Fluoride

What it is & it’s role in the management of dental caries

BY TRACY DOOLE

DIP DH PG DIP

A little about me…….

- Dental Hygienist NHS/Private General Practice & Specialist referral clinics.
- BSDHT Executive & Committee member Regional Rep for NI regional group.
- NSK Clinical Educator.
- Clinical Representative for Young Innovations Europe.
- Award winning Hygienist 2017 & 2021.
- PG diploma in Education, Coaching & Mentoring.

Aims & Objectives

- Understanding of GDC scope of practice and registrant responsibilities (professionalism, ethics, confidentiality, consent)
- Knowledge and application of Delivering Better Oral Health, including evidence-based guidance, caries process, and fluoride's role in caries prevention
- Practical training in fluoride varnish application
- Structured clinical assessment of fluoride application competence
- Communication skills training

Learning objectives

Define dental caries and the carious process

Describe the risk factors and the Stephan curve

Define fluoride & understand the history of fluoride in dentistry

Describe mode of action of fluoride in relation to caries prevention and control

Demonstrate fluoride varnish application

Assumed knowledge

Medical emergencies training is updated and aware of how to respond to any medical concerns or emergencies

GDC expectations of dental nurse – GDC Standards document

Safeguarding CPD

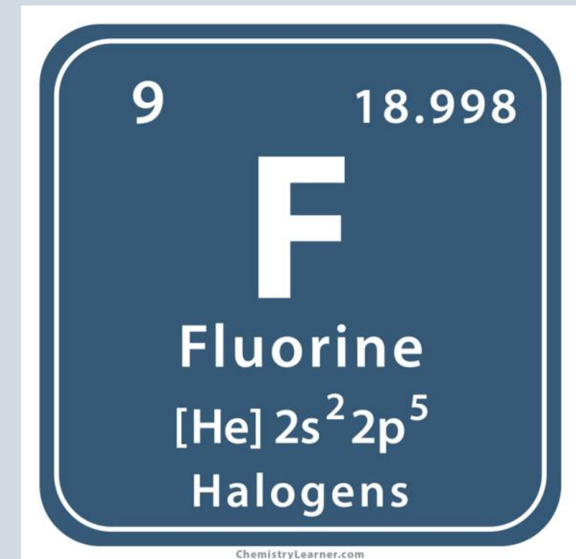
Introduction to Fluoride

- Fluoride is the 13th most abundant element present in the earth's crust

- Belongs to the halogen group of elements and is found naturally in water, soil, animals, and plants e.g. Fish, tea, beer and natural water supplies (well water)

- It is present in trace amounts in all mineralized tissues of the body such as enamel, dentine, and bone

- Due to these beneficial effects of fluoride, it was introduced into dentistry in 1940 and since then, it is being added to various consumer products e.g. Toothpastes and mouthwashes



Fluoride vs Fluorine

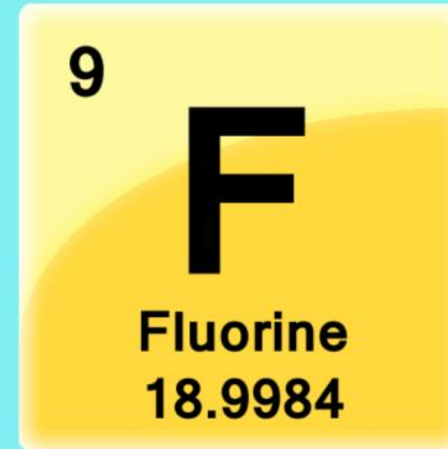
Fluoride is either the fluorine ion or a compound containing fluorine.

fluoride ion

NaF

sodium fluoride

Fluorine is an element on the periodic table.



sciencenotes.org

Anatomy of a tooth

enamel
dentine
Gingival tissue
Periodontal ligament
pulp
Root canal
cement
bone
crown
neck
root
Nerve and blood vessels

Composition of Tooth Tissues

Tissue	Inorganic (%)	Organic (%)	Water (%)	Main Components / Features	Function / Notes
Enamel	96%	1–2%	2–3%	Hydroxyapatite crystals; minimal proteins (amelogenin, enamelin)	Hardest body tissue; protects tooth; non-living (no repair).
Dentine	70%	20%	10%	Hydroxyapatite in collagen (Type I); tubules with odontoblasts	Supports enamel; sensitive; capable of limited repair.
Cementum	45–50%	50–55%	Small amount	Bone-like; collagen + hydroxyapatite	Anchors periodontal ligament fibres; covers root.
Pulp	0%	75%	25%	Soft connective tissue with vessels, nerves, odontoblasts	Provides nutrients, sensation, and dentine formation.

Dental caries

Caries is the progressive destruction of enamel, dentine and cementum, initiated by microbial activity at a susceptible tooth surface.

Caries is the Latin word meaning decay!

Dental Caries

Infectious microbial disease of the teeth that results in localised destruction of the calcified tissues

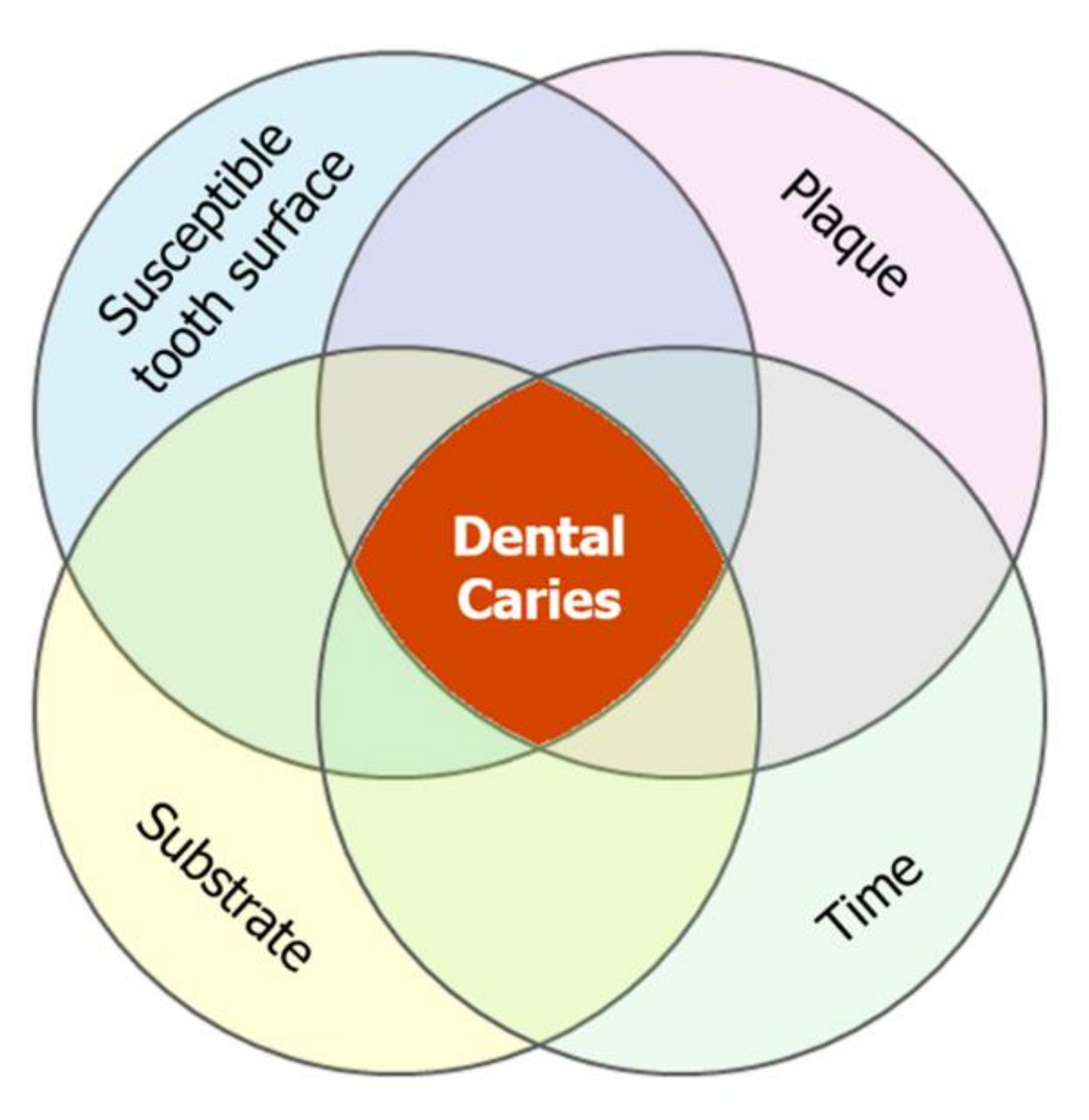
Main bacteria involvement:
Streptococcus mutans
Lactobacilli

