Fluoride

DEN 130 -Theory I

Objectives

1. Describe mechanisms of action of fluoride
2. Explain role of community water fluoridation
3. Recommend appropriate over-the-counter (OTC) and professionally applied fluoride therapies
4. Compare use of fluoride home products (OTC and prescription)
5. Incorporate fluoride into individualized prevention plans

“I do not want fluoride because it causes cancer and is a poison to your body.”

Introduction

- Beneficial application:
  - Caries prevention
  - Re-mineralization
  - Desensitization

- Systemic or Topical

What is the role of fluoride in the dental caries process?

Fluoride Metabolism

- **Intake**
  - Foods and Water
  - Ingestion of Topical Fluoride sources
  - Dietary Supplements

Foods with Fluoride

- Fluoridated Salt
- Tea and Fish have larger amounts
- Other examples include:
  - Meat
  - Eggs
  - Vegetables
  - Cereals
  - Fruits

Fluoride Metabolism

- **Absorption**
  - GI tract- Stomach and Intestines
    - Reduced if eaten with milk and other food
    - Absorbed within 60 mins
    - If not absorbed in the stomach, absorbed in the small intestine
  - Bloodstream
    - Plasma carries and distributes through the body
    - To the kidneys for elimination
    - Maximum blood level is reached within 30 minutes
    - Kidneys eliminate
    - Normal plasma levels are low and rise and fall according to uptake

Fluoride has a strong affinity for calcified tissue, i.e. bone

Fluoride Metabolism

- Distribution and Retention
  - (99%) Stored in mineralized tissues, i.e. bones and teeth
  - Stored as an integral part of the crystal lattice of teeth, mostly on the outer surface
  - Amount stored varies with intake, time of exposure, age, and stage of development
  - Teeth store small amounts, with the highest on the tooth surface
  - Fluoride accumulation in bone is mobilized slowly from the skeleton
  - Once tooth enamel is fully matured, the fluoride deposited during development can be altered caries, erosion, and mechanical abrasion
- Excretion
  - Kidneys- majority-through urine
  - Sweat glands and feces- small amounts
  - Breast milk- limited

Methods of Fluoridation

Pre-Eruptive: Mineralization

Pre-Eruptive: Maturation

Post-Eruptive

Methods of Fluoridation

- Pre-Eruptive - systemic
- Post-eruptive – topical

- Fluorosis is caused by systemic fluoride and will only result from excess fluoride during development.

What is fluorosis?

TABLE 21-2 • Scoring System for Dean's Fluorosis Index

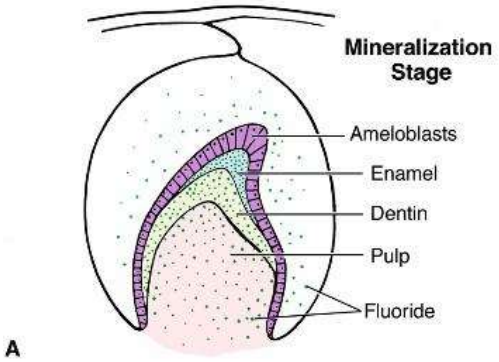
CATEGORY	DESCRIPTION	NUMERICAL SCORE
Normal	Smooth, creamy white tooth surface	0
Questionable	Slight changes from normal transparency	1
Very mild	Small, scattered opaque areas; less than 25% of tooth surface	2
Mild	Opaque areas; less than 50% of tooth surface	3
Moderate	Significant opaque and/or worn areas; may have brown stains	4
Severe	Widespread, significant hypoplasia, pitting, brown staining, worn areas, and/or a corroded appearance	5

Pre-Eruptive: Mineralization Stage

When is this stage occurring? Primary vs. Permanent?

Circulates in the bloodstream and is incorporated into all parts of developing teeth

Hydroxyapatite crystalline becomes fluorapatite – less soluble and may contribute to shallower grooves and reduced carious risk for a lifetime



Pre-Eruptive: Maturation Stage

After mineralization is complete, but before eruption

Deposition continues in the surface of the enamel from the nutrient tissue fluids surrounding the tooth

