Abstract
Fluoride has demonstrated its use in assisting caries prevention in children. Over the years it has evolved and has current modalities for adults as well. Fluoride options include systemic uptake via water and foods, and by topical applications such as gels, foams, varnishes, dentifrices, and mouth rinses. The highest levels of fluoride are stored on the tooth surface. Topical applications are most successful if they have a high fluoride release and fluoride uptake. Traditionally the tray method has been in use in dental offices since the 1940’s. More current application of fluoride includes a fluoride varnish method which uses a less amount of fluoride per application than the tray method. Varnish sets quickly and remains on the teeth releasing fluoride hours after it has been applied. Candidates for topical fluoride include patients with orthodontics, restorations, and exposed root surfaces, thus an adult population can benefit from fluoride. The use and ease of a fluoride varnish is a universal and modern approach to treating caries risk in children and adults.

Educational Objectives
The goal of this course is to provide the reader with contemporary information on intraoral digital radiography to optimize results. Upon completion of Part II of this course, the reader will be able to:
1. Discuss topical fluoride options available to patients.
2. Explain the preventive outcomes of topical fluoride.
3. Identify the differences in fluoride application modalities of gel, foam, and varnish.
4. Describe the key factors of a quality varnish.

Author Profile
Trish Jones, RDH, BS has been passionate about dentistry for over 25 years. With degrees in Dental Hygiene and a Bachelor of Science in Health Care Management from Southern Illinois University in Carbondale, she loves to speak and write about topics that have practical impact on dental offices. Trish is honored to be an Executive Coach with Fortune Management in San Antonio, Texas. She can be reached at gotrishjones@gmail.com

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Supplement to PennWell Publications
Written by Trish Jones, RDH, BS

The Modern Approaches to Fluoride: Applications for All Ages
A Peer-Reviewed Publication

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Fluoride has demonstrated its use in assisting caries prevention in children. Over the years it has evolved and has current modalities for adults as well. Fluoride options include systemic uptake via water and foods, and by topical applications such as gels, foams, varnishes, dentifrices, and mouth rinses. The highest levels of fluoride are stored on the tooth surface. Topical applications are most successful if they have a high fluoride release and fluoride uptake. Traditionally the tray method has been in use in dental offices since the 1940’s. More current application of fluoride includes a fluoride varnish method which uses a smaller amount of fluoride per application than the tray method, thereby maximizing the clinical benefits of topical fluoride application while minimizing ingestion that may cause gastric upset issues or in younger children other systemic issues. Varnish sets quickly and remains on the teeth releasing fluoride hours after it has been applied. Tooth structure benefits are dependant on contact time between the fluoride and enamel/dentin. Candidates for topical fluoride include patients with orthodontics, restorations, and exposed root surfaces, thus an adult population can benefit from fluoride. The use and ease of a fluoride varnish is a universal and modern approach to treating caries risk in children and adults and treat hypersensitive root surfaces.

Introduction
It was once thought that fluoride only assisted with caries prevention in growing children. Over the years, fluoride in various treatment modalities has been demonstrated to help children; and adults in prevention of the progression of dental caries. Fluoride now has additional, current applications beneficial for all ages.

Dental caries or cavities are caused by a breakdown of the tooth enamel and dentin. This breakdown is the result of bacteria on teeth that breakdown carbohydrates in the foods consumed and produce acid that destroys tooth enamel and dentin, resulting in tooth decay. The bacteria associated with the etiology of this disease are Streptococcus mutans, Lactobacillus, and Actinomyces viscosus and odontolyticus.

These organisms act upon fermentable carbohydrates such as sucrose, glucose, and fructose to produce acid by-products, reducing the pH of the associated oral structure. A more acidic environment begins the process of enamel demineralization. If frequency of ingestion of fermentable carbohydrates increases, so does the risk of demineralization of the enamel, increasing the risk of caries. Other factors that can affect the process include fluoride exposure, pH level, and salivary flow.