Fig 2. The invasion of bacteria into the tooth structure, starting on the outer side with enamel

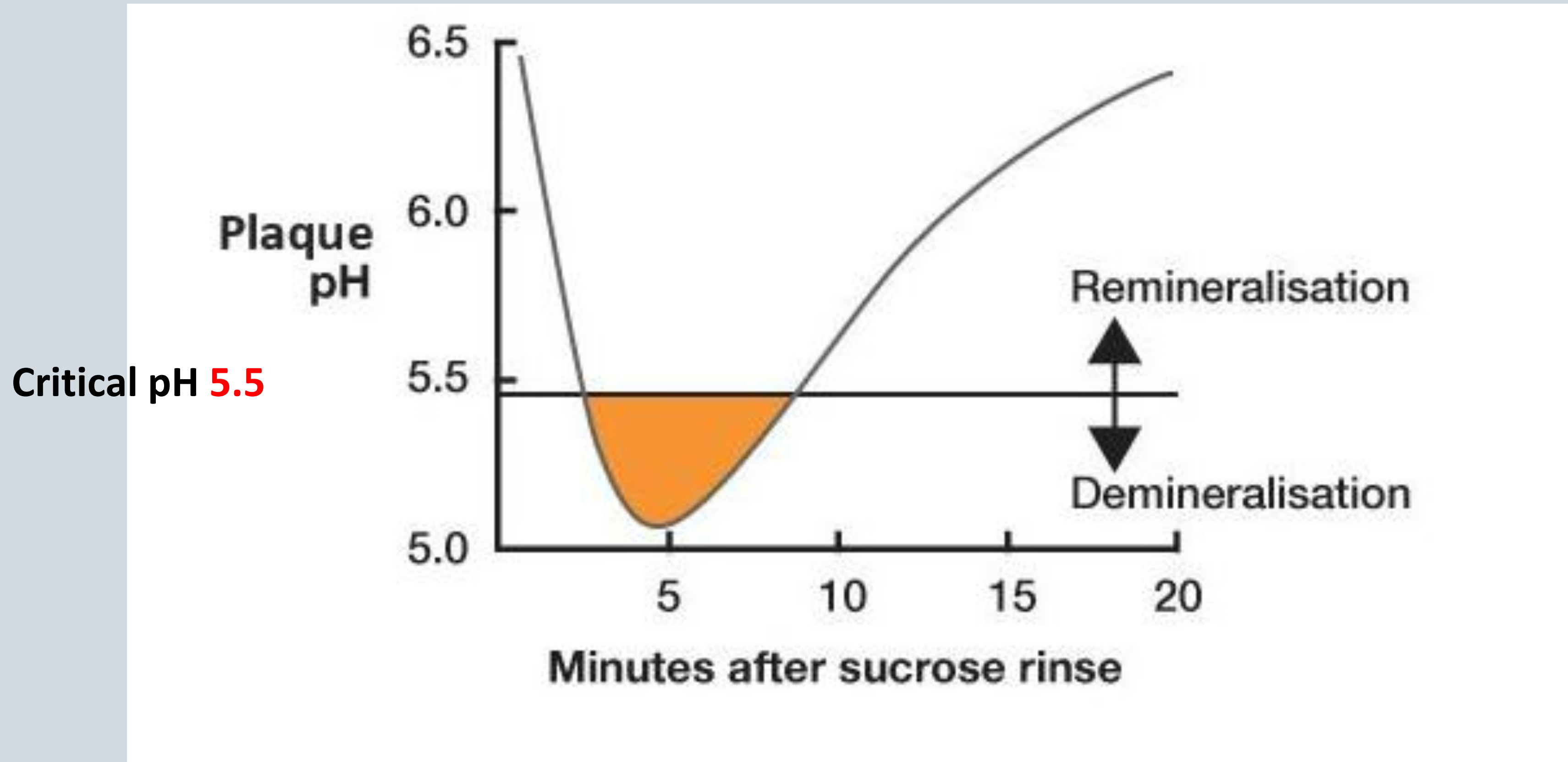
Fig 2

Aetiology & The Carious Process

(Shutterstock, 2022)

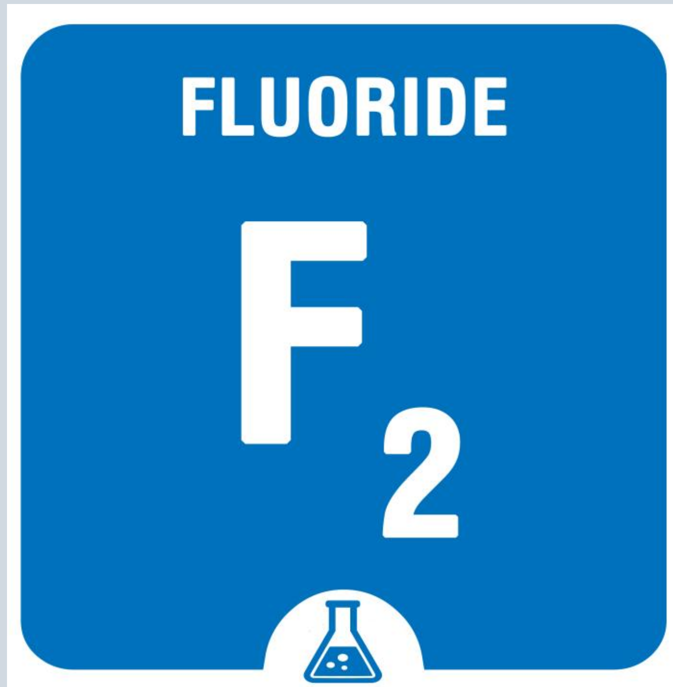

Susceptible tooth surface
Plaque
Dental Caries
Substrate
Time

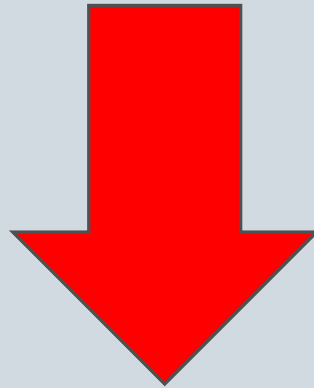
Dental caries and the carious process



Wrigley Oral Healthcare Program | The Stephan Curve

Coming back to….. Fluoride





History of Fluoride

100 years ago a dentist called Frederick Dr McKay in Colorado Springs in the USA, noticed patients were arriving with stains on their teeth.

Research revealed that fluoride naturally present in the water at 2.0 parts per million (ppmF) caused the mottling.

McKay noted that dental caries was low in the patients with stains, by reducing the fluoride to 1.0 ppm F caries remained lower without the stains

Fluoride has been added to toothpastes since the mid 1940’s

Fluoride toothpastes account for the majority of toothpastes on the market today

History of Fluoride

In 1945, Grand Rapids became the first city in the world to fluoridate its drinking water

During the 15-year project, researchers monitored the rate of tooth decay among Grand Rapids' almost 30,000 schoolchildren

After just 11 years, Dr. H. Trendley Dean announced an amazing finding

The caries rate among Grand Rapids children born after fluoride was added to the water supply dropped more than 60 percent.