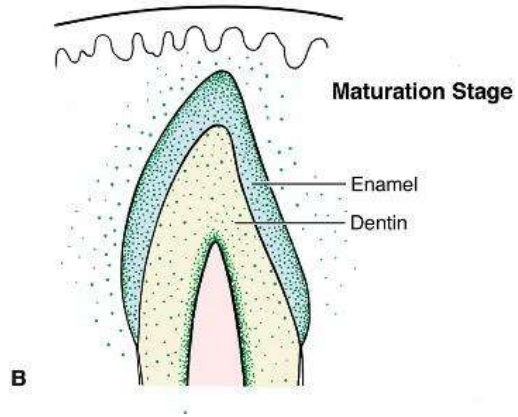


TABLE 47-4 • Tooth Development and Eruption: Primary Teeth

TOOTH	HARD TISSUE FORMATION BEGINS (WEEKS IN UTERO)	ENAMEL COMPLETED (MONTHS AFTER BIRTH)	ERUPTION (MONTHS)	ROOT COMPLETED (YEAR)
Maxillary				
Central incisor	14	1½	10 (8–12)	1½
Lateral incisor	16	2½	11 (9–13)	2
Canine	17	9	19 (16–22)	3¼
First molar	15½	6	16 (13–19 in boys; 14–18 in girls)	2½
Second molar	19	11	29 (25–33)	3
Mandibular				
Central incisor	14	2½	8 (6–10)	1½
Lateral incisor	16	3	13 (10–16)	1½
Canine	17	9	20 (17–23)	3¼
First molar	15½	5½	16 (14–18)	2¼
Second molar	18	10	27 (23–31 in boys; 24–30 in girls)	3

Post-Eruptive Fluoridation

Protection against demineralization and enhance remineralization

Where do we get daily exposure?

Rapid uptake of fluoride during the first years after eruption

Continuous daily presence of fluoride can inhibit initiation and progression of dental caries

Tooth Surface and Fluoride

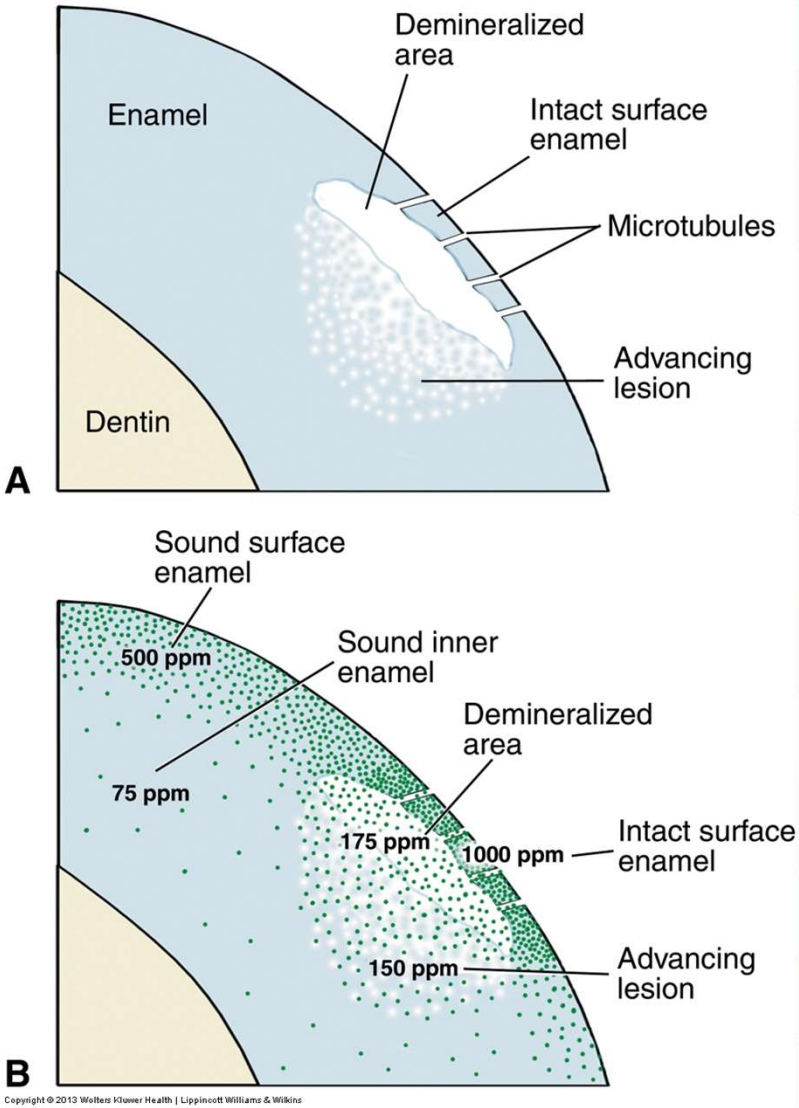
- Fluoride in Enamel
  - Fluoride is a natural component of enamel
  - Highest concentration on outer surface
  - Uptake depends on amount of fluoride and length of exposure
  - An area remineralized by fluoride will have a higher concentration of fluoride than sound enamel
- Fluoride in Dentin
  - Concentration highest at pulpal surface- exchange occurs here
  - Fluoride levels can be greater in dentin than enamel
- Fluoride in Cementum
  - High concentration that increases with exposure
  - Higher when there is recession and cementum is exposed

