Caries and fluoride

modes of action and vehicles

Lec. 15 & 16

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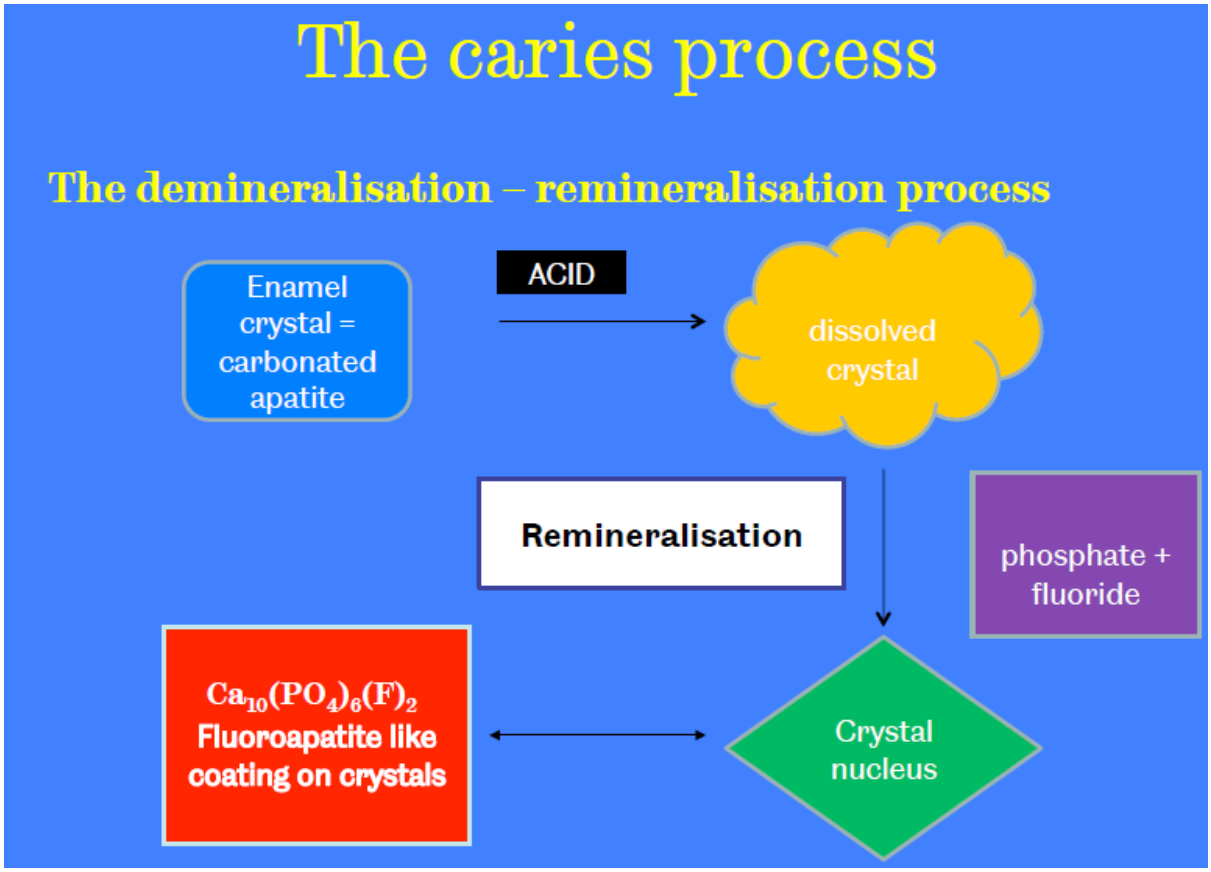
The Caries process

Although you should be familiar with the aetiology and pathogenesis of dental caries from your first years teaching, this lecture might provides a brief summary to inform your thinking about the prevention of dental decay at an individual and a population level.

Enamel and dentine are made of hydroxyapatite crystals embedded in a protein/lipid matrix.

The small pores between the crystals are filled with protein, lipid and water and allow the passage of small molecules (lactic acid) and ions (H+ and Ca2+). As you be aware, dental caries is a dynamic process with cycles of remineralisation and demineralisation of the tooth structure. Re-mineralised enamel is a blend of hydroxyapatite and fluorapatite and is much less soluble than the original mineral. The driving force for this remineralisation includes the degree of supersaturation of the mineralising fluid i.e. saliva in the mouth and the fluoride concentration in the oral fluids. The demineralisation-remineralisation process can be summarised diagrammatically as shown below:



Fluoride–modes of action:

Fluoride has 3 modes of action. The presence of fluoride in the oral environment will result in:

*Inhibits demineralisation.

