Caries Process and Prevention Strategies: Intervention

Video Transcript

Hello, and welcome to dentalcare.com's cariology series. This session focuses on intervention. This is part nine of a 10-part series entitled Caries Process and Prevention Strategies. This course introduces a dental professional to the important role of fluoride in the prevention and control of dental caries. Systemic and topical forms of fluoride delivery are discussed as options for the majority of patients, and professional forms of fluoride delivery are discussed as sometimes necessary measures for high-risk patients with severe caries.

First, let's take a couple of clinical significance snapshots, questions that may come up in your practice. First, how can I find out if my patients are getting fluoridated water? The best way is to contact the local water supplier or the State Health Department. Almost 70% of the US population receives water in which the concentration of fluoride has been adjusted to optimal levels. This percentage cannot increase much more, as it's challenging to adjust the fluoride content of wells and other individual water sources. With the increased consumption of bottled water, not all people living in an area of water fluoridation may be receiving the optimal amounts of fluoride.

Another question, are all fluoride toothpaste the same? Well, not necessarily. Every manufacturer uses its own proprietary formulations. Fluoride compounds are very reactive, and without good chemistry at the formulation stage, some or all of the fluoride can become bound to other ingredients in the paste and not be available for binding to the surfaces of the teeth. Commonly used fluoride sources include stannous fluoride, sodium fluoride, and sodium monofluorophosphate. A toothpaste brand carrying the Seal of Acceptance of the American Dental Association will have demonstrated in various studies that the fluoride is both safe and effective.

The learning objectives from this course for you the dental professional upon completion, are that you be familiar with the history of fluoride in caries control, to be able to discuss how fluoride is processed by the body, to be able to describe how fluoride concentration varies in different parts of the tooth, to identify the multiple ways in which fluoride provides protection from caries, to be able to explain the dental health consequences of too much fluoride exposure. And finally, to understand when professional forms of fluoride delivery may be necessary.

It can be argued that the role of fluoride in caries prevention is one of the biggest success stories in the field of public health. In fact, in 1999, the US Center for Disease Control or CDC declared water fluoridation to be one of the 10 most important public health measures of the 20th century. However, just as it is well documented that fluoride has beneficial effects on dentition because of its ability to reduce caries, it's also well known that ingestion of an excessive amount of fluoride during the early stages of tooth development can also have detrimental effects on teeth, namely in the form of dental fluorosis. Because of that,

there are many in the dental profession who advocate the use of fluoride, and some who are adamantly against it. What follows is a summary of what is known about the effects of fluoride on developing and erupted teeth, as well as information on the current forms of fluoride delivery. The goal is to get dental health professionals on the road to making informed decisions about fluoride use that maximize the anticaries benefits, while minimizing the risk of dental fluorosis.

To begin, let's watch a brief yet excellent video on the mechanism of action of fluoride by Dr. John Featherstone.

The action of fluoride on or in the tooth is... can be split up into three primary mechanisms. The first mechanism is that fluoride if it's present when the acids are produced by the bacteria, will go into the tooth at the same time or before the acid, it will stick or adsorb on the surface of the, the other tiny crystals inside the tooth, acting like a bodyguard and stopping the acid from dissolving the crystal surfaces. The second and extremely important mechanism is that if fluoride is present when the acid is neutralized, and that happens by action of the saliva in the mouth, then the fluoride together with calcium and phosphate from the saliva goes back into the tooth and remineralizes or grows a new surface on those tiny crystals, which is much more resistant. And the third important mechanism of action is that fluoride if present among the bacteria on the tooth when they produce acid, that fluoride gets taken into the bacteria, slowing them down or even killing them. So those are the three primary mechanisms of action of fluoride, so called topical mechanisms on the surface of the tooth.