Demineralization

- The breakdown of tooth structure with a loss of mineral content, primarily calcium and phosphorus
- Caused by acids produced after the metabolism of ingested fermentable carbohydrates
- Earliest detectable lesion = small white spot on the tooth

Process of Demineralization

- Acids produced pass through the microchannels between the enamel rods
- Demineralization occurs in the subsurface layer
- The area can be detected on clinical examination when the spot may become chalky or discolored
- Dental caries form with further demineralization



Remineralization

- The recovery of the demineralization process
- Saliva neutralizes the acid and carries the calcium and phosphate ions
- Saliva and biofilm are reservoirs for fluoride
- Fluoride attracts calcium and phosphate ions
- The white lesion will harden and the area can be hypermineralized with the enamel around it

Topical Effects of Fluoride

1. Fluoride can fight against an acid challenge (inhibit demineralization)

2. Fluoride absorbs into the crystal surface and attracts calcium and phosphate (enhances remineralization)

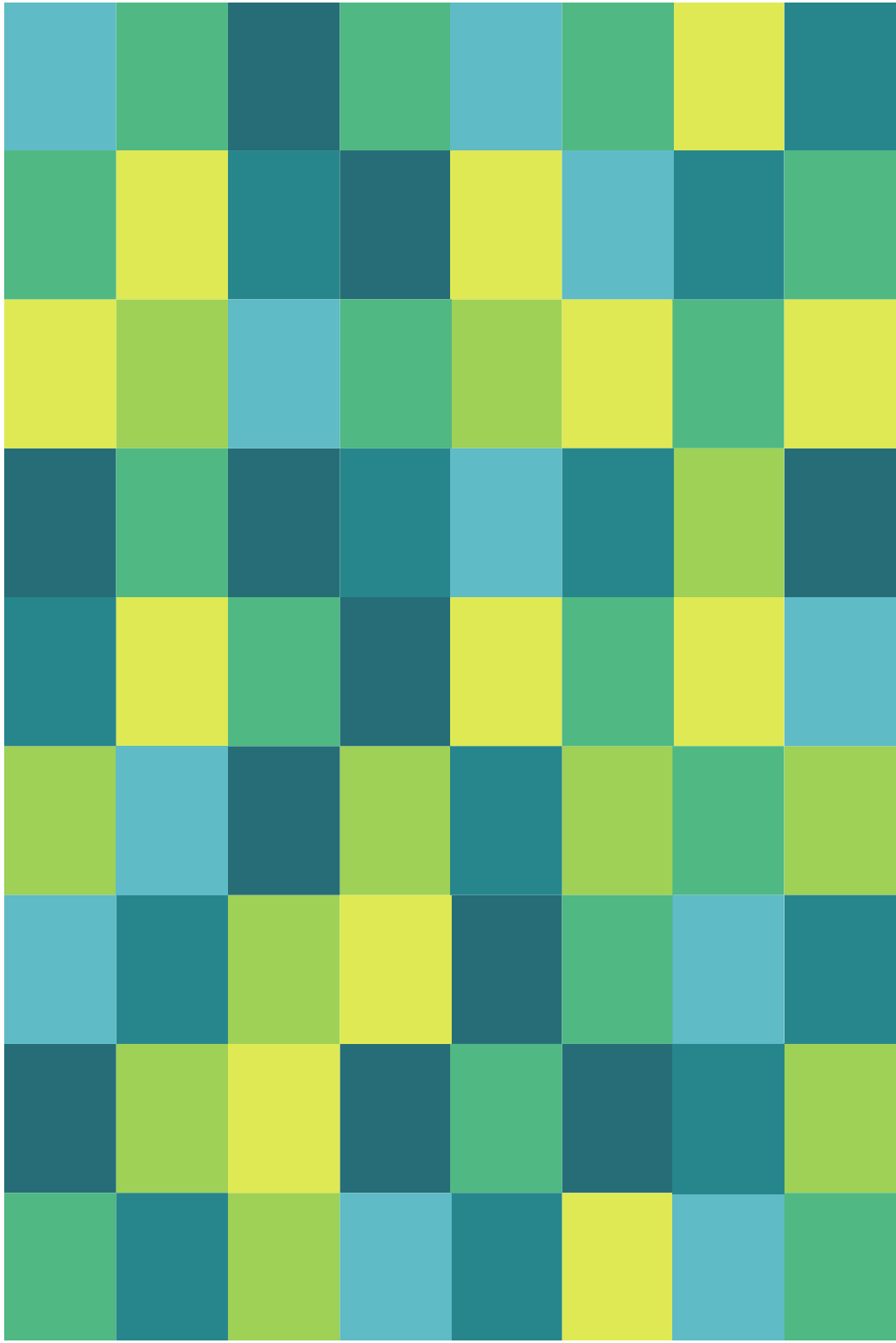
3. At high levels, fluoride can interfere with bacterial growth and metabolism