*Enhances remineralisation.

*Inhibits plaque bacterial metabolism.

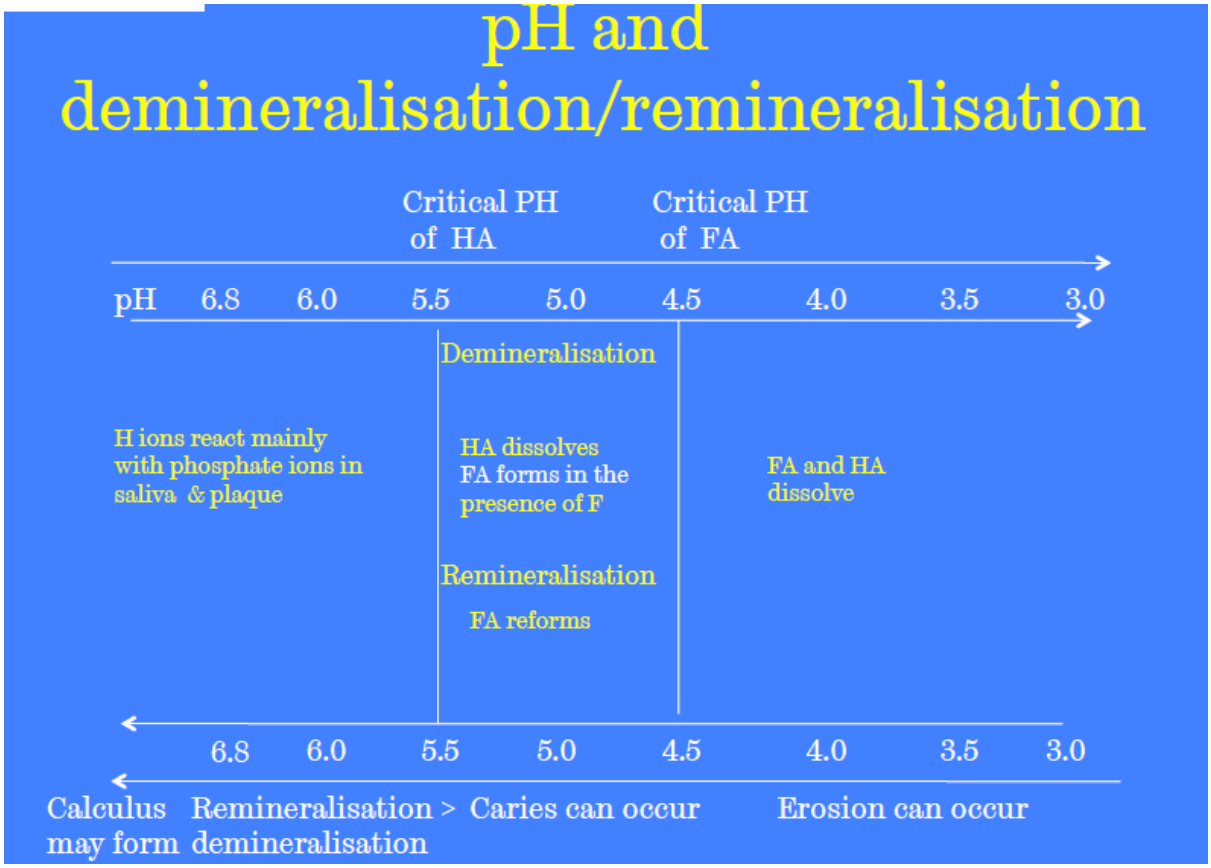
Over the past two decades there has been a change in the understanding of the mode of action of fluoride. It has been established that the primary mode is at a topical rather than at a systemic level. Any pre-eruptive benefit due to ingestion of fluoride

during the tooth development is now believed to be relatively unimportant. Fluoride incorporated developmentally into normal tooth mineral is insufficient to have a measurable effect on acid solubility and is therefore relatively unimportant in providing any protection from dental caries.

However, the post-eruptive effect is cumulative. With this topical effect, the fluoride surrounding carbonated apatite crystals is more effective at inhibiting demineralisation than F incorporated in the crystals.

