Hypersensitive Dentin Updates
A Peer-Reviewed Publication
Written by Catherine D. Saylor BSDH, MS and Pamela R. Overman BSDH, MS, EdD

Abstract
Dentinal hypersensitivity is characterized by a short, sharp pain in response to stimuli. Dentinal hypersensitivity, which is more commonly seen in adults in the 20-40 year old age group, has several etiological factors. Gingival recession and enamel loss both contribute to the prevalence of this condition, resulting in the exposure of dentin. Dentinal hypersensitivity is believed to occur due to the movement of fluid within the dentinal tubules occurring in response to thermal, chemical, tactile and evaporative stimuli, in accordance with Bränström’s Hydrodynamic Theory. Treatment options include in-office procedures and home use products that are aimed at occluding the dentinal tubules or preventing neural transmission, thereby blocking the pain response.

Educational Objectives: Upon completion of this educational activity the participant will be able to:
1. List and describe the anatomical features of dentin that predispose it to dentinal hypersensitivity.
2. List and describe the etiological factors in dentinal hypersensitivity.
3. List and describe the prevalence and most common sites for dentinal hypersensitivity.
4. List and describe the home and in-office options for the treatment of dentinal hypersensitivity.

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Abstract
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Introduction
Dentinal hypersensitivity can be a challenging condition for patients to describe and dental professionals to accurately diagnose. It consists of short, sharp pain that occurs when a stimulus reaches exposed dentin. This stimulus is most commonly thermal, either hot or cold, but can also be tactile, chemical, or evaporative. Typically, no other pathology can be found for the pain associated with dentinal hypersensitivity.1,2,3,4 Patients may or may not report this painful and often chronic condition to their dentist or dental hygienist and when they do, they report experiencing short, sharp pain after a variety of stimuli.4,5 A definitive diagnosis of dentinal hypersensitivity can be challenging and practitioners must rule out other problems, such as caries, fractured or cracked teeth, defective restorations, occlusal trauma, or gingival conditions that could be the underlying cause of the dental pain a patient experiences.4,7

Dentin consists of an organic component containing collagen fibers in a matrix of collagenous proteins and an inorganic component containing hydroxyapatite crystals. Dentinal tubules run from the pulp to the outer dentinal surface and are easily identifiable on scanning electron microscopic images of cross-sections of dentin as either open or plugged dentinal tubules. The number of tubules varies and can be as many as 30,000 in a square millimeter of dentin. The dentinal tubules contain Tomes’ fibers, first described by Sir John Tomes in 1850, that extend into the dentinal tubules from the odontoblasts that communicate with the pulp.8,9 Three types of nerve fibers (A-delta fibers, A-beta fibers, and C-fibers) are found within the dentin. Hypersensitive dentin typically consists of large, numerous dentinal tubules open to the oral cavity and a thin, poorly calcified (or absent) smear layer. This smear layer is composed of a deposit of salivary proteins, debris from dentifrices and other calcified matter that helps protect the cementum and dentin.4 In normal dentin the smear layer covers the openings of the dentinal tubules and reduces the risk that a stimulus for hypersensitivity reaches the dentinal tubules.4

![Figure 1. SEM showing open dentinal tubules](image1)

Courtesy of Dr. Charles Cobb

![Figure 2. Brännström's Hydrodynamic Theory](image2)

Note the outward flow of fluid in response to stimuli, represented by the black arrows.
The mechanism by which the pain associated with dentinal hypersensitivity is currently believed to occur is described by Brännström’s Hydrodynamic Theory. This theory states that stimuli (thermal, chemical, tactile or evaporative) are transmitted to the pulp surface due to movement of fluid or semi-fluid within open dentinal tubules. Anatomically, the areas of the tubules closer to the pulp chamber are wider and the fluid movement away from the pulp activates the nerves associated with the odontoblasts at the end of the tubule; resulting in a pain response. The fluid movement stimulates the small, myelinated A-delta fibers, which then transmit to the brain and result in the sensation of well-localized, sharp pain that is associated with dentinal hypersensitivity.

Etiology of dentinal hypersensitivity

Gingival recession and enamel loss

Gingival recession and enamel loss have multiple causes that result in cementum and/or dentin exposure. Exposed cementum due to gingival recession tends to be thin, can easily be abraded or eroded and may contribute to sensitivity. Gingival recession is more common as patients age. Some common causes of gingival recession include the anatomy of the labial plate of the alveolar bone, toothbrush abrasion, periodontal disease and surgery, poor oral hygiene, acute or chronic trauma, frenum attachment, and occlusal trauma.

