BMJ* 2000; 321(7265):855–9.

5. Ishii T, 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(6):952–6.

6. Whyte MP, Essmyer K, Gannon FH, Reinus WR. Skeletal fluorosis and instant tea. *Am J Med* 2005; 118(1):78–82.

7. Warren JJ, Levy SM. Current and future role of fluoride in nutrition. *Dent Clin North Am* 2003; 47(2):225–43.

8. Ismail AI, Bandekar RR. Fluoride supplements and fluorosis: a meta-analysis. *Community Dent Oral Epidemiol* 1999; 27(1):48–56.

9. Limeback H, Ismail A, Banting D, DenBesten P, Featherstone J, Riordan PJ. Canadian Consensus Conference on the appropriate use of fluoride supplements for the prevention of dental caries in children. *J Can Dent Assoc* 1998; 64(9):636–9.

10. Swan E. Dietary fluoride supplement protocol for the new millennium. *J Can Dent Assoc* 2000; 66(7):362–3.

11. Limeback H. A re-examination of the pre-eruptive and post-eruptive mechanism of the anti-caries effects of fluoride: is there any anti-caries benefit from swallowing fluoride? *Community Dent Oral Epidemiol* 1999; 27(1):62–71.

12. American Dental Association. ADA offers interim guidance on infant formula and fluoride. Posted November 9, 2006. Available: www.ada.org/prof/resources/pubs/adanews/adanewsarticle.asp?articleid=2212.

13. Feng YW, Ogura N, Feng ZW, Zhang FZ, Shimizu H. The concentrations and sources of fluoride in atmospheric depositions in Beijing, China. *Water Air Soil Pollut* 2003; 145:95–107.