Fluoridation

- The adjustment of the natural fluoride ion content in domestic municipal water supply to the optimum concentration that will maximize caries prevention and limit enamel fluorosis.

- Fluoridation is the most efficient, effective, reliable, and inexpensive means for improving and maintaining oral health for everyone.

What's the history of fluoridation in dentistry?



Fluoridation: Historically

- Mottled enamel and Dental Caries
  - Early 1900s - Dr McKay researched the brown stain > mottled enamel > dental fluorosis, but less caries
  - 1931 - Churchill isolated fluorine as the cause

- 1930s - Dr. H. Trendley Dean
  - concluded 1 ppm fluoride was the ideal level in water – showed many benefits and healthy lives
  - Fluorosis > 2 ppm
  - Concept of adding fluoride developed

Fluoridation: Historically

- 1945 – Research began to obtain baseline information and then the 1st community water fluoridation started
- 1960 – Some communities discontinued fluoridation and saw clear effects (drop in number of caries free children)
- 1962 – recommended optimal fluoride concentration of .7 ppm (for warmer climates) and 1.2 ppm (for colder climates)
- 2014 - 66.3% of the US population received fluoridated water and 74.4% of public water sources provided community fluoridation
- 2015 – updated recommendation for fluoridation is 0.7 ppm in all communities

Community Fluoridation

- Average cost is $0.13-$5.48 per person/year (depends on the size of the community)
- All fluoride chemicals conform to the American Water Works Association standards to ensure safe drinking water
- Regulated by the (EPA)
  - **Mandates** defluoridation if community levels > 4 mg F/L of water
  - **Recommends** defluoridation if F level is between 2 and 4 mg F/L of water

Community Fluoridation

- Fluoride ions are derived from components that are naturally occurring and mined all over the world
  - Common sources are fluorspar, cryolite, and apatite.
  - They must be:
    - Soluble
    - Inexpensive
    - Readily available

- Compounds used in water include:
  - Dry: sodium fluoride (NaF) and sodium silicofluoride
  - Liquid: hydrofluorosilicic acid

Root Caries

- Dental caries that occur on the root surface that is exposed
- Caries rate is 50% less for residents that live in fluoridated communities

Dental Caries: Primary Teeth

The risk of caries is reduced by 40% with fluoridation from birth.

Dental Caries: Adults

- When a person resides in a community with fluoride in the drinking water throughout life, benefits continue.

- In Colorado Springs, adults aged 20–44 years who had used water with natural fluoride showed 60% less caries experience than did adults in fluoride-deficient Boulder, Colorado. In Boulder, adults also had three to four times as many permanent teeth extracted.

- In a survey of adults in Rockford, Illinois (no fluoride), there were about seven times as many edentulous persons as there were in a comparable group in Aurora, Illinois (natural fluoride).

School Fluoridation

- In rural areas where there is no community fluoridation, adding fluoride to the school water is an alternative.
- It is added at a higher level since they are only there 5 days a week.
- Today, it is mostly phased out. Operations and maintenance were problematic.

