FLUORIDE IN DENTISTRY

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Specific Objectives

After this session the students will be able to:-

1. outline the historical background of fluoride in relation to dentistry
2. understand the metabolism of fluoride
3. explain the mechanism of actions of fluoride
4. discuss the methods of introducing fluoride to prevent dental caries
**FLUORIDE**

- **Fluorine**: Freely available in nature, not in its elemental state — high reactivity. fluospar $\text{CaF}_2$; Fluorapatite $\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2$
- Oxidation state of fluoride ion: -1
- Concentration varies: earth, fresh ground water, sea water
- Dietary constituents: fish, tea
- Non-dietary: toothpaste, mouth rinses, etc
1892

The use of fluorides for dental purposes began in the nineteenth century.

Sir James Crichton Browne emphasized the importance of fluoride:
- relate the change of taking bread with husk parts of wheat to white bread and the increase of dental caries.
- suggested that *fluoride* missing from the husk parts of wheat be reintroduced into the diet of child-bearing women and children to decrease the incidence of dental caries.
HISTORICAL BACKGROUND

• 1901
  - Dr. Frederick McKay, highlighted the impact of fluoride in water.
  - children living in the Colorado Springs all their lives, had permanent stain on their teeth: Colorado Stain (Mottled enamel).

• 1916
  - McKay and Dr. G.V. Black and mapped the geographical area of the stain → 87.5% children in native area with the stain: 9 out of 10 children

• 1939
  - McKay and Trendly Dean concluded that the incidence of mottled enamel were halted by reducing the level of fluoride in water to 1ppm.
HISTORICAL BACKGROUND

• **1902** - fluoridens, Copenhagen, Denmark
• Contained 83.7% Calcium Fluoride
• In the UK: mix with salt - 1tsp fluoridens to 2tblsp salt → no effort from user
METABOLISM OF FLUORIDE

• Most of ingested fluoride are absorbed in the digestive tract → the blood
• only small amounts unabsorbed: → excreted in the faeces
• Circulating plasma fluoride: → deposited to teeth and bone and → v. small amount to soft tissues
• excreted via: → urinary system (major pathway) and sweat, small amount in milk, saliva and digestive juice
METABOLISM OF FLUORIDE

Diet

Digestive tract → Faeces

Digestive juice

Circulating Plasma fluoride

Placenta & fetus

Saliva

Teeth

Soft Tissue

Milk

Urine

Sweat

Bone
METABOLISM OF FLUORIDE

- Absorption occur in the stomach and duodenum by passive diffusion
- Presence of calcium, aluminium and magnesium reduce the absorption probably by formation of insoluble complexes with fluoride
- Sodium fluoride (4% solubility), stannous fluoride (10% solubility) and sodium monofluoro-phosphate (25% solubility) are highly soluble
- Calcium fluoride (0.0016% solubility) are virtually insoluble
1. Acute poisoning
   - Refer to rapid intake of an excess dose over a short time.
   - Certainly lethal dose (CLD):
     • Adult = 5-10 g NaF taken at one time or
       = 32-64 mg F / Kg body weight
     • Children = 2.5 g of NaF
   - Safety Tolerated Dose (1/4 CLD)
     • Adult = 1.25-2.5 g NaF or
       = 8-16 mg F / Kg body weight
TOXICITY OF FLUORIDE

1. Acute poisoning (S/S)
   Begin within 30 minutes of ingestion
   a. GIT
      Fluoride in the stomach is acted by hydrochloric acid to form hydrofluoric acid that is irritable to stomach lining, causing:
      - Nausea, vomiting & diarrhea
      - Abdominal pain
      - Increased salivation & thirst
   b. Systemic
      - CVS : Hyperreflexia, convulsions & paresthesia
      - CVS : Cardiac Failure
      - Resp : Paralysis
TOXICITY OF FLUORIDE

1. Acute poisoning (S/S)

   Emergency Treatment
   a. Induce vomiting
   b. Administration of fluoride binding liquid if patients do not vomit
      - Milk
      - Lime water → gastric lavage
   c. Support respiratory and circulation
   d. Call emergency services and transport to hospital
2. **Chronic poisoning**

- Applies to long-term ingestion of fluoride in amounts that exceed the approved therapeutic levels.