Dental caries remains the most common chronic disease of children aged 6 to 11 years and adolescents aged 12 to 19 years. Tooth decay is four times more common than asthma among adolescents aged 14 to 17 years. Dental caries also affects adults with nine out of ten over the age of 20 having some degree of tooth-root decay. Caries, especially of the root surface is a common occurrence in patients over age 60 and may be related to decreased salivary flow as well as less hand dexterity making home care less effective. With the increasing demographic of the aging population who are retaining teeth, the challenge is preventing and treating root caries in this older age group who may exhibit gingival recession and root exposure. It is estimated there will be 7.5 million older patients via the “baby boomer” generation (1946-1964) by year 2030. With a greater awareness of their health and a longer retention of their natural teeth, dental caries is likely to be a concern with this generation.

Fluoridation has been a proven method to prevent cavities. Named by the Centers for Disease Control and Prevention (CDC) as one of the ten great public health achievements of the 20th century, water fluoridation has been a major contributor to the decline of the rate of tooth decay. Studies have shown that water fluoridation can reduce the amount of decay in children’s teeth by 18-40%.

Fluoride options
Fluoride can help achieve optimum oral health by two general routes. One route is systemic ingestion, specifically, fluoride in water, foods, and beverages, or by fluoride supplements to meet optimal levels for developing teeth. The other route is topical fluoride. Topical fluoride is placed directly on exposed surfaces of the teeth for uptake. Topical fluoride includes gels, foams, varnishes, dentifrices, and mouth rinses.

Systemic application: water fluoridation
Fluoride research had its beginnings in 1901, when a young dental school graduate named Frederick McKay opened a dental practice in Colorado Springs, Colorado. He was astounded to find scores of Colorado Springs natives with brown stains on their teeth. McKay searched for information on this bizarre disorder. He found no mention of brown-stained teeth in any of the dental literature of the day.

McKay’s break came in 1909, when renowned dental researcher Dr. G. V. Black agreed to come to Colorado Springs and collaborate with him on the mysterious ailment.
Black investigated fluorosis for six years, until his death in 1915. He and McKay made two crucial discoveries. First, mottled enamel (as Black referred to the condition) resulted from developmental imperfections in children’s teeth. Second, teeth afflicted by Colorado Brown Stain were surprisingly and inexplicably resistant to decay.6

The architect of the first fluoride studies in the 1930s was Dr. H. Trendley Dean. Dr. Dean concluded that the optimal level of fluoride in the water to minimize the risk of dental caries was 1 ppm.5

Fluoridation of water in communities first occurred in 1945. After much research in 2015, the US Department of Health and Human Services (HHS) updated the optimal concentration of water fluoridation to be 0.7 ppm.4 This level provides an effective level of fluoride to reduce the incidence of dental caries while minimizing the risk of fluorosis.4

Fluoride is an important part of the crystal lattice of teeth and bones. Structurally, fluoride and calcium can both occupy the same molecular position in the enamel or dentin. But higher amounts of acid are required to remove the fluoride from the tooth structure then calcium. Incorporation of fluoride into the enamel during tooth development results in the formation of fluorhydroxyapatite, which is more resistant to the acid attacks of the decay process and is a systemic benefit.3,7,9

Certain foods such as tea, fish, meat, eggs, vegetables, fruits, and cereals contain fluoride, which alone is not enough to provide for caries prevention. Bottled water normally does not contain fluoride unless indicated. In regards to water filters, reverse osmosis and water distillation systems remove the fluoride, whereas water softeners do not. Fluoride can be removed from treated water by carbon filters containing activated alumina.7

In communities with no water fluoridation, fluoride supplements may be prescribed in forms of tablets, lozenges, drops, and a swish/swallow rinse.7

Homes using well water may contain anywhere from no or low levels of fluoride to very high levels depending on the location. It is recommended that these water sources be checked for fluoride levels and either supplemental fluoride be added to the diet or in the case of excessive levels filtered to lower the level to an accepted level.

Over-the-counter toothpastes and mouth rinses may contain fluoride and can be recommended to patients as well.