After demineralisation occurs, saliva is supersaturated with calcium and phosphate which is the driving force for remineralisation with partially dissolved hydroxyapatite crystals act as precursor for remineralisation. There have been a number of mechanisms identified by which fluoride can have a topical effect on dental caries. Fluoride plays an important role in enhancing remineralisation as it acts to speed up remineralisation by adsorbing to the surface of the mineral bringing the calcium and phosphate ions together. It is also reduces solubility and so the tooth surface is more resistant to acid attack. It is also suggested that fluoride inhibits plaque bacteria and when diffused in plaque as hydrogen fluoride, as it inhibits bacterial metabolism by interfering with essential enzyme (enolase) activity.

The diagram below illustrates the effect of pH on remineralisation and demineralisation.



The dissociation equilibrium of hydroxyapatite is very sensitive to the surrounding pH. At neutral pH (7.0), saliva is supersaturated with calcium phosphate. As the pH becomes more acidic, this supersaturation decreases which results in demineralisation. This is called the Critical pH and is between a pH of 5.2 - 5.5, depending on individual saliva composition. If the pH becomes more alkaline, the degree of saturation increases and the calcium phosphate precipitates as calculus.

The demineralisation/remineralisation balance

So, if we synthesise what we have learned about the pathogenesis of caries and the modes of action of fluoride, you can see that there is a

balance between demineralisation remineralisation which is influenced by protective and pathological factors,

*Caries progression v reversal is a delicate balance between:

– Pathological factors (bacteria and carbohydrates)

– Protective factors (saliva, calcium, phosphate, fluoride)

*Driving force for remineralisation:

– Degree of supersaturation of mineralising fluid (saliva in the mouth)

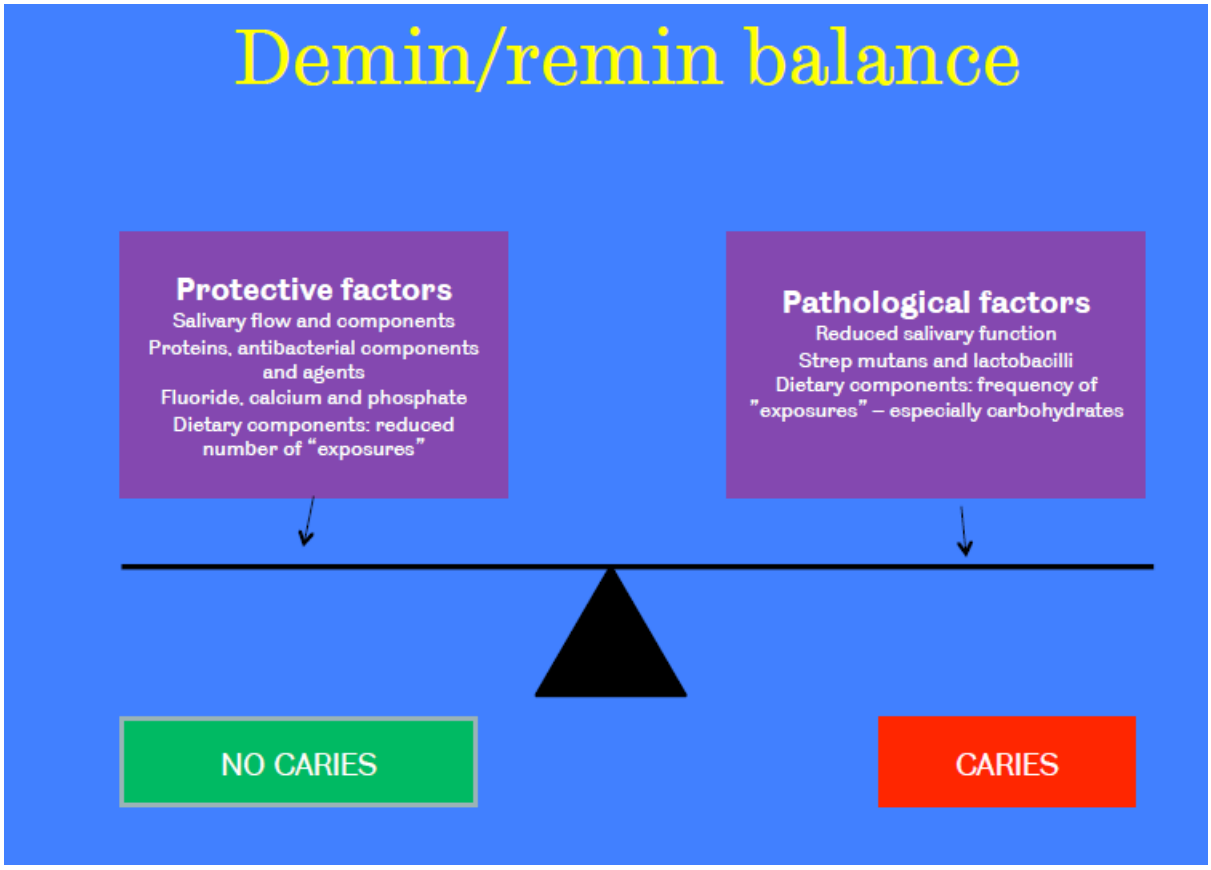
– Fluoride concentration in the oral fluids