- Continued ingestion of high doses of naturally occurring fluoride will be reflected in changes in the teeth. *Fluorosis* of enamel is caused by defective matrix formation (hypoplasia) probably due to direct effect of fluoride on ameloblast metabolism. Lesion is usually confined to outer third of the enamel giving opaque white flecks appearance in mild fluorosis.
FLUOROSIS

Normal

Moderate

Severe

Fluorosis
FLUORIDE in TEETH

- Fluoride: identified as one of the elements present in dental hard tissues.
- Fluoride ion is "calcium-seeking"
- Apatite: the principal mineral of skeletal tissues. Crystallized form of calcium phosphate: $\text{Ca}_{10}(\text{PO}_4)_{6}(X)_2$. If:
  - ‘$X$’ is OH $\rightarrow$ hydroxyapatite
  - ‘$X$’ is F $\rightarrow$ fluoroapatite: more regular
Mechanism of Fluoride Exchange

Basic structure of apatite crystal: honeycomb viewed from above along its long axis: ➔ crystal lattice

Hydration Shell

Bound ion layer

Hydroxyapatite Nucleus

\[ \text{Ca}_{10}(\text{PO}_4)_6 \cdot (\text{OH})_2 \]

layer of adsorbed water, normally surround the crystal
Fluoride Concentration in Teeth

• It is estimated that substitution of only 10% of hydroxyl groups in enamel apatite by fluoride, renders the enamel maximally resistant to caries

• Concentration of fluoride is higher:
  ➢ on the surface enamel compared to the deeper layer,
  ➢ in permanent teeth compared to dec. teeth formed under the same circumstances
Theories of Modes of Actions of Fluoride

1: Fluoride were incorporated into tooth structure ➔ increased resistance to acid attack

a) Fluorapatite forms more compact and regular crystals than hydroxyapatite ➔ present less surface area for the action of acids

b) Higher concentration of fluoride on outer enamel ➔ protection against acid attack
Theories of Modes of Actions of Fluoride

2: Fluoride influence the solubility rate
   a) Calcium and fluoride ions released from the apatite during initial dissolution forms Calcium Fluoride (CaF$_2$) on the surface of the fluorapatite hence reducing it solubility.
Theories of Modes of Actions of Fluoride

3: Fluoride catalyses stable apatitic phase
   
a) Fluoride ions replace carbonate ions in the apatite structure.
   
   Apatite crystals with low carbonate contents are more stable and are less soluble compared to those with high carbonate ion content.
4: Fluoride favours remineralization of early carious lesions
   a. Plaque fluid contain fluoride. 
      decreased pH $\rightarrow$ fluoride level increased. 
      $\rightarrow$ enhance re-mineralization of enamel 
      by facilitating the re-precipitation of 
      calcium and phosphate ions into the 
      enamel $\rightarrow$ fluoroapatite.
Mineral loss fr. lesion occurs when plaque pH drops. Mineral flows back when plaque acids neutralized. Saliva serves as a natural source of acid-neutralizing buffers and mineral ions, which may be supplemented by fluoride fr dentifrices/water fluoridation - Mellberg, 1988)
Theories of Modes of Actions of Fluoride

5: Effect on acid production

Fluoride inhibit enolase and ATP-ase activity (Embden-Meyerhof pathway in bacterial metabolism) in oral streptococci hence reduce acid production.

→ adversely effects the uptake of glucose by bacteria into the cells and subsequently lactic acid formation.

→ further prevent the synthesis of glycogen (carbohydrate stored in bacterial cells which enable them to continue to produce acid even without dietary sugars ion oral environment.

* About 1.0ppm F needed to inhibit bacteria activity (Bibby et al; 1940)
Theories of Modes of Actions of Fluoride

6: Fluoride affects the morphology of the teeth making them more self-cleansing

a) Fluoride administered during tooth formation may result in shallower and wider fissures, more rounded cusps thus → reducing the number and size of sites where food and plaque could accumulate.
Theories of Modes of Actions of Fluoride

6. Fluoride affects the morphology of the teeth making them more self-cleansing
Theories of Modes of Actions of Fluoride

7. Different agents with specific effects

- Stannous ion in \( \text{SnF}_2 \) may affect surface wettability and reduce plaque formation
Schematic illustration fluoride action

Fluoride in:
- Enamel crystals
- Plaque
- Cells and fluids

Cariostatic Mechanism
- Improves crystallinity
- Decreases solubility
- Catalyzes stable apatitic phase
- Promotes remineralization
- Increases less soluble phase
-Decreases acid formation
- Improves crown morphology

Reduced caries formation
Fluoride Therapy

Systemic: Water Fluoridation

Topical: Fluoridated Toothpaste
How Much Fluoride Is Actually Needed?
Water fluoridation

- Fluoridation is the controlled adjustment of a fluoride compound to a public water supply in order to bring the fluoride concentration up to a level which effectively prevent caries.

- “Community water fluoridation is safe and cost-effective and should be introduced and maintained wherever it is socially acceptable and feasible. The optimum water fluoride concentration will normally be within the range of 0.5ppm - 1.0ppm.”