The credit for the identification of fluoride as an effective means of caries prevention can be largely accredited to two American dentists, Frederick McKay, and H. Trendley Dean. Interestingly, this knowledge came about by first noting the detrimental effect of excessive fluoride on tooth enamel. This is a condition called dental fluorosis, in which teeth become speckled with white flecks. In more severe cases of excessive fluoride ingestion, teeth can become mottled with brown stains and pieces of surface enamel might easily break off. So these types of effects are limited to the most severe cases, and are not, not generally seen in the United States.

As a practicing dentist in Colorado Springs, Colorado in 1901, McKay noticed many of his patients had what was locally called Colorado Brown Stain. He moved out of the area, but returned in 1908 to study the phenomenon in more detail, and found that as many as 90% of children were affected. In addition, after conferring with other dentists worldwide, he found similar occurrences of mottled or brown enamel in other towns in the United States, in England and in Italy. Because the phenomena was isolated to specific geographical areas, McKay thought that the water supply might be an important factor. He puts this theory to test in Oakley, Idaho, where mottled enamel was common by having a pipeline with an alternative water source pumped into the town. After 10 years of the new water supply, new cases of brown stain had disappeared. To add another piece of the puzzle, analysis of water in another American town plagued by mottled enamel, Bauxite, Arkansas, uncovered an unexpectedly high level of fluoride, and these high levels were confirmed in the water supply of other towns with rampant dental fluorosis.

The discovery of high concentrations of fluoride was a concern because it was known that high doses of the mineral could be poisonous. That is when H. Trendley Dean who worked with the US Public Health Service came on scene. He took up the investigation mapping areas were mottled enamel was present and relating the severity of mottled enamel to fluoride concentrations, noting that a certain range of fluoride concentrations in drinking water that was not very high or very low, was linked with a reduced caries risk.

In a publication in 1942, Dean published his findings of his landmark 21 City Study, actually a series of studies, where he examined the association between the fluoride levels in drinking water and caries levels in children, and he developed the first classification system for recording the severity of mottled enamel using the terms questionable, very mild, mild,

moderate, and severe. These findings from the first half of the 1900s led to a greater understanding of fluoride's effects on enamel development, and how dental fluorosis develops, and advances in the, the delivery of beneficial amounts of fluoride to reduce caries. Here's another short video by Dr. George Stookey, who provides an accurate explanation of the enamel maturation, and how fluoride is incorporated into the inorganic phase of enamel both in pre and post-eruptive stages.

Fluoride is incorporated into the inorganic, part of enamel, the inorganic phase by substitution for either hydroxyl ions or carbonate ions within the apatite lattice. And in order for that to occur, in an already maturated or developed apatite crystal, there has to be some demineralization. So, you have to have a demineralization, and then the reverse, uh, reprecipitation, uh, will favor the incorporation of fluoride into the apatite crystal because fluoride is the most electronegative of all elements and therefore bonds very firmly with calcium.

The best time, the best time for having this occur is actually right after tooth erupts. When the tooth erupts, it's not yet fully maturated. In other words, it's not yet fully calcified. It takes two more years for each tooth to calcify after it erupts into the oral cavity. That is the prime time for caries to occur because the tooth is very susceptible. It's also the best time to apply fluoride, whether that be fluoride in a dentifrice or professional fluorides, and that's true for both the primary dentition, the baby teeth, as well as, uh, the permanent dentition. So pre-maturation is post-eruptive but pre-maturation is the best time to apply fluoride. So that covers the period from, from two years of age up to about 15 years of age for different teeth in the oral cavity.

Following the ingestion of fluoride from a water, food or supplements source, 86% to 97% of the element is absorbed in the stomach and small intestine. Fasting states are ingested on an empty stomach, increases fluoride absorption, while the intake of other dietary nutrients such as calcium, aluminum and magnesium tends, tends to decrease fluoride absorption. Most of the fluoride absorbed systemically, it is not excreted via normal pathways. In other words, through the kidneys, the colon, or by sweating, it's deposited in mineralizing tissues such as bone and developing teeth. Fluoride is present in saliva at very low levels, around 0.01 to 0.04 part per million, and in human milk at low levels around 0.1 part per million. While the concentration of fluoride in these body fluids is minimal, studies show it is enough to impact dental caries.