The nature of tooth mineral re-mineralised enamel is:

*A blend of hydroxyapatite and fluoroapatite (assuming presence of F).

*Much less soluble that the original mineral.

Which is summarised in the diagram below.



Low levels of salivary fluoride and remineralisation

Low levels of fluoride in saliva and plaque play an important role in preventing caries. Small increase in F concentration in saliva and plaque can prevent caries due to increased chance of remineralisation. In lab-based models - levels of 0.03ppm F or higher were incorporated in artificial saliva, remineralisation was enhanced.

Fluoride can be retained in concentrations in the saliva between 0.03 and 0.1 ppm for 2-6 hours, depending on the individual and the vehicle by which fluoride is delivered. Children with high concentrations of fluoride in saliva (>0.075ppm) are more frequently caries free ($p<0.02$).

The clinical implications of the impact of low levels of fluoride in saliva in preventing dental caries are well recognised. Maximising the anti-caries action can be achieved by keeping fluoride in the oral

cavity as long as possible and giving due consideration to the concentration and frequency of applications**.**

However, caution needs to be applied in minimising ingestion due to risk of fluoride toxicity associated with excessive dosages. Symptoms include gastro-intestinal and central nervous systems complications with fatality within 4 hours. The probable toxic dose equates to

5mgF/kg with lethal dose being in the range of 16-32mgF/kg.

Fluoride vehicles

Fluoride toothpaste

It was widely accepted that toothpaste is the most cost-effective topical fluoride agent. It was the main reason for the decline in caries in the last 30 years in the developed world – 24% reduction of caries.

Fluoride concentration of toothpaste more important than the efficiency of plaque removal.

• Recommendations for children

– Up to 3 years, no less than 1000ppm – smear.

– 3-6 years, 1350 – 1500 ppm (I) – pea sized.

– From 7 years – no less than 1350ppm.

– Children should be assisted with brushing until 7 years.

– Low fluoride toothpastes i.e.500-600ppm (Tooth Patrol, Milk Teeth) – now not recommended worldwide.

*For adults should be at least 1350ppm, higher concentration (>2000ppm) available for adults – more effective than 1500ppm (I)

Fluoride mouth rinses

• Mouth rinse could be used daily or weekly, it is effective – 26% reduction in caries. There are two concentrations for rinses which are:

– 0.05%

– 0.2%

• Recommended for:

–More than 8 years with active caries.

– High risk patients, teeth erosion and medically compromised patients.

-Not recommended for < 8 years.

Fluoride varnishes

• Effective in deciduous (33% caries reduction) and permanent teeth (46% caries reduction)

•It is recommended for all 3-16 year olds, used twice yearly and 3-16 year olds with high risk of caries should be used 3-4 times yearly. The regular 3 - 6 monthly applications recommended for non-cavitated lesions. Rinses applied professionally, so they are expensive. Its concentration reaches 22600 ppm and some of them were higher. Caution should be taken with patients because some of them might develop allergies.

Fluoride supplements

Drops & tablets

They are effective and recommended for high risk of decay, caries hazardous to health and treatment hazardous to health. They were not recommended for those receiving fluoridated milk / water and those with history of toothpaste eating or if parental compliance is poor. Now it restricted to high risk children with motivated parents/carers.

Fluoridated milk

Fluoridated milk manufactured by adding significant amounts of fluoride to the milk, e.g. 0.5mg in 250ml in UK – equivalent to daily supplement for 3-6 year olds, while it is 1.5mg in 250ml elsewhere in the world. The trials suggest that the fluoridated milk is effective.

Fluoridated water

It is an effective way of fluoride application, usually done by adding fluoride to water at percentage of 0.8ppm to 1ppm which is recommended in temperate climates, other places ranging from 0.5-0.8ppm. It is very important to balance between benefit and harm. There are a significant number of evidence of effectiveness, but a lot of them are old and not high quality evidence. It is used in US, Canada, Australia, Cuba and UK.