World Health Organisation Expert Committee on Oral Health Status and Fluoride Use 1994
Caries Experience And Concentration Of Fluoride In Water

- Marked reduction of caries when fluoride water level were at 1-2 ppm
- Mottling of enamel started to be noticeable at 1.5 ppm
- Basis for introducing fluoride water level at 1 ppm in USA
Malaysian Scenario

• 1957 - Johor was the first state to benefit from water fluoridation.

• June 1966 - A committee was set to consider fluoridation throughout the country.

• April 1971 - A report was submitted by the committee suggesting fluoridation at national level.

• 1972 - Malaysian cabinet approved the addition of fluoride to public water supplies as a primary prevention programme against dental caries.

(Source: MOH 2001)
Malaysian Scenario

As of the year 2000:
- 267 water treatment plants with F feeders
- 224 plants with active F feeders
- 72.7% of Malaysian population received fluoridated water.

Before 1995: Kelantan had 26 water treatment plants with active feeders.

October 1995: Kelantan ceased water F
(2006: 5 plants fluoridated with 37% population receiving the water supply)

Year 2000: Terengganu follow suit

(MOH report of National Oral Health Plan Seminar, 2001)
1. Without fluoride in drinking water, a sensible alternative is to give fluoride tablets.

2. 2.2 mg NaF contains 1.0 mg fluoride ion. Table shows F ion in relation to age & fluoridation level

<table>
<thead>
<tr>
<th>Age</th>
<th>Water Fluoridation Concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 0.3</td>
</tr>
<tr>
<td>&lt; 6 mo</td>
<td>-</td>
</tr>
<tr>
<td>6 mo - 3 yrs</td>
<td>0.25 mg</td>
</tr>
<tr>
<td>3-6 yrs</td>
<td>0.50 mg</td>
</tr>
<tr>
<td>6-16 yrs</td>
<td>1.0 mg</td>
</tr>
</tbody>
</table>
Fluoridated Milk & Salt

1. Milk: recommended good food for infants and children, hence, considered as suitable vehicle for children’s fluoride intake.

2. As dietary vehicle, domestic salt comes second to drinking water. It has been reported that 250 ppm F in salt or 250 mg F / Kg salt is effective.
Topical Fluoride

In the form of fluoride solutions, gel, paste or dentifrice.

- applied direct to the teeth: dentist/ staff

Higher concentration of fluoride for topical application.

- 2% - 8% for professionally applied: 2-3 times
- 0.05%-0.2% for mouth rinses: daily/ weekly
- 0.1% for dentifrice
## Evidences in Caries Reduction

<table>
<thead>
<tr>
<th>Method</th>
<th>Dose/ concentration</th>
<th>% Reduction in Caries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Fluoridation</td>
<td>0.5 – 1.2 ppm</td>
<td>50 - 65</td>
</tr>
<tr>
<td>Mouthrinses</td>
<td>0.05% NaF daily, 0.2% NaF (wkly)</td>
<td>20 - 30</td>
</tr>
<tr>
<td>Dentifrices</td>
<td>0.4% SnF&lt;sub&gt;2&lt;/sub&gt;, 0.76% MFP, 0.22% NaF</td>
<td>20 - 30</td>
</tr>
<tr>
<td>Professionally Applied</td>
<td>2.0% NaF, 8.0 or 10% SnF&lt;sub&gt;2&lt;/sub&gt;, 1.23% APF</td>
<td>30 - 40</td>
</tr>
</tbody>
</table>
Fluoride

- **Anti-caries effect**: widely accepted throughout the world.

- Various ways of using fluoride for prevention of dental caries.
  - **Systemic**: Water fluoridation, tablets, drops, fluoridated milk/salt
    * *benefit:* *pre- and post eruptive phase*
  - **Topical**: Solution, Gel, Mouth rinses, toothpaste
    * *benefit:* *post eruptive phase*

*Choice*: depends on current levels of fluoride intake, caries status and age of subjects in the area.
Summary

• When communal water supplies are available, water fluoridation is the most effective, efficient and economical of all known measures for the prevention of dental caries.

• Greatest benefit: made available both
  ➢ **systemically** during tooth development
  ➢ **topically** after eruption

• Lifetime protection against dental caries results from the continuous use of low concentration of fluoride

• Careful assessment of patient is necessary to decide the best method of administering fluoride.
Yes!
I have the mouse in the upper right corner,
I click and... nothing!

Doesn't work!
Summary

- Need to remember other means of reducing dental caries
  - Brushing teeth
  - use of fluoride therapy eg. Fluoride tablets / gel, fluoridated toothpaste
  - reducing the amount and frequency of sugar consumption
  - Frequent dental checkups
References