Supplemental Fluoride

Dietary Supplements

- Used in areas without fluoridated water or minimal fluoridation
- Ages 6 months to 16 years – if they are high risk or do not have fluoridated water as their primary drinking source
- Pill, chewable tablet, lozenge, drop, mouth rinse
- Individually prescribed for home-use or public health programs in school
- Chewing and rinsing with tablets
  - Systemic and topical use
  - Swish chewing mixture for 1 min then swallows

Supplemental Dosage

- Ensure no supplement is being taken
- Check water fluoride levels
  - Test water or call state/local health departments
- Infants
  - Low in breast milk: additional .25mg
  - Should use optimally fluoridated water when mixing formula

TABLE 36-1 Fluoride Supplements Dose Schedule (Mg NaF/d)[a]

AGE OF CHILD (Y)	WATER FLUORIDE ION CONCENTRATION (PPM)		
	LESS THAN 0.3	BETWEEN 0.3 AND 0.6	GREATER THAN 0.6
Birth–6 mo	0	0	0
6 mo–3 y	0.25 mg	0	0
3–6 y	0.50 mg	0.25 mg	0
6–16 y	1.0 mg	0.50 mg	0

[a]About 2.2 mg of sodium fluoride provides 1 mg of fluoride ion.
Source: American Dental Association and the American Academy of Pediatrics.

Professional Topical Fluoride

Professional Topical Fluoride

- Critical part of a total preventive program for patients of all ages
- Professionally applied
  - Foams
  - Varnish
- Self applied – toothpastes, rinses, prescriptions, trays, etc.
- Assess patient's caries risk to determine their need
- Remember to follow manufacture instructions, as they all differ.

TABLE 34-2 • Professionally Applied Topical Fluorides

AGENT	FORM	CONCENTRATION	APPLICATION MODE/FREQUENCY	NOTES
NaF neutral or 7 pH	2% Gel or foam[a]	9,050 ppm 0.90% F ion	Tray (4 min)/no currently recommended interval	Do not overfill: see Figure 34-5
Acidulated phosphate 3.5 pH	1.23% Gel or foam[a]	12,300 ppm 1.23% F ion	Tray (4 min)/at least every 3–6 mo[47]	Do not overfill: see Figure 34-5
NaF neutral or 7 pH	5% Varnish	22,600 ppm 2.26% F ion	Apply thin layer with a soft brush (1–2 min)/at least every 3–6 mo[47]	Sets up to a hard film
SDF pH 8–10	5.0–5.9% Fluoride	44,800 ppm 4.48% F ion	Apply a thin layer with a microbrush (1 min and let dry, then rinse with water)/at least every 6–12 mo[63]	Goes on clear, becomes black/gray upon application to cavitated areas

Neutral Sodium Fluoride

- Neutral pH of 7.0
- 2% (foam/gel) - 5% (varnish)
- Available in gel, foam, or varnish
  - Tray or Paint On
- Salty taste
- No tooth staining
- 4 minute application required for trays

Fluoride Varnish

- Contains 5% NaF (22,600 ppm)
- Used to desensitize exposed roots and caries prevention
- Retained for 24-28 hours
- **14%** more effective than topical gels!

Acidulated Phosphate Fluoride

- pH of 3.5- acidic- enhanced uptake
- 1.23%
- Available in Gel or Foam
  - 4 minute application
- Non staining
- Not used on sealants, composites, porcelain or implants - acid in fluoride etches the glass components in the restoration causing surface roughening and pitting over time

Silver Diamine Fluoride

- 5-5.9% fluoride
- 24.4-28.8% silver (antimicrobial)
- pH 8-10
- A topically applied fluoride used to relieve sensitivity and to arrest active caries
- Applied only to specific sites of need
- Can be used **prior** to restoration placement to reduce risk of recurrent decay
- Hygienists can place it after dentist has prescribed

Silver Diamine Fluoride

- Silver acts as an antimicrobial agent against cariogenic bacteria
- Water- provides a liquid base
- Fluoride – helps with remineralization
- Ammonia – helps the solution remain concentrated so its maximally effective against caries
- One drop = 2.24 mg of fluoride and 4.74 mg of silver

History of Silver Diamine Fluoride

- Used worldwide for more than eighty years
- 2015: Approved by U.S. Food and Drug Administration (FDA) for treatment of dentin hypersensitivity
- 2016: FDA designated it as a "breakthrough therapy" for arrest of dental caries, but it is still awaiting FDA approval
- It is currently being used "off-label" for caries

SDF is Beneficial For:

- Children
- Special needs patients
- Elderly
- Pts with limited access to dental care
- Noncooperative/noncompliant patients
- Rampant or difficult-to-repair caries
- Failing prosthodontic restorations
- Those who refuse extraction of nonrestorable teeth
- Temporary condition which restricts traditional treatment
- Patient who opts for minimally invasive treatment