Topical application of fluoride
The highest levels of fluoride are stored on the tooth surface. Topical application of fluoride has been mainstream in dental offices since the 1940s as part of the oral prophylaxis. Topical fluoride helps prevent dental caries in three different ways. These include inhibiting demineralization, enhancing remineralization of incipient caries lesions, and glycolysis inhibition. Fluoride enhances remineralization by combining with the tooth and making the coronal enamel and root surfaces more resistant to decay. The more resistant remineralized enamel in turn serves as a deterrent to acid, which acts to remove minerals from the tooth surface.3,6-10 Fluoride inhibits bacterial activity by inhibiting enolase, which is an enzyme needed by bacteria to metabolize carbohydrates.8

Topical fluoride modalities include 2.0% sodium fluoride (NaF) or 1.23% acidulated phosphate fluoride (APF) gel or foam in a tray delivery method. Another more modern method is 5% neutral sodium fluoride (NaF) varnish.

Toxicity
Acute fluoride toxicity results from short-term ingestion of higher concentrations of fluoride. Symptoms can range from mild nausea to more severe GI symptoms and, in extremely rare cases, death.7,9 The severity of symptoms is affected by the amount of fluoride ingested, the patient’s weight, and the patient’s health status.10,15 Mild nausea is the most common form of fluoride toxicity and is experienced when patients swallow too much topical fluoride. The fluoride reacts with the stomach acid, forming hydrogen fluoride, and produces symptoms of nausea, cramps, and vomiting, usually within 30 minutes of ingesting.10,15,16

Positive outcomes of fluoride treatments
Fluoride release is the amount of fluoride that the product unlocks as it is in contact with the tooth. A higher rate of fluoride release means that more fluoride is available for absorption. A higher rate is also more efficient than a low release rate since it provides more available fluoride per treatment. In order to be truly effective, however, a product must have both a high fluoride release and a high fluoride uptake.20

Fluoride uptake is the amount of available fluoride ions that are actually absorbed into the tooth. Without a high fluoride uptake, a fluoride treatment is largely ineffective, as the fluoride has no opportunity to provide any benefit. It merely sits on the tooth without penetrating the enamel.20

Dental biofilm plays a part in the application of fluoride. Biofilm has several functions. It acts as an interface between the oral surface and its surroundings; it harbors bacteria and interacts with other bacteria; and disrupts the pH level. Remineralization of enamel is affected adversely by high calcium and phosphate concentrations in biofilms, saliva or artificial calcifying agents. It provides a barrier against uptake of fluoride for remineralization. It is advantageous to remove the plaque biofilm prior to any fluoride treatment modality to maximize the uptake and benefits of fluoride.9,18
Tray delivery system
Neutral sodium fluoride (NaF) has a pH level of 7 and is safe for porcelain and composite restorations that may be present in the oral cavity. Acidulated phosphate fluoride (APF) has a low pH of 3.5, which enhances fluoride uptake; however, it is recommended as a 4-minute application. APF can etch porcelain, composite, and sealant materials, so a thorough dental health history and evaluation should be taken into consideration in determining which tray fluoride material and method is best. Patients should be advised not to rinse, eat, or drink for 30 minutes following high-concentration fluoride applications to maximize effectiveness. In children under six, the tray method may not be ideal due to the possibility of ingestion. Additionally, patient cooperation can be a factor in these young children and fluoride varnishes are quicker to apply and require less patient cooperation during treatment.

Five percent neutral sodium varnish has been widely used and has proven to be safe, effective, fast, and easy, and patient compliance and acceptance is good.

Fluoride varnishes
The United States Food and Drug Administration (FDA) approved fluoride varnish in 1994 for use as a cavity liner and treatment for hypersensitivity. As compared to a gel or foam, varnish has a higher concentration of fluoride. Since varnish is painted on or layered similar to a lacquer, less amount of fluoride is used per application than the tray method. A key factor in using varnish is that it sets quickly and remains on the teeth, releasing fluoride hours after it has been applied. This helps with reducing caries in pits and fissures, and in interproximal and cervical areas where it is needed the most. It is effective in remineralizing lesions regardless of whether the varnish is applied over or around the lesion. Thus, the use of varnish in orthodontics or around restorations is beneficial as it helps reduce demineralization around the brackets and/or the restorations present. Varnish may also help older people with exposed root surfaces as it can help diminish dentin hypersensitivity by blocking dentinal tubules. It has also been demonstrated that varnish may be indicated for those with xerostomia caused by factors such as head-and-neck radiation and saliva-depressing drug therapy. Proper application technique reduces the possibility that a patient will swallow varnish during its application as compared to the traditional tray method.

