ANTICARIES AGENTS

Dental caries is a pathologic process of microbial etiology that results in localized destruction of tooth tissues. The process of tooth destruction involves dissolution of the mineral phase, consisting primarily of hydroxyapatite crystals, by organic acids produced by bacterial fermentation.

The biologic basis of dental caries involves four principal factors:

1- The host, particularly the saliva and teeth;

2- The microflora; and their substrate,

3- The diet

4- Time, must be considered in any discussion of the causes of caries.

Modern-day caries prevention is based on attempts to modify these core features.

Examples include therapies used with the intent to

(1) Increase the resistance of the host (fluoride therapy, occlusal sealants, immunization),

(2) Reduce the number of cariogenic microorganisms in contact with the tooth (plaque control and antiplaque agents),

(3) Modify the substrate by selecting non cariogenic foods, and

(4) Reduce the time that the microflora is provided with substrate by limiting the frequency of intake of fermentable substrate.

Fluoride therapy for the prevention of dental caries

In biologic mineralized tissues, such as bones and teeth, Fluoride occurs as an impure apatite crystal, not as fluorapatite ($Ca_{10}[PO4]_6F_2$). The lattice of biologic apatite crystals contains many impurities, either in the lattice itself or adsorbed on the surface. Carbonate ions (2% to 5%) substitute for some phosphate ions; some Ca++ is substituted by other ions, such as Na+, K+, Mg++, and Zn++; and **some hydroxyl ions are substituted by fluoride**. The approximate representation of the formula of this apatite is $\mathbf{Ca_{10-x}(Na)_x(PO4)_{6-y}(CO3)_z(OH)_{2-u}(F)_u}$.

Although only some of the hydroxyls of the apatite lattice are substituted by fluoride (i.e., u is much smaller than 2), this change profoundly alters the resistance of enamel to demineralization.

SYSTEMIC FLUORIDE

The fluoride-containing water, tablets, or drops are being ingested, or indirect, from the slight elevation in salivary fluoride concentration after ingestion. Exert a systemic effect on teeth that are still undergoing mineralization.

Classic epidemiologic surveys of the prevalence of dental caries, carried out by Dean and others during the late 1930s and early 1940s, showed an inverse relationship between caries prevalence and fluoride concentration in drinking water.

Subsequently, it was shown that adults and children who have continually consumed fluoridated water lose fewer teeth and have lower incidences of decayed, missing, and filled teeth.

The optimal concentration depends on the annual average maximum daily air temperature in the community (temperature influences the amount of water ingested). In temperate climates, where the annual average maximal daily air temperature is 14.7° C to 17.7° C, the optimal level of fluoride **is 1 ppm**.

Communal water fluoridation continues to be the cornerstone of an ideal caries prevention program. Its efficacy in reducing caries prevalence has been amply shown. Its safety has also been well established. The cost benefits are impressive.

Fluoridation of School Water Supplies

Adjusting the fluoride content of a school's water supply because central water supplies are unavailable to large segments of the world's population. The currently recommended concentration for school water fluoridation is 4.5 times the optimal value recommended for community water fluoridation in the same geographic area.

Disadvantages of school fluoridation are:

1- Children are 5 to 6 years old before they begin attending school and drinking the water. Maximal caries prevention accrues when fluoridated water is consumed from birth.
2- Continued protection is not provided when the children leave school.
3- Operating and maintaining small fluoridation systems (i.e., systems serving <500 people) creates practical and logistic difficulties.

Fluoride Supplements

Supplements offer an alternative source of systemic fluoride. Fluoride tablets, drops, and lozenges have been proved unequivocally to be effective cariostatic agents, provided that such supplements are taken on a daily basis continuously from birth to approximately 16 years of age.

The correct dosage in prescribing fluoride supplements depends on two factors: **the age of the child** and **the existing fluoride concentration in the water supply** . The latter information can be obtained from the local water supply authority . Failure to determine the fluoride concentration in the communal water source can result in a fluoride over dosage and consequent dental fluorosis.

In the 6-month to 3-year age cohort, it is recommended that fluoride drops be prepared in a more dilute form, such as containing 0.25 mg of fluoride in 0.25 mL (instead of in a single drop), to minimize over dispensing errors at home.