This finding, considering the thousands of participants in the study, amounted to a giant scientific breakthrough that promised to revolutionize dental care, making tooth decay for the first time in history a preventable disease for most people

And so began the widespread use of fluoride to prevent dental decay

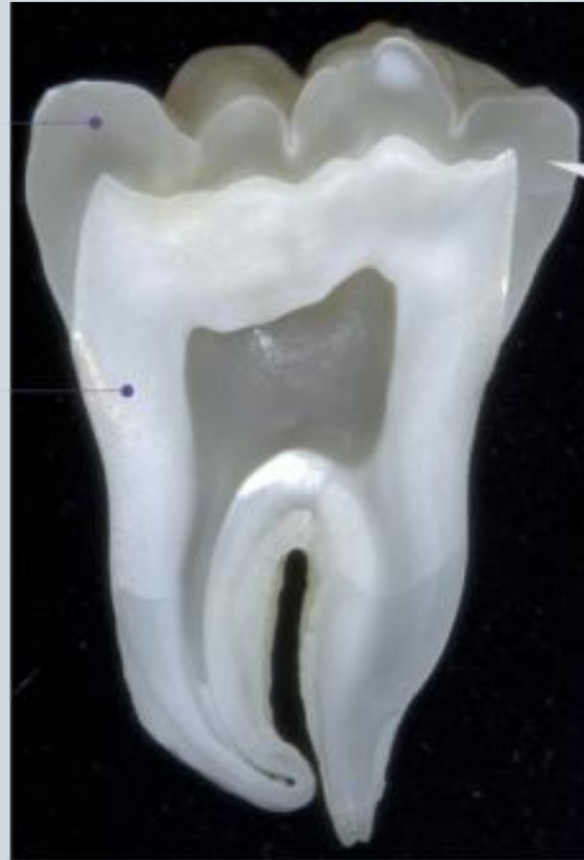
The role of fluoride

Enamel

97 % Hydroxyapatite
translucent

Dentin

70 % Hydroxyapatite
ivory colored



Hydroxyapatite rods

What is enamel?

Enamel is the hardest tissue in our body.
But its smooth appearing surface is actually a complex structure made up of countless hydroxyapatite rods, which are vulnerable to acid attacks.

(FE-REM)

The role of fluoride

The hydroxyapatite of tooth enamel is primarily composed of phosphate ions (PO_4^{3-}) and calcium ions (Ca^{2+})

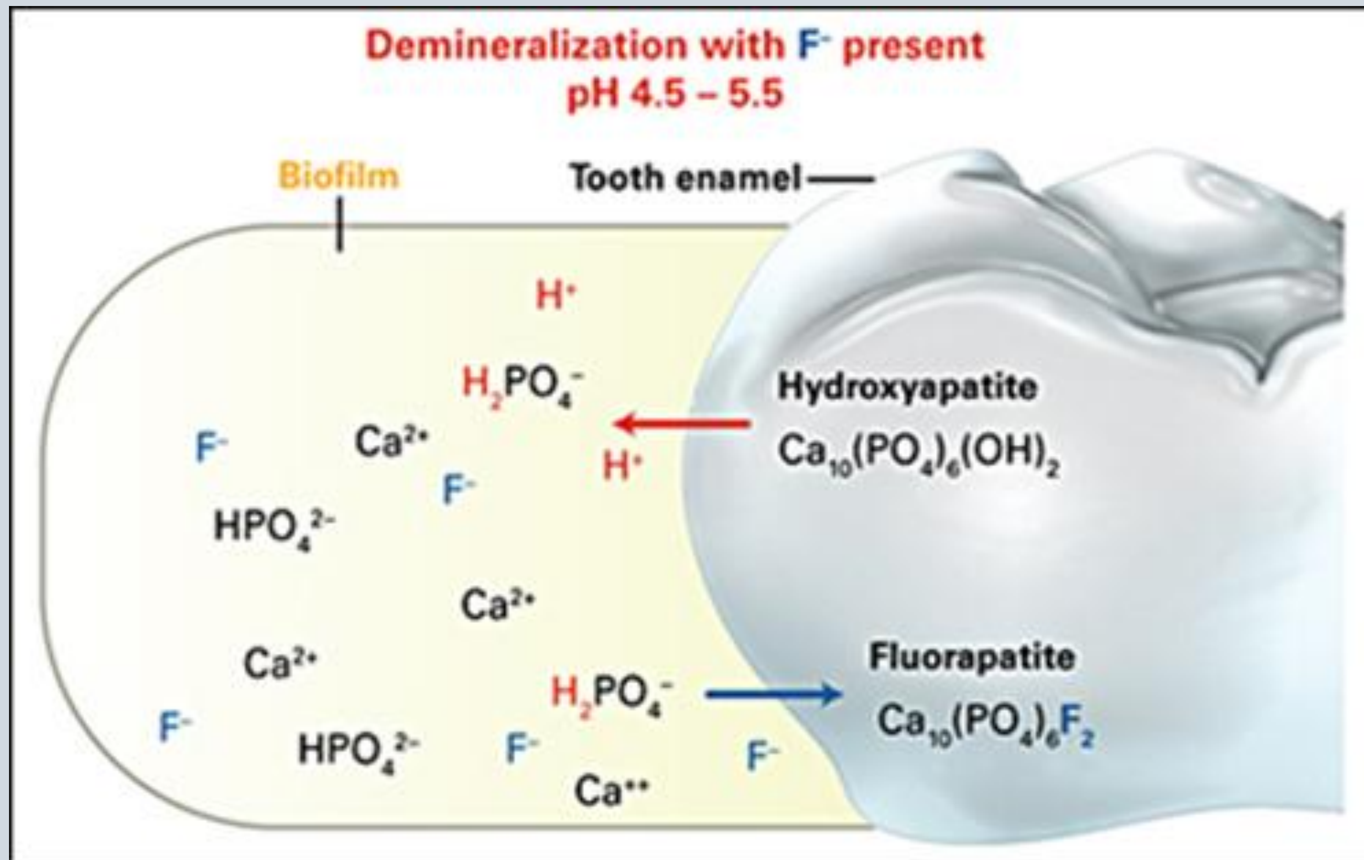
Under normal conditions, there is a stable equilibrium between the calcium and phosphate ions in saliva and the crystalline hydroxyapatite that comprises 96% of tooth enamel

When the pH drops below a critical level (approximately 5.5 for enamel, and 6.2 for dentine), it causes the dissolution of tooth mineral (hydroxyapatite) in a process called demineralisation

When the natural buffer capacity of saliva elevates the pH, minerals are reincorporated into the tooth through the process of remineralisation

Fluoride’s Mechanism of Action - Fundamentals of Dentifrice: Oral Health Benefits in a Tube - Dentalcare