High-frequency beverage consumption of sodas, citrus juices, sports drinks, tea, coffee, and wine provides an acidic environment that exposes teeth to an acidic pH for longer periods of time, thus increasing the risk of demineralization. Normal pH of the oral cavity is 7. A pH of 5.5 provides an environment in which hydroxyapatite dissolves. Fluorapatite begins to demineralize/dissolve in an environment of 4.5.

<table>
<thead>
<tr>
<th>Table 1. Topical Fluoride Concentrations</th>
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<tbody>
<tr>
<td>NaF</td>
</tr>
<tr>
<td>APF</td>
</tr>
<tr>
<td>Varnish</td>
</tr>
<tr>
<td>Dentifrice</td>
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</tbody>
</table>

Varnishes are becoming a popular option for topical fluoride. They are ideal for children under six due to the decreased risk of swallowing the fluoride. Varnishes are also recommended for children and adults with orthodontics, adults with sensitivity and/or root exposure, and children and adults who have xerostomia due to factors such as medication.

Patients with xerostomia or chronic root sensitivity and increased caries potential can be trained to apply fluoride varnishes at home under dental professionals' guidance.

Before recommending a product, in addition to noting the ingredients, it is ideal to learn more about the product’s fluoride release and uptake as this assures the most efficient and effective product is used.


This survey provides effective management of dental caries based on assessment of the caries risk level. There are two surveys available: one for 6 years old and under and another for 6 years old and older.

Benefits of a fluoride varnish include taste; color (clear); lack of gritty texture; patient acceptance, especially with adults; uptake and release of fluoride; contact time; and multifunctional use on children, orthodontic patients, and adult patients.
Modern choice
Fluoride varnish is a more modern approach to treating caries risk. Its ease of use and universal application in regard to treating young patients, adults with restorations and/or recession, and orthodontic patients of all ages make it a popular choice. Evaluation of the quality of fluoride, its availability to adhere to the teeth, and the uptake and release of the fluoride maximizes its benefits to the patient.

References
18. Garcia-Godoy F., Hicks MJ. Maintaining the integrity of the enamel surface. JADA, Vol. 139, 2008; 25-34.

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Questions

1. What is the revised ppm fluoride that is recommended currently for community water fluoridation?
   a. 0.5 ppm
   b. 0.7 ppm
   c. 1 ppm
   d. 2 ppm

2. Which of the following topical fluorides has the lowest risk for swallowing?
   a. Dentifrices
   b. Mouth rinses
   c. Gels
   d. Varnishes

3. Which fluoride is best for patients with porcelain and composite restorations present?
   a. 2.0% fluoride gel
   b. 5% neutral fluoride varnish
   c. 1.23% acidulated phosphate fluoride
   d. Both a and b

4. Fluoride release is:
   a. The amount of fluoride that the product unlocks as it is in contact with the tooth.
   b. When the tray is in contact with the teeth
   c. The same as fluoride uptake
   d. Not as important as the uptake of fluoride

5. The normal pH level is 7 for the oral cavity. At what level does hydroxyapatite dissolve?
   a. 6
   b. 4
   c. 5
   d. 3.5

6. Topical fluoride applications may be indicated for:
   a. Children over 6 with a high caries risk
   b. Adults with hypersensitivity
   c. Orthodontics patients
   d. All of the above

7. Varnish has what ppm of fluoride concentration?
   a. 20,000
   b. 21,400
   c. 9,000
   d. 22,600

8. Which beverages may affect enamel demineralization?
   a. Milk
   b. Soda
   c. Drinking water
   d. Both a and b

9. Proper risk assessment of adults and children include:
   a. Taking a survey to assess sugar intake, salivary function, and medications and creating a plan of action
   b. Assessment of the gag reflex when the tray is in the oral cavity
   c. Assessing nutritional intake
   d. Talking to the patient about the beverages they drink

10. Benefits of fluoride varnish from the patient’s perspective include:
    a. Taste
    b. Color
    c. Texture
    d. All of the above