TABLE 44-2

*American Dental Association Dosage Schedule (mg/day) for Fluoride Supplements**

	FLUORIDE CONCENTRATION (ppm) IN PRIMARY DRINKING WATER		
AGE (yr)	<0.3	0.3-0.6	>0.6
0-0.5	0	0	0
0.5-3	0.25	0	0
3-6	0.5	0.25	0
6-≥16	1	0.5	0

*Council on Dental Therapeutics, 1994.

TOPICAL FLUORIDE

The efficacy of topical fluoride in caries prevention depends on:

1- The concentration of fluoride used,
2- The frequency with which it is applied
3- The duration of application, and,
4- To some extent, the specific fluoride compound used.

Professional Topical Application of Fluorides Solutions, gels, and foams

Semi-annual topical application of concentrated fluoride (2% sodium fluoride, 8% stannous fluoride, or APF containing 1.23% fluoride) by a dentist or dental hygienist provides an average 26% reduction of decay of permanent teeth of children living in non-fluoridated areas.

Specific fluoride compound Neutral sodium

Neutral sodium fluoride solutions (2%) were first tested in the early 1940s and were shown to reduce caries. Teeth first cleaned with pumice paste, and the solution applied to the teeth for 3 minutes. The application, but not the pumicing, was repeated at weekly intervals for a total of four applications at ages 3, 7, 11, and 13 years.

Stannous fluoride

In 1958, 8% **stannous fluoride** was also shown to be an anticaries agent. The procedure again involved coronal polishing, and the stannous fluoride was applied for 4 minutes semi-annually. Aqueous stannous fluoride solutions have the disadvantages:

1-Undergoing rapid hydrolysis and oxidation; because of this instability, they must be freshly prepared for each treatment.

2- Stannous fluoride has a low pH (approximately 2.7) and has a disagreeable acidic and metallic taste.

3- Reported teeth stain (from light brown to black) at carious lesions, hypocalcified areas, and around the margins of restorations after stannous fluoride application. This discoloration

caused by the conversion of tin phosphates, which form on the enamel, to tin sulfides, which have the characteristic dark brown or black color.

Acidulated phosphate fluoride (APF)

In the United States, the most popular form of office fluoride therapy is the application of APF in the form of a solution, gel, or foam. APF agents should have a pH of approximately 3.0 and contain 1.23% fluoride and 0.1 mol/L of orthophosphoric acid. The low pH of this agent favours more rapid fluoride uptake by enamel, and the presence of the orthophosphate prevents enamel dissolution by the common ion effect. A coronal polishing precedes application of one of these solutions or gels, and the agent should be applied for 4 minutes, usually in a disposable tray applicator. The procedure should be repeated semi-annually.

Varnishes

The previously discussed agents (sodium fluoride, stannous fluoride, and APF) are all aqueous preparations, but other research has involved no aqueous solutions that are applied as varnishes with **longer retention time on the tooth surface**. Types of Varnishes

1- Duraphat (2% sodium fluoride lacquer in an alcoholic solution of natural resins)
2- Difluorosilane agent containing 0.7% fluoride in a polyurethane varnish. This agent boasts a high fluoride uptake by enamel. It is available in the United States as a cavity varnish to seal and prevent the permeation of fluids and metal ions.
3- In 1994, a 5% sodium fluoride varnish under the name of **Duraflor** obtained FDA approval for its use in the United States as a cavity liner.
4- The Duraphat formulation of 5% sodium fluoride varnish received FDA approval as a dentin-desensitizing agent and as a cavity liner.

Self-Applied Topical Fluoride in the Home

One of the most effective means of caries reduction involves the daily (on school days) selfapplication of 1.1% sodium fluoride gel in custom-fitted trays for 5 minutes daily.

This form of self-therapy is best suited only for

1- High-risk caries patients who are sufficiently motivated to conform to the daily regimen.
2- It is not intended for very young children, but is appropriate for school-aged children.
3- Effective for adults with xerostomia after radiation therapy to the head and neck region.