After fluoride is ingested, it's distributed from the plasma to all tissues and organs of the body and gradually becomes incorporated into the crystal lattice structure of teeth in the form of fluorapatite. In teeth the fluoride concentration is very high on the surface enamel that falls steeply within the first 100 microns, then fluoride concentration remains constant to the enamel-dentin junction. Fluoride concentrations once again increase inside the dentin, increasing deeper into the tubes with fluoride steadily accumulating over a lifetime at the dentin-pulp interface. It should be noted that there is no homeostatic mechanism that maintains fluoride concentration in the body. Therefore, regular exposure is required to maintain fluoride concentrations in enamel, saliva and in biofilm on dental surfaces. Fluoride provides protection for caries and also can cause dental fluorosis. There are a couple of mechanisms we wanted to discuss in more detail here. These include reduced demineralization, enhanced remineralization, the antimicrobial qualities and of course, dental fluorosis.

Reduced demineralization and enhanced remineralization. This is the main mechanism by which fluoride exerts anticaries benefits. It's been established that hydroxyapatite starts to dissolve when pH drops below pH 5.5. And fluorapatite starts to dissolve when the pH drops below 4.5. If biofilm pH is lower than 5.5, but higher than 4.5, and fluoride is available in low concentrations, fluorapatite forms on the surface layers of enamel, even if hydroxyapatite dissolves in the subsurface enamel, the overall effect is reduced dental demineralization thanks to the protective outer layer of fluorapatite. When oral pH normalizes after an acid attack and rises again above 5.5,

fluoride enhances enamel remineralization. If fluoride is no longer available, the oral environment begins to favor demineralization if the pH falls below 5.5.

From an antimicrobial perspective, fluoride ions inhibit the bacterial enzyme enolase which interferes with the production of phosphoenolpyruvate or PEP. PEP is a bacterial source of energy, and a molecule that is necessary for the uptake of sugar, which provides bacterial nutrition. A dental biofilm that contains just one to five part per million of fluoride, an amount that is reached by using fluoride toothpaste is found to inhibit the adhesion, growth, metabolism and multiplication of caries linked to oral streptococcus. The presence of higher concentrations of fluoride between 10 and 100 part per million, which can be attained after use of prescription fluoride preparations has also been found to inhibit acid production by most plaque bacteria.

And now on to fluorosis, exposure to an abnormally high concentration of fluoride during the early stages of tooth development, can lead to hypomineralization of the tooth's enamel and increased porosity that is reflected in the opacity of enamel as chalky white lines or stains. In general, teeth with more severe dental fluorosis have significantly higher levels of fluoride in the enamel than those with less severe forms of dental fluorosis. Also the extent and degree of hypomineralization increases with increased fluoride exposure during development. In cases of severe hypomineralization, porous enamel appears brown and it can be very fragile, with surface damage occurring quite easily during chewing, attrition and abrasion.

A primary method of fluoride delivery is systemic being artificially provided in water, no salt or supplements, which must be ingested to be able to have any effect on the teeth. In all of these applications, the primary action of fluoride in promoting remineralization and reducing demineralization is due to the pre- presence of fluoride in a beneficial amount and at the right time. What follows is a brief discussion of the main forms of systemic fluoride delivery employed by dental professionals worldwide today.

Water fluoridation is the primary systemic method of fluoride delivery to the American population. Fluoride occurs naturally in water supplies, usually at very low concentrations of about 0.1 part per million. Community water studies have uncovered a few key findings. Overall, there's a 50% reduction in dental caries rates among children with one part per million fluoride in the community drinking water. However, this caries protection occurs only with consistent fluoride exposure. This is evident in studies that found the children who moved to a non-fluoridated water community experienced an increase in caries rates. In addition, adults also benefit from fluoride with reduced coronal and root caries rates among those residing in fluoridated water communities.