11. Which of the following bacteria is associated with etiology of dental caries?
    a. Actinomyces coli
    b. Streptococcus mutans
    c. Lactobacillus strep
    d. E. coli

12. Which of the following increases the risk of demineralization of the enamel?
    a. The frequency of intake of fermentable carbohydrates
    b. Drinking bottled water
    c. Decreased Salivary flow
    d. Both a and c

13. Which topical fluoride treatment modality delivers the highest parts per million of fluoride?
    a. Fluoride rinse
    b. APF foam
    c. Varnish
    d. NaF gel

14. Which statement is true?
    a. Dental caries primarily affects children under the age of 14.
    b. Fluoridation has been named by the CDC as one of the ten great public health achievements of the 20th century.
    c. Dr. McKay concluded the level of fluoride in water that minimizes the risk of dental caries averages 1 ppm.
    d. Studies have shown that water fluoridation can reduce the amount of decay in children’s teeth by 41-50%.

15. Which statement is false?
    a. Certain foods such as tea, fish, meat, eggs, vegetables, fruits, and, cereal contain enough fluoride for caries prevention.
    b. In communities without water fluoridation, supplements may be indicated.
    c. The highest levels of fluoride are stored on the tooth surface.
    d. Fluoride enhances remineralization by combining with the tooth and making the coronal enamel and root surfaces more resistant to decay.

16. Symptoms of acute fluoride toxicity include:
    a. Mild nausea to more severe GI symptoms
    b. Cramps
    c. Vomiting
    d. All of the above

17. Fluoride uptake:
    a. Is the amount of available fluoride ions that are actually absorbed into the tooth
    b. Occurs when fluoride just sits on the tooth
    c. Works best when fluoride release is low
    d. Is largely ineffective when it is high

18. 5% neutral sodium varnish has been widely used and has been demonstrated to be:
    a. Safe
    b. Effective
    c. Fast
    d. All of the above

19. The following statement is true:
    a. More fluoride is used in a varnish as compared to a tray method.
    b. Varnish takes hours to set since it is painted on.
    c. Varnish remains on the teeth, releasing fluoride hours after it has been applied.
    d. Varnish does not help patients with orthodontics or dental restorations.

20. Varnish can help:
    a. Reduce dentinal hypersensitivity
    b. Protect exposed root surfaces
    c. Reduce demineralization around orthodontic brackets or dental restorations
    d. All of the above
The Modern Approaches to Fluoride: Applications for All Ages

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Course Evaluation

1. Were the individual course objectives met?
   - Objective #1: Yes No
   - Objective #2: Yes No
   - Objective #3: Yes No
   - Objective #4: Yes No

2. To what extent were the course objectives accomplished overall?
   - 5
   - 4
   - 3
   - 2
   - 1
   - 0

3. Please rate your personal mastery of the course objectives.
   - 5
   - 4
   - 3
   - 2
   - 1
   - 0

4. How would you rate the objectives and educational methods?
   - 5
   - 4
   - 3
   - 2
   - 1
   - 0

5. How do you rate the author's grasp of the topic?
   - 5
   - 4
   - 3
   - 2
   - 1
   - 0

6. Please rate the instructor's effectiveness.
   - 5
   - 4
   - 3
   - 2
   - 1
   - 0

7. Was the overall administration of the course effective?
   - 5
   - 4
   - 3
   - 2
   - 1
   - 0

8. Please rate the usefulness and clinical applicability of this course.
   - 5
   - 4
   - 3
   - 2
   - 1
   - 0

9. Please rate the usefulness of the supplemental webliography.
   - 5
   - 4
   - 3
   - 2
   - 1
   - 0

10. Do you feel that the references were adequate?
    - Yes
    - No

11. Would you participate in a similar program on a different topic?
    - Yes
    - No

12. If any of the continuing education questions were unclear or ambiguous, please list them.

13. Was there any subject matter you found confusing? Please describe.

14. How long did it take you to complete this course?

15. What additional continuing dental education topics would you like to see?
No one wants to leave the dentist's office with a gritty film masking their teeth. That’s why we developed Enamelast with an exclusive formula that provides sustained fluoride release and leaves the teeth feeling natural and smooth.