The role of fluoride

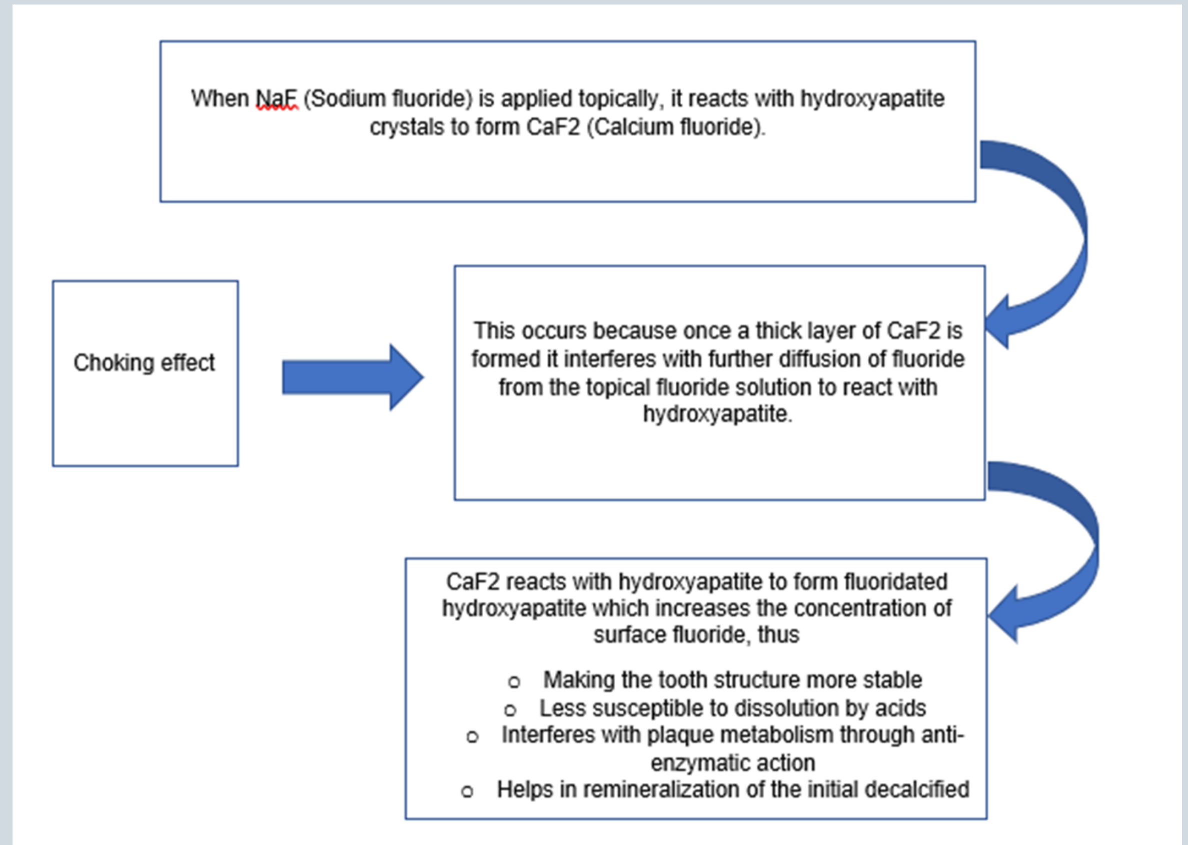


Critical pH of Fluorapatite is approx. 4.5

The “Choking” Effect

- **Acid attack begins** - hydroxyapatite starts to dissolve
- **Fluoride is present in the surrounding fluid**
- Fluoride reacts with released calcium(previous slide) forms:
  - **Fluorohydroxyapatite**, and/or
  - **Calcium fluoride–like layer (CaF_2)**
- This newly formed surface layer:
  - **Reduces ion diffusion**
  - **“Chokes” further mineral loss**

In simple terms: **fluoride plugs the exit**, slowing down demineralisation.



The role of fluoride

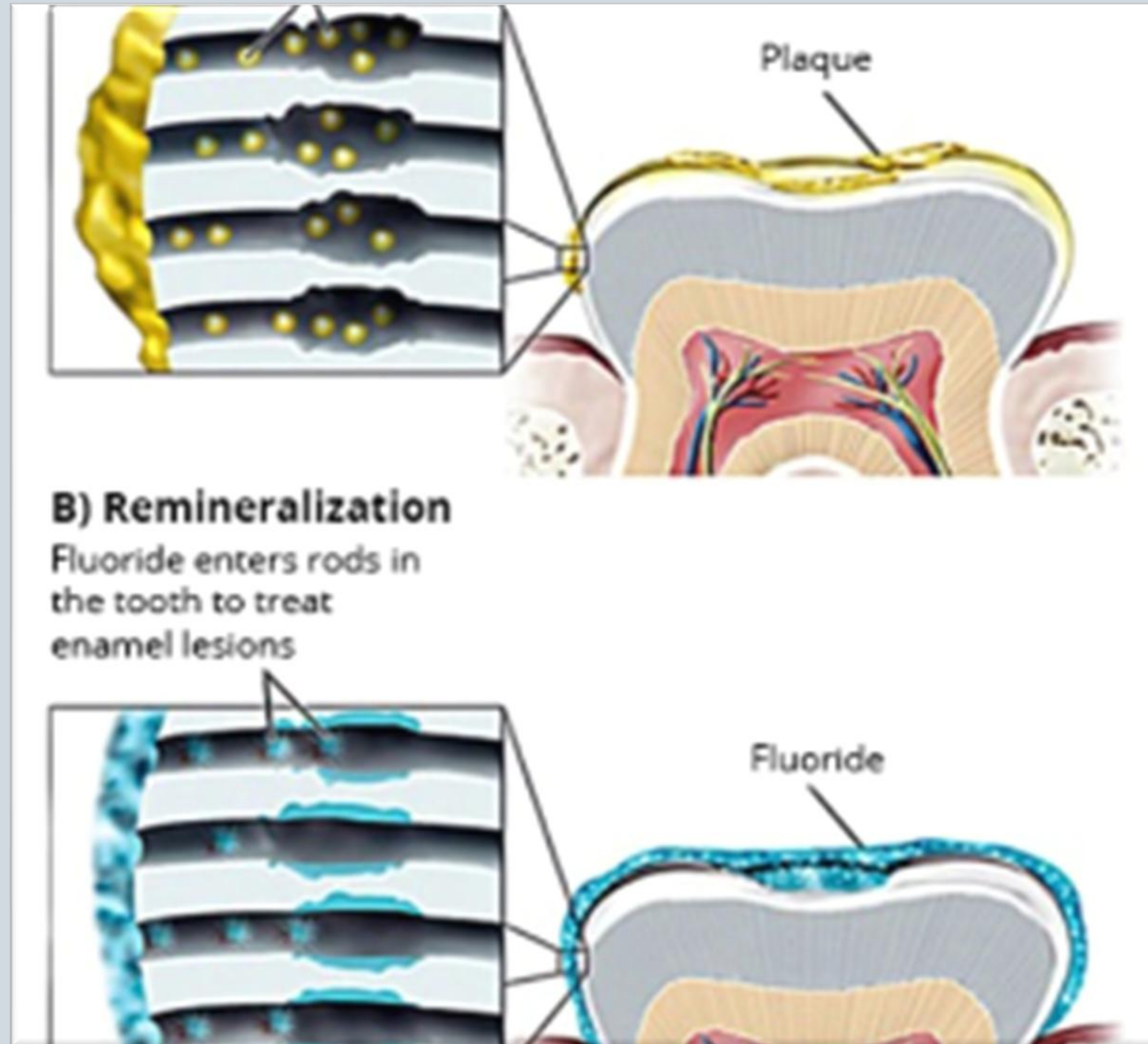
Fluorapatite is inherently less soluble than hydroxyapatite, even under acidic conditions (pH 4.5)

When hydroxyapatite dissolves under cariogenic (acidic) conditions, if fluoride is present, then Fluorohydroxyapatite will form

Because Fluorohydroxyapatite is less soluble than hydroxyapatite, it is also more resistant to subsequent demineralisation when acid challenged

N.B Fluorapatite formation requires long-term fluoride exposure during crystal growth; topical fluoride mainly produces fluorohydroxyapatite and CaF_2 reservoirs.

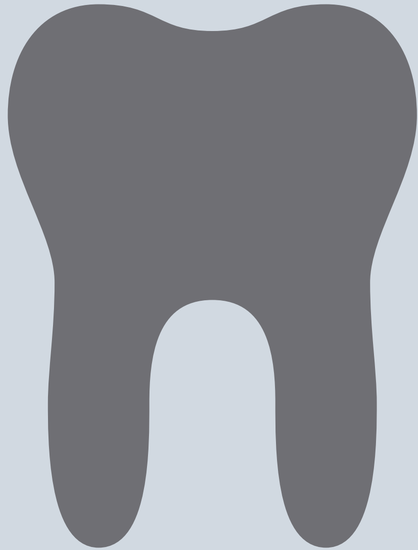
Fluoride's Mechanism of Action - Fundamentals of Dentifrice: Oral Health Benefits in a Tube - Dentalcare



Fluorides Mechanism in Action

Fluoride’s Mechanism of Action - Fundamentals of Dentifrice: Oral Health Benefits in a Tube - Dentalcare

Effect of fluoride on tooth surface (Summary)



Fluoride can be taken into the crystalline structure of enamel to form fluorohydroxyapatite crystals, replacing the normal hydroxyapatite crystal structure

Fluorohydroxyapatite can resist acid attack to a greater degree and thereby reduces the solubility of enamel in acid

Fluoride inhibits the bacterial enzyme enolase which comes mainly from Strep Mutans, thus reducing acid production to help reduce a carious attack

Fluoride

Fluoride is a member of the halogen family and is the most electronegative and reactive of all the elements

Fluoride can be delivered via two modes

- Topical fluoride
- Systemic fluoride

Topical fluorides	Systemic fluorides
Placed directly onto the teeth	These circulate through the blood stream and are incorporated into developing teeth
Some preparations provide high or low concentrations of fluoride over a short period of time	They provide a low concentration of fluoride over a long period of time

Types of fluoride delivery modes

Topical

- Strengthens enamel
- Promotes remineralization
- Inhibits bacterial activity

- Fluoridated toothpaste
- Mouth rinses
- Professional fluoride gels, foams, varnishes

Systemic

- Strengthens tooth structure before eruption
- Provides ongoing low-level fluoride in saliva