In the United States, it's estimated that more than 204 million people or approximately 75% of the population are served by fluoridated water supply systems. This is a relatively inexpensive endeavor. The annual cost of fluoridating the drinking water for a community larger than 20,000 people in this country averages about 50 cents per person. Just $1 invested in this preventive measure yields approximately $38 in savings in dental treatment costs. The Center for Disease Control monitors the progress of the country as well as each individual state toward meeting what were called the Healthy People 2020 Objective on community water fluoridation, that by the year 2020, it was hoped that 79.6% of people on community water systems will be receiving water that has the optimal level of fluoride recommended for preventing tooth decay. The results of that are pending.

Salt fluoridation is a method of fluoride delivery used primarily in Europe, as well as Costa Rica, Colombia and Jamaica. A landmark Swiss study found that fluoridating table salt reduce children's caries levels by 50% over a 10 year period. An additional study in Jamaica reported similar results in a 10 year study in that country. There are concerns about excessive fluoride intake in the emergence of

dental fluorosis, however, as well as concerns about increased salt intake.

Adding fluoride to liquid powdered and long life milk has been implemented in Eastern Europe, China, the UK, and South America. It has the advantage over water fluoridation in that it can be targeted directly at certain segments of the population and then take can be controlled. However, well controlled studies have not yet been conducted. And this is necessary before this method can be recommended for implementation in the United States. Both the US Center for Disease Control or CDC and the American Dental Association, the ADA currently recommended oral fluoride supplements be used only in high-risk children residing in non-fluoridated areas. The recommended supplemental fluoride dosage schedule is, is co- contained in this table, and is also available on the American Dental Association's website.

Another main method of fluoride delivery is topical in the form of toothpaste, gels, varnishes and mouth rinses that come in contact with the surface of the tooth. Toothpaste has come a long way from its beginnings as pastes made from things like mashed egg shells and bones mixed with myrrh. The first clinically proven fluoride toothpaste was introduced in 1955 by Crest. It contains 0.4% stannous fluoride, or SnF_2. Each decade after that brought further advancements. In the 1960s gel products hit the market. In the 1970s antiplaque claims were introduced. Tartar control products were first marketed in the 1980s, and in the 1990s were marked by specialty products on the market, such as anti-gingivitis, whitening agents, and changes in the type of container used to deliver the dentifrice such as pumps and dual chambers.

Today, most over-the-counter dentifrice products in the United States contain between 850 and 1150 parts per million fluoride. Clinical trials indicate a dose-dependent relationship between fluoride concentration in caries prevention with a 6% increase in efficacy and 8.6% reduction in caries for every 500 part per million of fluoride in the increase. To recap the caries reducing benefits of fluoridated dentifrice. Research has documented that a regular low dose source of fluoride is the most efficient means to prevent demineralization of teeth and to enhance remineralization. Fluoride becomes incorporated with the enamel apatite crystal, rendering the enamel more resistant to acid dissolution. Fluoride and saliva and plaque also promote remineralization. And finally, fluoride also has a modest antimicrobial effect on plaque bacteria, with stannous fluoride being particularly effective against *streptococcus mutans*.

The most common forms of fluoride used in US dentifrices are sodium fluoride, otherwise called NaF, sodium monofluorophosphate, also called SMFP, and stannous fluoride, SnF_2. Mixtures of NaF and SMFP, and NaF and SnF_2 and amine fluoride or AmF are also recognized as safe and effective forms of fluoride in over-the-counter therapeutic dentifrices in markets outside of the United States. There are also prescription fluoridated gels that contain 5000 part per million of fluoride that are intended for limited use in high caries risk patients. One 6-month study conducted in adults found that 57% of root caries lesions became hard in subjects using a 5000 part per million gel, compared to 29% per subjects who use at 1100 part per million toothpaste.