Fluoride Mouth Rinses

In the mid-1960s, Scandinavian researchers showed that a biweekly rinse for 1 minute with a solution of 0.2% sodium fluoride (920 ppm of fluoride) was more effective in reducing decay than an annual treatment with 10% stannous fluoride professionally applied. Fluoride mouth rinses were prescription items when originally introduced, and the 0.2% sodium fluoride rinse still requires a prescription.

Fluoride Dentifrices

The widespread use, most commonly twice a day, of fluoride-containing dentifrices has had a profound effect in reducing caries in many developed countries and accounts for some of the

secular decline in caries observed in communities lacking optimal fluoride concentrations in the water supply.

TABLE 44-6

Clinically Effective Fluoride Abrasive Systems in Dentifrices

FLUORIDE COMPOUND	ABRASIVE SYSTEM	FORMULA
Stannous fluoride (SnF_2)	Calcium pyrophosphate	$Ca_2P_2O_7$
	Insoluble sodium metaphosphate	$(NaPO_3)_x$
	Silica	SiO_2
Sodium fluoride (NaF)	Calcium pyrophosphate	$Ca_2P_2O_7$
	Insoluble sodium metaphosphate	$(Na_2PO_3)_x$
	Polymethyl methacrylate	*
	Silica	SiO_2
Sodium monofluorophosphate (Na_2PO_3F)	Calcium carbonate	$CaCO_3$
	Aluminum oxide	Al_2O_3
	Insoluble sodium metaphosphate	$(Na_2PO_3)_x$
	Silica	SiO_2
	Dibasic calcium phosphate	$CaHPO_4$
	Calcium pyrophosphate	$Ca_2P_2O_7$
Amine fluoride	Insoluble sodium metaphosphate	$(Na_2PO_3)_x$

$x, \geq 2$.
*Composed of repeating units of methylmethacrylate:

FLUORIDE TOXICOLOGY

Acute Toxicity

When ingested in amounts of 1 to 3 mg/day, as would be the case in optimally fluoridated communities, fluoride is perfectly safe. **A dose of 5 to 10 g of sodium fluoride (approximately 2.5 to 5 g of fluoride) is fatal for an adult, however, and lesser amounts are lethal to children**.

Patients with severe fluoride poisoning characteristically exhibit nausea, vomiting, and diarrhea; progressive hypotension, pronounced hypocalcemia and hypomagnesemia, and acidosis; and cardiac irregularities, including ventricular tachycardia and sometimes fibrillation and asystole.

Successful treatment is based on early initiation of the following procedures:

1. Steps to prevent further systemic absorption of fluoride (e.g., administration of emetics to induce vomiting, gastric lavage with fluids containing Ca++)
2. Cardiopulmonary monitoring and preparation for endotracheal intubation and direct-current cardioversion
3. Prompt and frequent blood analyses, especially for plasma Ca++, Mg++, K+, and pH
4. Intravenous infusion of salt solutions as needed to correct acid-base imbalances and restore plasma electrolytes to the normal range
5. Alkaline diuresis to enhance fluoride excretion.
6. Appropriate treatment of severe cardiac arrhythmias.

Note: the topical application of fluoride agents in the office or the self-application of fluoride agents in the home does not pose a risk of acute toxicity.

Chronic Toxicity

Dental fluorosis: is a hypomineralization of enamel produced by chronic ingestion of excessive amounts of fluoride during tooth development. Fluorosis may range in severity from a few white flecks to extensive brown staining and pitting.

Chronically high concentrations of fluoride interfere with deposition of mineral, degradation of matrix proteins (amelogenin and enamelin), and withdrawal of water during enamel maturation.

The prevalence and severity of fluorosis depend on the **amount or concentration of fluoride**, **the duration of exposure**, the **state of tooth development** (i.e., age when exposed), and **individual variations in susceptibility** (e.g., body weight).

Prevention

1-Some fluorosis can also be prevented by stopping the use of fluoride supplements in communities that already provide optimal levels in the water supply.

2-Because supplements require a prescription, dentists, physicians (particularly pediatricians), and pharmacists need to be better educated on when supplementation is indicated and when it is not.

3-Fluorosis can be prevented by decreasing the unintentional ingestion of fluoride from dentifrices by young children. Children younger than 6 years need to be instructed to use only a pea-size portion of paste, to spit out thoroughly after brushing, and to avoid swallowing the paste.