- Fluoridated drinking water
- Fluoride supplements (tablets, drops)
- Fluoridated foods and beverages

Types of Topical Fluoride

Sustainability of Different Fluoride Delivery Methods

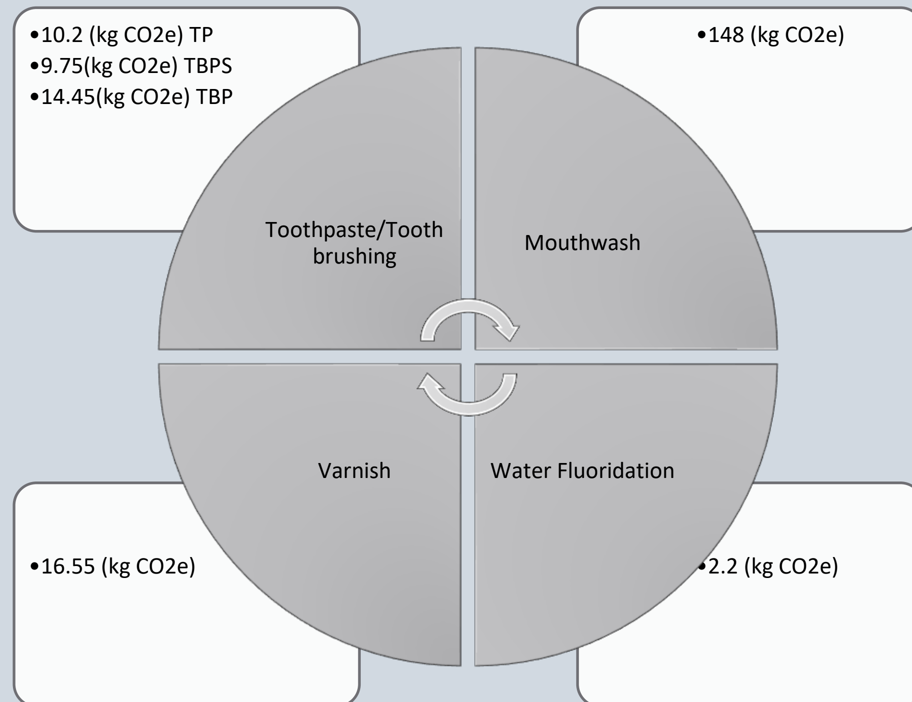
Toothpaste Tubes, toothbrush programmes, Mouthwash, Fluoride Varnish & Water Fluoridation

LCA on Environmental Impact (16 impact categories)

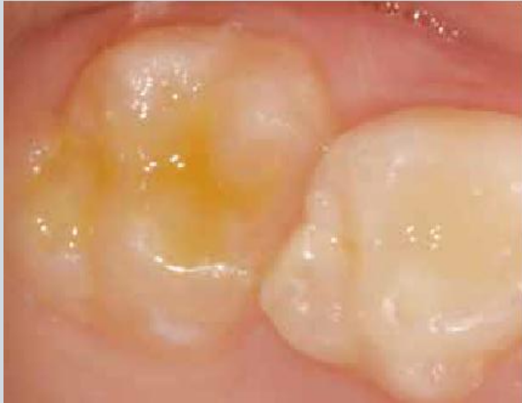
5-year climate change impact carbon footprint (KG CO2e)

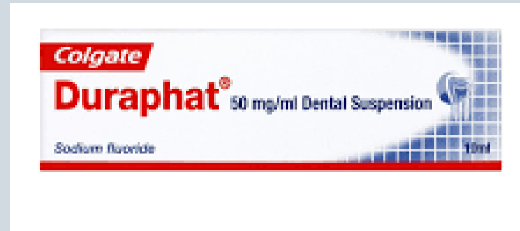
Elleray et al

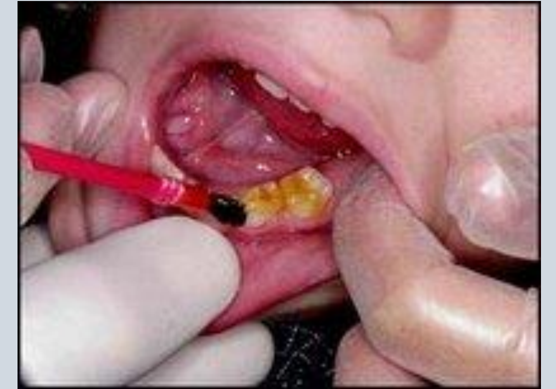
Sustainability of Different Fluoride Delivery Methods



- TP 6 tubes x annually 100ml low carbon impact (No difference in F- concentrations).
- TP Tablets (no formal LCA done), however lighter & don't contain sorbitol .
- School programmes-Supervised –(TBPS) -CDS provide TB/TP and School Staff supervise toothbrushing 1 x daily.
- School Programme (TBP)-TB/TP supplied for children to brush at home – delivers 4 x annually.
- Supervised school programme lower EI –Suggested dry brushing /recycled TB/ Greener staff travel - great population level prevention but needs to be targeted .
- Mouthwash –used weekly less EI (daily m/w has more EI than toothbrush when used daily).
- Fluoride varnishes- better at GDP Exam, targeted School Programmes with reusable instruments & Greener Travel
- Water Fluoridation lowest EI





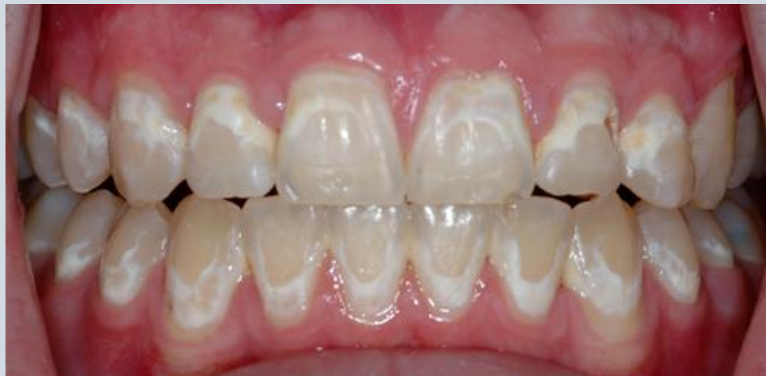


Fluoride Varnishes

Rationale for Topical Fluoride

Rationale for using topical fluoride agents

- To speed up the rate and increase the concentration of fluoride acquisition above the level which occurs naturally
- The initial caries lesion characterized by a white spot is porous and accumulates fluoride at a much higher concentration than adjacent sound enamel



What is Fluoride Varnish

It is a protective coating painted onto a child's teeth to reduce dental caries

Fluoride can slow down or help stop cavities from progressing further into the tooth structure

Multiple brands on the market

Increasing the time of contact between enamel surface and topical fluoride agents favours the deposition of Fluorapatite(small deposits) and Fluorohydroxyapatite

Indications for use

- First developed in Europe by Schmidt in 1964
- A fluoride varnish should provide protection from demineralisation (caries process) or erosion
  - Moderate-high caries risk patients
  - As a primary prevention measure
  - Patients with reduced salivary flow
  - As a treatment for hypersensitive teeth
  - To decrease post operative sensitivity

b **Caries Risk Assessment Form (Ages >6)**

Patient Name: Score:
Birth Date: Date:
Age: Initials:

		Low Risk (0)	Moderate Risk (1)	High Risk (10)	Patient Risk
	Contributing Conditions				
I.	**Fluoride Exposure** (through drinking water, supplements, professional applications, toothpaste)	Yes	No		
II.	**Sugary or Starchy Foods or Drinks** (including juice, carbonated or non-carbonated soft drinks, energy drinks, medicinal syrups)	Primarily at mealtimes		Frequent or prolonged between meal exposures/day	
III.	**Caries Experience of Mother, Caregiver** and/or Other **Siblings** (for patients ages 6-14)	No carious lesions in last 24 months	Carious lesions in last 7-23 months	Carious lesions in last 6 months	
IV.	**Dental Home:** established patient of record, receving regular dental care in a dental office	Yes	No		
	General Health Conditions				
I.	Special Health Care Needs*	No	Yes (over age 14)	Yes (ages6-14)	
II.	Chemo/Radiation Therapy	No		Yes	
III.	Eating Disorders	No	Yes		
IV.	Smokeless Tobacco Use	No	Yes		
V.	Medications that Reduce Salivary Flow	No	Yes		
VI.	Drug/Alcohol Abuse	No	Yes		
	Clinical Conditions				
I.	**Cavitated or Non-cavitated** (incipient) **Carious Lesions or Restorations** (visually or radiographically evident)	No new carious lesions or restorations in last 36 months	1 or 2 new carious lesions or restorations in last 36 months	3 or more carious lesions or restorations in last 36 months	
II.	Teeth Missing Due to Caries in past 36 months	No		Yes	
III.	Visible Plaque	No	Yes		
IV.	**Unusual Tooth Morphology** that compromises oral hygiene	No	Yes		
V.	Interproximal Restorations - 1or more	No	Yes		
VI.	**Exposed Root Surfaces** Present	No	Yes		
VII.	**Restorations with Overhangs** and/or **Open Margins: Open Contacts** with Food Impaction	No	Yes		
VIII.	**Dental/Orthodontic appliances** (fixed or removable)	No	Yes		
IX.	Severe Dry Mouth (Xerostomia)	No		Yes	
				TOTAL:	

Patient Instructions:

Indications for use

Caries Prevention

- Patients at **high caries risk**
- Children, adolescents and adults
- Patients with **poor oral hygiene**
- Individuals with **frequent sugar intake**

Early Caries Management

- White spot lesions
- Arresting root caries

Patients with special health care needs

Orthodontic patients (around brackets)

Reduced Salivary Flow

- Xerostomia
- Radiotherapy to head and neck
- Medication-induced dry mouth

Hypersensitivity

Indications for use

Before deciding to use a varnish, the dentist should acquire the following information

- Does the patient get enough fluoride?
- Are the child/patient brush their teeth every day?
- What is the family history and risk status for tooth decay?
- What is the child/patients diet/feeding habits?

- N.B Delivery better oral health toolkit advice

Duraphat Varnish

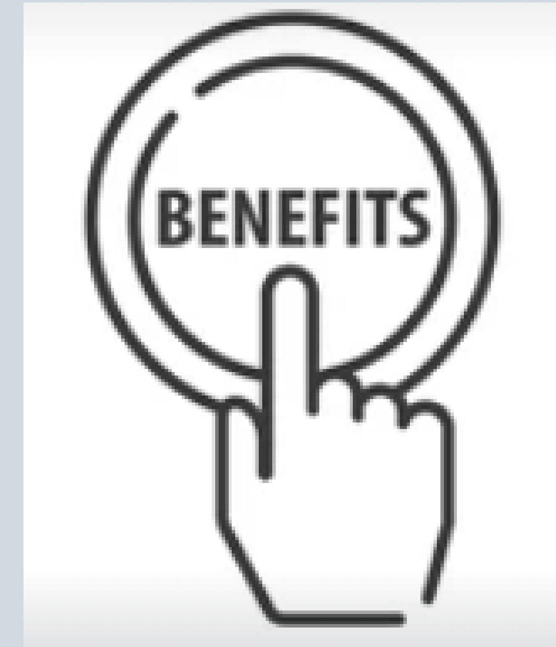
- First fluoride developed in Germany

- Yellow viscous material containing 22,600ppm fluoride as sodium fluoride

- 2.26% (22,600ppm) Sodium Fluoride;
- 1ml contains 50mg fluoride
- Duraphat has shown caries reduction between 30-40% in permanent dentition and 7-44% in primary dentition

Benefits of Fluoride Varnish

- Protect the teeth from caries through the release of fluoride
- Fluoride reduces the demineralisation of dental enamel and antimicrobial substances combatting cariogenic bacteria
- Clinicians find it easy to use and fast to apply
- Fluoride can be swabbed directly on the teeth in less than 3 minutes and sits within a minute of contact with saliva
- Other fluoride products such as gels or foams often require the use of suction and air-drying which may trigger gag reflexes and pose a patient dislike in some cases



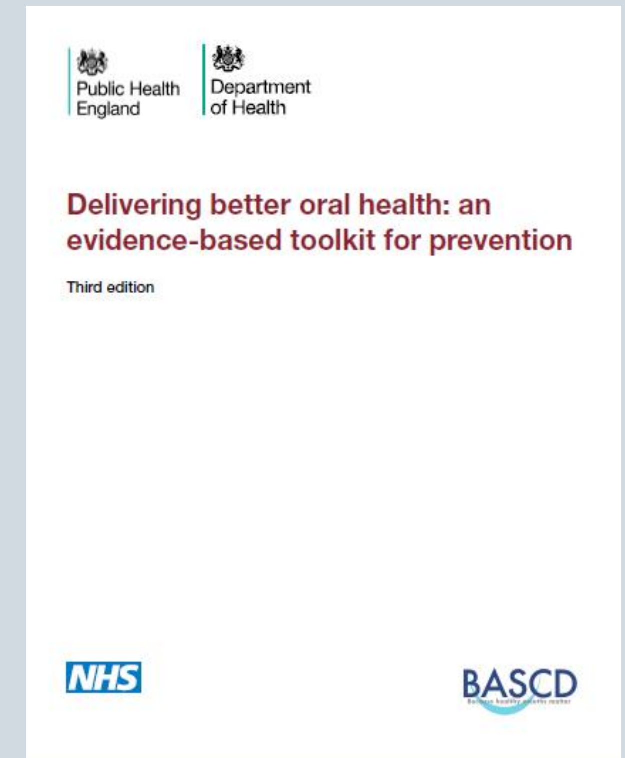
Guidance for fluoride varnish

Delivering better oral health (DBOH) states that high quality evidence of the caries-preventive effectiveness of fluoride varnish in both permanent and primary dentition is available

Several systematic reviews conclude that applications **two or more times** a year produce a mean reduction in caries increment of **37% and 43% in primary and permanent** dentition respectively

The evidence based guidance for fluoride varnish states:

- ❑All children aged three years and above should have fluoride varnish applied twice yearly (2.26% NaF)
- ❑Those children giving concern should receive two or more applications per year
- ❑Adults giving concern should also receive two applications per year



Marinho VCC, Worthington HV, Walsh T and Clarkson JE (2013) Fluoride varnishes for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev* **11(7):** CD002279
Seppä L (1984) Fluoride Content of Enamel during Treatment and 2 Years after Discontinuation of Treatment with Fluoride Varnishes. *Caries Res* **18:** 278-81.

What to look for in a Fluoride Varnish

- DBOH also states that **clinicians should be aware** that there are many fluoride varnishes on the market
- Although they may have similar formulations, they **may not be licensed** for caries control
- Clinicians should therefore take this into consideration with respect to prescriber’s responsibilities
- A licensed product must prove it provides a progressive release of fluoride over this period in order to deliver caries prevention

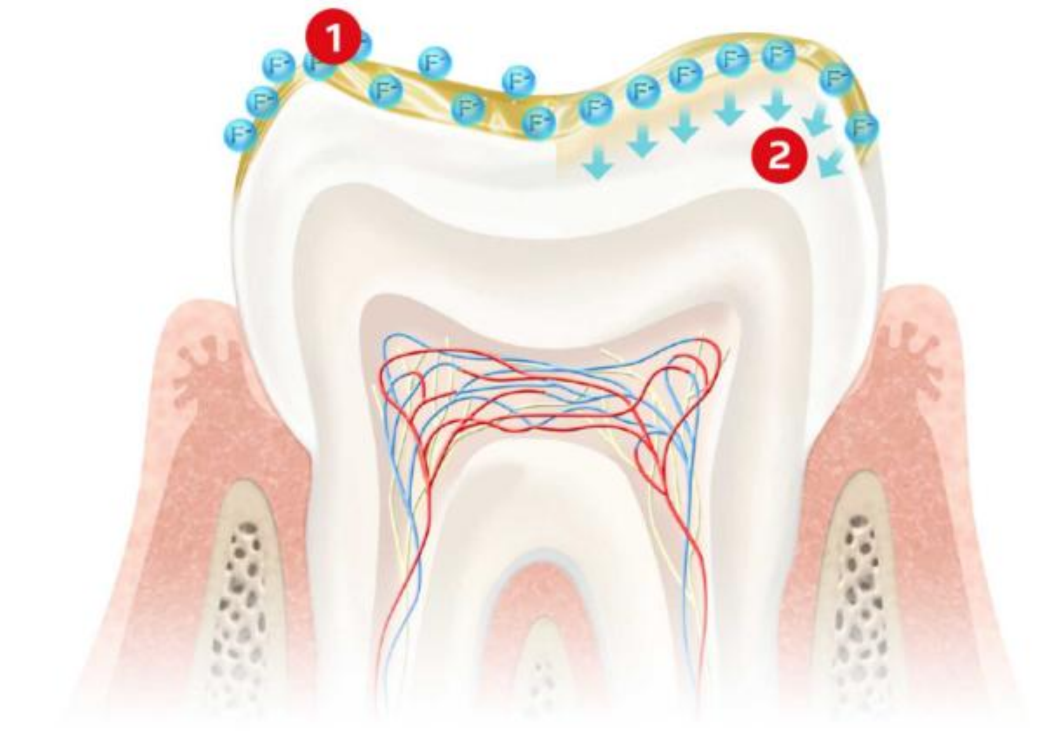
Does your fluoride varnish deliver? - Dentistry