Clinical studies have found little association between the amount of toothpaste use and anticaries efficacy. Instead, as explained above, fluoride concentration is the important determinant of anticaries efficacy. Therefore, using more toothpaste than is recommended, such as a pea-sized amount for children does not provide more caries protection. Brushing behavior is also important. Brushing twice a day is linked to a 20 to 30% lower likelihood of caries compared to brushing once or less daily. It should be noted that brushing frequency is linked to socio-economic status, with children in poorer families brushing less and this being one reason they experience more caries. While there has been much debate about whether it's better to brush before or after meals, there's little scientific evidence to indicate the better option. However, data do show that brushing immediately before bed plays an important

role in reducing plaque load in the oral environment during sleep, and salivary flow and buffering capacity are naturally reduced. Therefore, the recommendation to brush just before going to bed, and at least one other time during the day before or after a meal time is appropriate for most patients.

Fluoridated toothpaste can also be used therapeutically by asking the patient to apply a dab of paste with a finger or brush directly to a cleaned active lesion immediately before going to bed. This also allows an increased concentration of fluoride in the vicinity of the lesion at a time of day when the salivary output is naturally low. Rinsing behavior is another determinant of anticaries efficacy. Studies show that people who use a cup to rinse with water after brushing, and so put more water in their mouth have approximately 20% more caries than those who use a toothbrush or hand to collect water. This is because more fluoride is washed away when rinsing with a cup of water after brushing.

In summary, dental professionals should recommend to their patients, number one, an accredited fluoride toothpaste. Number two, a toothpaste with an appropriate fluoride concentration after assessing potential caries risk and overall fluoride exposure. Three, to brush twice daily, once at night, and once more at another time during the day, preferably around a mealtime. And four, the children be given a minimum amount of toothpaste and be supervised when brushing.

Toothpaste and gels also contain abrasives such as hydrated silica to clean the teeth, binders such as xanthan gum, carrageenan, or Carbopol to prevent the separation of ingredients. Coloring for visual appeal. Humectants such as glycerin or sorbitol, to retain moisture. Buffers such as phosphates to maintain products stability. Flavorings, such as peppermint and cinnamon, and surfactants, such as sodium lauryl sulfate to produce a foaming action, and reduce a surface tension.

While the focus of this education course is caries, it's also useful to know the other types of dentifrices to help address other individualized needs of the patient. These types provide plaque and gingivitis protection, tartar control, whitening, sensitivity protection, erosion protection, and protection from oral malodor. Many fluoride dentifrices today cover some combinations or all of these benefit areas in one dentifrice.

Fluoride mouth rinses are most commonly available as 0.02% NaF, sodium fluoride, which is 100 part per million for twice a day rinsing, 0.05% NaF, 227 part per million fluoride for daily rinsing and 0.2% NaF for 909 part per million fluoride for weekly rinsing. These latter two higher concentration rinses is mainly to prescription even if they are intended for home use. Mouthwashes have been formulated with acidulated phosphate fluoride, stannous fluoride, ammonium fluoride and amine fluoride. Although some of these come with precautions, for example stannous fluoride rinses have been associated with discoloration of teeth and tooth restorations, and acidulated phosphate fluoride is contraindicated in people with porcelain or composite restorations, because it can cause pitting or etching.

Many of the fluoride mouth rinses on the market internationally also contain antimicrobial ingredients. These include chlorhexidine cetylpyridinium chloride, delmopinol, hexetidine, and sanguinaria extract. Many of these have little to no caries reducing effects or have not been studied for their anticaries effects. Typically, it's recommended that 10 milliliters of the mouth rinse solutions be swirled around in the mouth for one minute. Clinical Trials of both the daily and weekly regimen show an average caries reduction of around 30%. The benefit of daily rinsing is marginally greater than weekly rinsing but not statistically significant. Overall, fluoride mouth rinses are considered beneficial from a public health perspective, only if groups of people at high-risk of caries are being targeted, since they are not cost effective in a population with a low incidence of disease. While weekly rinsing public health programs have been used in the United States to target groups of people that are at high risk of caries, other countries stopped regular rinsing either daily or weekly, with fluoridated mouthwashes in the 1980s.