Tooth Selection for SDF

- No clinical pulpal inflammation
- No spontaneous pain
- No radiographic evidence of carious lesion encroaching on the pulp
- Carious lesion must be accessible with a brush or floss for applying SDF

Contraindications

- Allergy to silver or other heavy-metal ions
- Pregnancy
- Ulcerative gingivitis or stomatitis

Side Effects

- Stains carious lesions black (certain brands do not)
- Stains margins of restorations
- Temporary metallic taste – may cause taste-induced nausea
- Temporary staining of soft tissues – hydrogen peroxide may lighten immediately or it will resolve in 2-3 weeks
- Pulpal Irritation

Application of SDF

- Signed informed consent
- Follow manufacture instructions
- One drop will treat 5-6 teeth
- Will stain skin, clothing, surfaces, etc.
- After absorbed for 2-3 minutes you can blot the excess or apply fluoride to prevent spread and accidental staining of other surfaces
- Highest success is with biannual application
- D1354: Interim Caries Arresting Medicament Application

Efficacy of SDF

- Anterior teeth have higher rates of caries arrest
- Posterior teeth and teeth with large caries more often need reapplication
- Annual SDF application is more effective than 3 month application of 5% sodium fluoride
- SDF and fluoride varnish may have additive or synergistic actions - Some recommendations to use alternating at 3-month intervals

Self-Applied Fluoride Treatments

- **Which type of patient would be appropriate?**

- **Tray**
  - Custom or disposable
  - Held in mouth for 4 minutes

- **Mouth rinses**
  - Swish for 1 minute
  - Expectorate when finished

- **Brush on toothpastes**
  - Gel or paste used for regular brushing
  - In addition to regular brushing

Guidelines for Clinic

- Fluoride treatment after polishing, pit and fissure sealants, and amalgam polishing
- **4 minute uptake-** even if bottles advertises 1 minute application
- DO NOT LEAVE PATIENT ALONE
  - Stay with them and observe for the entire four minutes
  - Patient could choke on saliva and foam, have an allergic reaction, gag on the tray
- Always follow up with patient to make sure they are not having a reaction
  - Ask them if they are experiencing any itching or burning
  - Check for any clinical signs

Acute Toxicity

- Rapid intake of an excess over a short period of time

- **Certainly Lethal Dose (CLD)**
  - Amount of drug likely to cause death if not treated ASAP
  - Adult CLD: 5-10g sodium fluoride at 1 time
  - Child CLD: 0.5- 1 g- varies by size and weight

- **Safely Tolerated Dose (STD)- ¼ of CLD**
  - Adult STD: 1.25 to 2.5g of sodium fluoride
  - Child STD: varies by age and weight

Signs and Symptoms of Acute Toxicity

- Begins within 30 minutes of ingestion and can last as long as 24 hours
- GI tract- nausea, vomiting, diarrhea, abdominal pain, increased salivation, thirst
- Systemic involvement
  - Blood- calcium binds with fluoride- hypocalcaemia
  - CNS- convulsions and paresthesias
  - Cardiovascular and Respiratory Depression
    - Can occur if left untreated

Fluoride safety and management

- Beneficial in small amounts but dangerous if used without attention to correct dosage and frequency

- Dental professionals need to be familiar with:
  - Approved procedures and dosages
  - Toxic effects of fluoride
  - Emergency management of fluoride overdoses

Emergency treatment

- Induce Vomiting- fingers, ipecac syrup
- Call 911
- Administer milk or lime water (binds with fl2)
- Support respiration and circulation
- Emergency room:
  - Calcium gluconate for muscle tremors
  - Gastric lavage
  - Cardiac and blood monitoring
  - Endotracheal intubation
  - Intravenous feeding

Chronic Toxicity

- **Skeletal fluorosis**
  - 20 or more years of exposure
  - Osteosclerosis- elevation in bone density
- **Dental fluorosis**
  - Only occurs during enamel formation when fluoride is ingested (birth to 8/9 years)
  - Mild, Moderate, Severe
  - Results in discontinuity of crystal growth

Documentation

- Caries risk
- Current use of fluoride
- Type, concentration, mode of delivery, and post-op instructions
- Type, amount, and instructions for use of daily fluoride products

From what you've learned today, how would you respond?

What type of fluoride do I use?

- Consider:
  - Caries Risk
  - Periodontal health
  - Restorations
  - Age
  - Daily fluoride exposure
  - Sensitivity

Questions?