Table 3 – Fluoride varnishes currently available in the UK

Manufacturer	Product name	Fluoride content	Regulatory Status	Product Indications	Notes
Colgate	**Duraphat**	5% Sodium Fluoride 22,600ppm	**POM**	• Caries prophylaxis • Treatment of hypersensitive teeth • prevention of decalcification around orthodontic appliances	• Contains Colophony • The container of this medicinal product contains latex rubber • Contains alcohol
VOCO	**Bifluorid 10**	5% Sodium Fluoride 6% Calcium Fluoride 22,600ppm	**MD**	• Treatment of hypersensitive teeth	• Colophony free • Latex safe • Contains alcohol
VOCO	**Profluorid**	5% Sodium Fluoride 22,600ppm	**MD**	• Treatment of hypersensitive teeth	• Contains Colophony • Latex safe • Contains alcohol
Ivoclar Vivadent	**Fluor Protector**	0.9% Difluorsilane 1000ppm	**MD**	• Long-term caries prevention • Treatment of hypersensitive teeth	• Colophony free • Latex safe
Ivoclar Vivadent	**Fluor Protector S**	1.5% Ammonium Fluoride 7700ppm	**MD**	• Caries prophylaxis • Treatment of hypersensitive teeth	• Colophony free • Latex safe • Contains alcohol
SDI	**Riva Star**	38% Silver Diamine Fluoride 44,800ppm	**MD**	• Treatment of hypersensitive teeth	• Solution can stain.
3M ESPE	**Clinpro White Varnish**	5% Sodium Fluoride tri-calcium phosphate 22.600ppm	**MD**	• Treatment of hypersensitive teeth	• Latex safe • Contains Colophony • Contains alcohol
Dentsply	**NUPRO varnish**	5% Sodium Fluoride 22,600ppm	**MD**	• Treatment of hypersensitive teeth	• Gluten safe • Latex safe • Contains Colophony
Henry Schein	**HS Fluoride varnish**	5% Sodium Fluoride 22,600ppm	**MD**	• Treatment of hypersensitive teeth	• Contains Colophony • Contains alcohol

Brown et al 2021

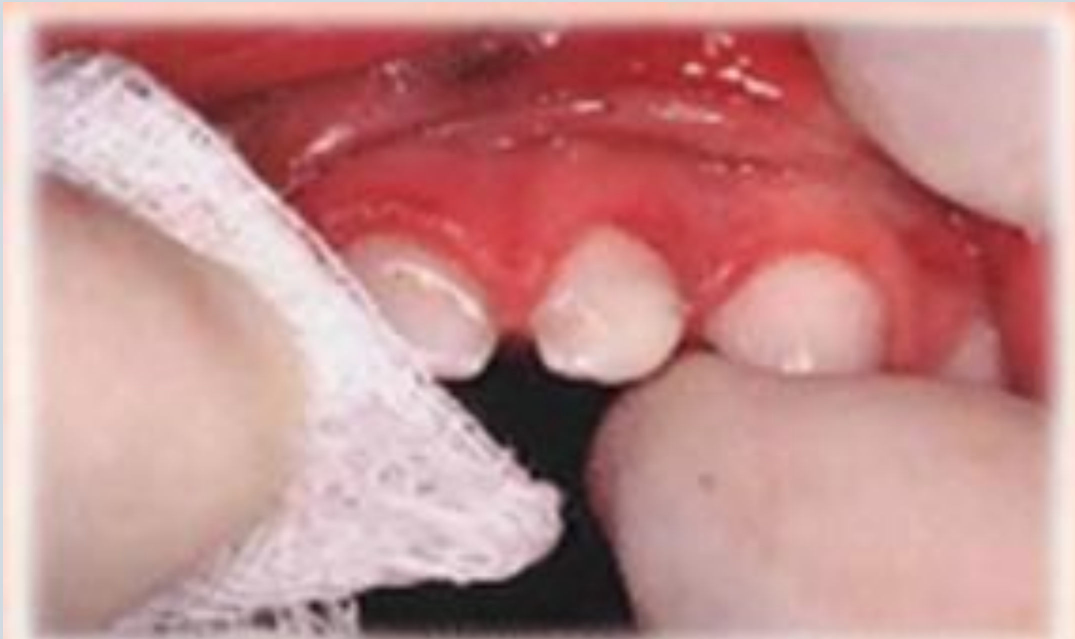
What to look for in a Fluoride Varnish



Application of fluoride varnish

It is very easy to apply

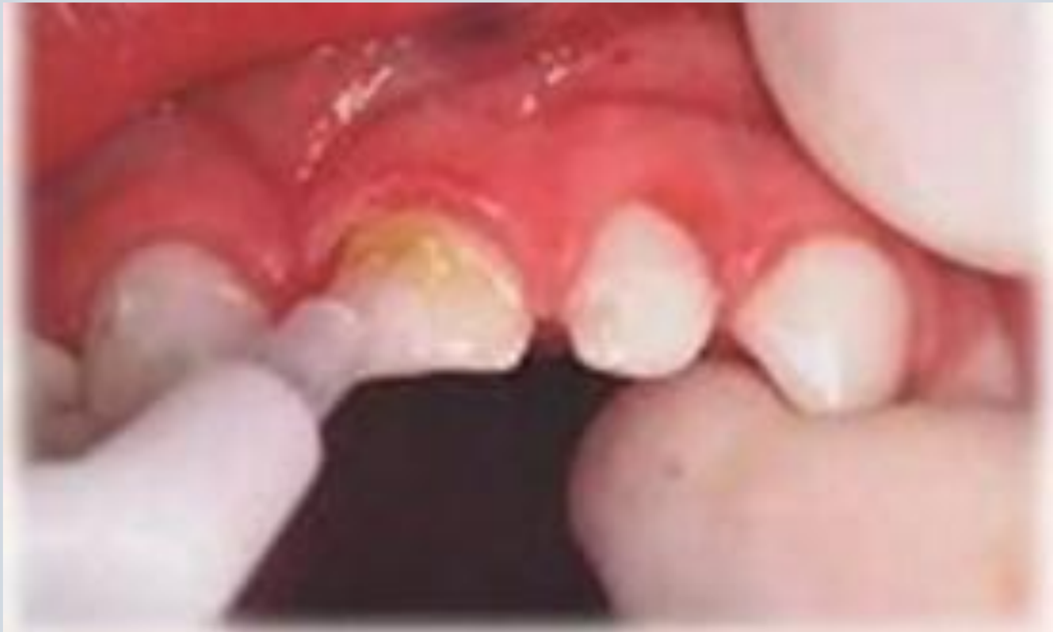
Dry all teeth with gauze as seen in the picture