When a patient is at extremely high risk of caries, inappropriate dental care measures, such as good oral hygiene or the use of the fluoride toothpaste are not working, or are not being followed, professional forms of fluoride delivery may be considered. These contain higher concentrations of fluoride than products sold over the counter for home use. They typically contain 5000 to 12,300 part per million fluoride and are applied only in the dental office. They are generally recommended for use twice yearly, although in severe cases they may be applied more frequently. Significant reductions in dental caries as much as 41% have been seen when applied in this way; however, no benefit has been seen with the use of single applications or infrequent applications.

Professional fluoride varnishes contain a high level of fluoride around 22,600 part per million, and are applied only in dentists offices. varnishes are used to deliver fluoride to a specific site or surfaces within the mouth, and are typically applied every three or six months. The correct application of a fluoride varnish has been linked with a 38% reduction in dental caries. Varnishes are designed to harden on the tooth, forming a deposit of calcium fluoride that can act as a reservoir for the slow release of fluoride over time.

And professionals slow, slow release fluorides. Methods to deliver small amounts of fluoride throughout the day are still being developed. Currently, materials such as silicate and glass-ionomer cements that contain between 15 to 20% fluoride are being used, and this, and this amount of fluoride is also being added to composite and amalgam fillings. The concept is that these materials could provide a reservoir of fluoride to prevent secondary caries and to help remineralize caries in adjacent surfaces. Fluoride release begins high but reduces as the available fluoride... as available reservoir depletes. Glass-ionomer cements are unique in that they are also able to absorb fluoride from other sources, such as toothpaste, and also slow to release this into the oral cavity long after the fluoride that was originally placed in the glass-ionomer has dissipated. It should be noted however, the clinical data on these methods of slow release delivery have not yet been confirmed, to the extent that they're able to provide any therapeutic benefits. In conclusion, fluoride is an effective therapeutic and preventive agent for dental caries. The mineral alters the caries process by interfering with the dynamic of lesion development by enhancing remineralization, reducing demineralization and inhibiting bacteria. While there are many forms of fluoride delivery, the corporation of fluoride dentifrices has proven to be one of the most effective prevention and intervention strategies for dental caries.

It should be noted that although, although fluoride therapy is important for caries control, it does not always stop caries development and progression. The tried-and-true public health recommendations of proper oral hygiene, such as brushing teeth at least twice a day, flossing to clean them between teeth, and cutting back on dietary sugar intake continued to be very important in fighting caries. Here's one final video that provides an excellent perspectives by Dr. Margherita Fontana from the University of Michigan's School of Dentistry on how to determine which preventive agents to use.

I guess one of the things I feel very passionate about is that we have wonderful management strategies, and sometimes they're underutilized. We have so many new things and exciting things, and it's sometimes very confusing for the practitioner to know what do you incorporate and when. And I, I guess one of the messages I would like to come across is that sure, try incorporate new things, but do not do it at the expense of things that we know work very well, and we have long evidence to suggest that they work very well and two examples are fluoride and sealants. Every practitioner should be using fluoride and sealants based on best available evidence and their patient's risk and desires and needs to be able to manage disease process. Everything else that they want to try, it's fine. There's going to always be new products and new strategies out there with varying levels of evidence, depending on how new they are or how old they are, but let's not substitute the things that we know work until we're sure there's something else that works as well as that.

Let's conclude this section by discussing how this information can help you in your practice. First, fully understanding intervention and inf- information will help you clearly identify evidence based and scientifically supported interventions to reduce subsurface mineral loss and making decisions regarding your patients' at-home care and reduction of caries risk. Second, intervention information when communicated at the level of the patient can be a powerful tool in driving compliance and overall adherence to your at-home oral care recommendations. Describing how caries develop and making the connection to your specific recommendation instills a strong sense of trust and confidence in patients and can be far more powerful than simply instructing patients to brush more often. Thank you.