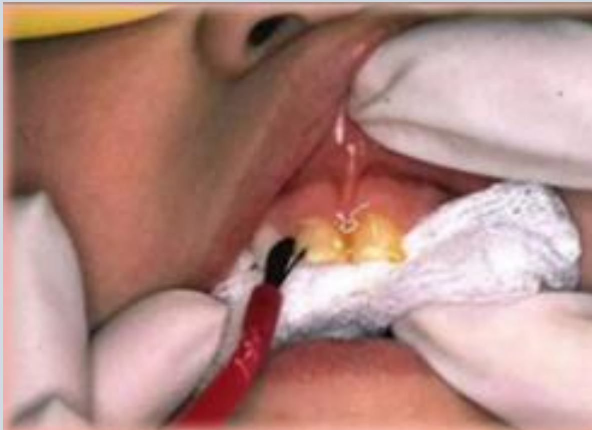
Application of fluoride varnish

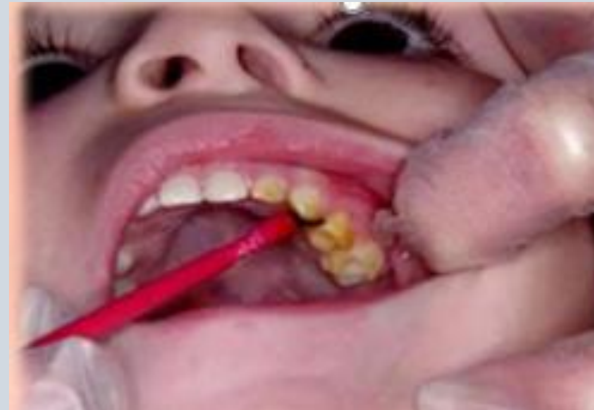
Paint the fluoride varnish on all tooth surfaces with a bendy micro-brush

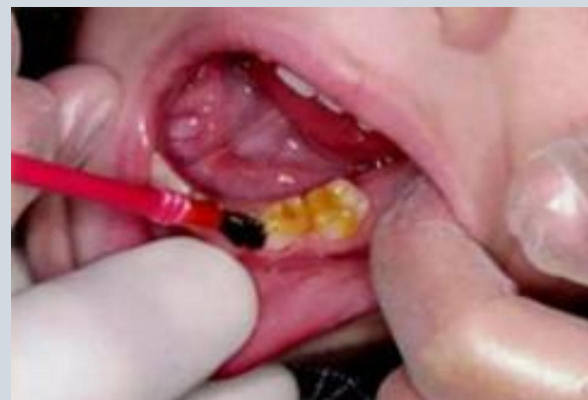
Apply to clean dry teeth only



Application of fluoride varnish

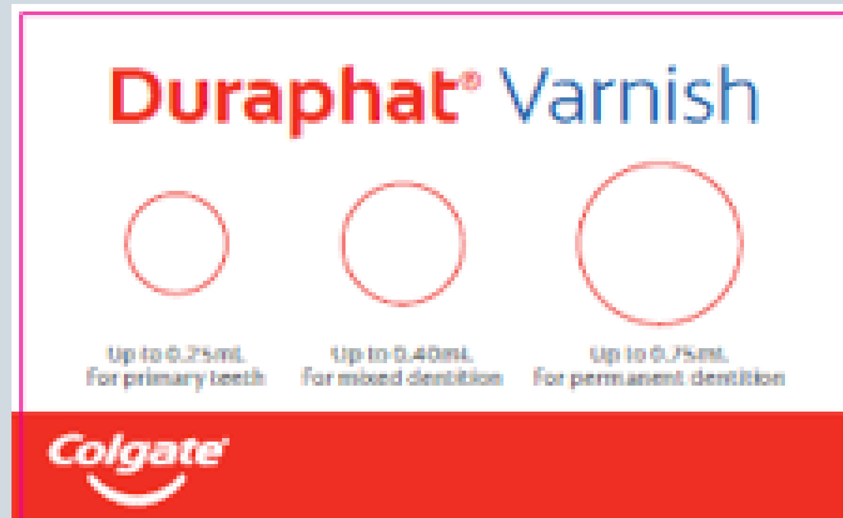






Colgate Duraphat

[Guide: Fluoride Varnish Dosing Pad| Colgate® Professional (colgateprofessional.co.uk)]



Guide: Fluoride Varnish Dosing Pad| Colgate® Professional (colgateprofessional.co.uk)

Colgate Duraphat

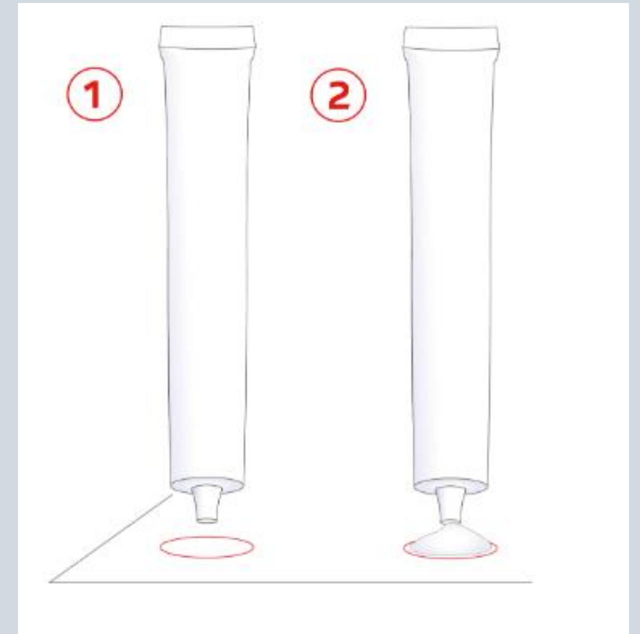
Fluoride Varnish Dosing Pad – Instructions for Use

Place the tube vertically above the centre of the relevant circle, 2 to 3 mm from the surface of the pad

Maintaining this position, press the tube until Colgate® Duraphat® varnish covers the totality of the surface area (up to the red circle)

Remove the tube vertically

Use a microtip to apply the varnish to surfaces of the teeth



Guide: Fluoride Varnish Dosing Pad | Colgate® Professional (colgateprofessional.co.uk)

Colgate Duraphat

Fluoride Varnish Dosing Pad – Dosage Guidance

The circles provide safe guidance on the volume to be applied for the prevention of caries, according to the dosage stated in the Summary of Product Characteristics (SPC):

- **Primary dentition up to 0.25 ml**
- **Mixed dentition up to 0.40 ml**
- **Permanent dentition up to 0.75 ml**

These quantities refer to a single application to the full dentition

For a partial treatment of the dentition, use the lower dosage e.g. for half of adult dentition, use the 0.40 ml circle

This visual dosage guide is specific to the viscosity of Colgate® Duraphat® Fluoride Varnish, licensed for caries control

Note: dosing pad is for visual guidance only

Guide: Fluoride Varnish Dosing Pad| Colgate® Professional (colgateprofessional.co.uk)

Application of fluoride varnish

Advantages & Disadvantages of Fluoride Varnish

Advantages:

- Fluoride varnish is safe and poses less risk of an adverse reaction because only a small amount is used and less is swallowed
- Could be applied in any setting not just dental surgery example: Childsmile

Disadvantages:

- Yellow discolouration of teeth initially, gradually fades
- Undesirable taste in the mouth after application, gradually fades also

Post Operative Instructions

- ❑Don’t eat or drink for one hour
- ❑Don’t chew food for 4 hours (hard foods)
- ❑Eat only soft foods at next meal time
- ❑Avoid sticky foods for the rest of the day (fruit, chewing gum etc)
- ❑Don’t brush until the next morning

In Summary

You will need	Gauze, fluoride varnish (Duraphat), Disposable micro-brushes, dental mouth mirror, Duraphat dispensing pad
Position the child	For an infant: place the child on the parent's lap in the dental chair
Apply the varnish	Using gentle finger pressure, open the child's mouth Clean and dry with a gauze square **(teeth must be dry)** Use your fingers and gauze to isolate the teeth and keep dry You will usually be able to isolate a quadrant of teeth at a time (fewer in younger children) Once the varnish is applied it sets quickly. Repeat the process as per prescription
Instruct the parent	Eat a soft, nonabrasive diet for the rest of the day Do not brush teeth until the next day Advise re~: yellow colour which will come off once teeth are brushed Give the parent age appropriate information sheet

Cost of using Duraphat

Duraphat costs in the region of £29.00 incl VAT for 10ml tube.

That is 25 applications for a child with mixed dentition per tube, i.e. around £1.14 per application – a little less for a child who has only deciduous teeth.

It costs about £2.50 to apply Duraphat twice a year to children at high risk of caries

References

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The Story of Fluoridation | National Institute of Dental and Craniofacial Research (nih.gov)

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Childsmile Programme

[Fluoride varnish: what it is, what it is used for and what are the risks - NHS Health Scotland (child-smile.org.uk)]