With respect to the anatomy of the labial plate, the alveolar bone may be thin, fenestrated, or even absent and is a large factor in causing recession. Tooth anatomy and tooth position may also affect the thickness of this labial plate of alveolar bone. Poor oral hygiene is another contributing factor for gingival recession. Plaque-induced gingivitis may progress to recession and attachment loss if inadequate plaque control continues. Toothbrushing techniques causing gingival trauma are also a significant factor for gingival recession. The frequency, duration and force of brushing all contribute to recession. Excessive force and improper technique may lead to gingival irritation that over time can also lead to recession. Paradoxically, patients with better home care have shown more gingival recession than those with poor home care due to the physical act of removing the smear layer.

Occlusal trauma and improper frenal attachments are two other factors that may contribute to recession and hypersensitivity. A frenal pull that results in the tissue moving more towards the cemento-enamel junction (CEJ) may result in recession. Occlusal trauma appears to be a risk factor for attachment loss in individuals with active periodontal disease since the occlusal forces may lead to further recession of the periodontally involved apparatus. Other less common causes of gingival recession include inadequate attached gingiva, periodontal surgery, aggressive scaling and root planing, excessive tooth cleaning and flossing, loss of gingival attachment due to specific pathologies, and loss of attachment during restorative procedures. These potential etiologies may lead to exposed root surfaces which are predisposed to dentinal hypersensitivity.
Loss of enamel results in exposed dentin and therefore is associated with dentinal hypersensitivity. Attrition, abrasion, erosion, and abfraction are conditions that affect enamel. Abrasion can be caused by a number of factors related to tooth brushing; the stiffness and configuration of the toothbrush bristles in combination with force, the brushing method and frequency, the abrasiveness of toothpaste, and the duration of brushing all contribute to loss of tooth structure. Once enamel is lost and/or recession is present, the exposed cementum and/or dentin are abraded, worn and eroded more quickly than enamel due to their lower inorganic mineral content. Dentin abrades 25 times faster than enamel and cementum abrades 35 times faster.4

Exposed cementum and/or dentin are readily abraded, compared to enamel. Dentin abrades 25 times faster than enamel and cementum abrades 35 times faster.
Table 2. Risk factors for enamel loss

| Abrasion  | Attrition | Erosion | Abfraction |

Erosion is one of the most common causes of enamel loss and is irreversible. It is also one of the more common chronic conditions in children and adolescents, and is common in adults of all ages. Only recently has this condition been recognized as a dental health problem.\textsuperscript{16,17,18} Erosion can be of intrinsic or extrinsic origin. Gastric acid regurgitation associated with medical conditions such as acid reflux disease and disorders such as bulimia results in intrinsic erosion. By far the most common causes of extrinsic erosion are dietary factors that contribute to a more acidic oral environment. Frequent consumption of carbonated, acidic drinks, fruit drinks and fruit are the primary causes. In general, the dissolution of enamel occurs at a pH below 5.0–5.7.\textsuperscript{19,20} Highly acidic foods and drinks remove enamel over time exposing the dentin. They also have the ability to remove smear layers and open the exposed dentinal tubules causing sensitivity and pain.\textsuperscript{20}

Table 3. Common risk factors for erosion

| Acid reflux disease | Bulimia | Frequent consumption of acidic drinks | Frequent consumption of acidic foods |

Erosion is a more important factor than abrasion in removing the smear layer or dentinal plugs thereby causing dentinal hypersensitivity.\textsuperscript{21} In addition, once erosion has occurred, patients are then more susceptible to subsequent abrasion, further exacerbating the loss of tooth structure and risk of dentinal hypersensitivity. Attrition can also be accelerated by the presence of softened tooth surfaces following erosion.

Prevalence of dentinal hypersensitivity

Dentinal hypersensitivity presents as early as the teen years and through old age. Higher incidences of this condition occur in the 20 to 40 year old age group, corresponding with the age at which gingival recession is often seen.\textsuperscript{22,23} There is a wide range in the reported prevalence of dentinal hypersensitivity, ranging from 4-98%, depending on the population group. Hypersensitivity occurs most commonly in periodontal patients with a reported frequency of 60-98% and 57% of the general population experiences hypersensitivity.\textsuperscript{20,24,25} The higher prevalence for this group of individuals may be attributed to root surface exposure from the periodontal disease process and treatment. Between 9% and 23% of patients have reported root sensitivity before root planing, while after root planing approximately 55% of patients have reported experiencing dental hypersensitivity. This increase in sensitivity occurred for a one-to-three week period after the procedure and then gradually decreased over time.\textsuperscript{15,23} Over and above the removal of the superficial smear layer during scaling and root planing that can result in sensitivity, aggressive scaling and root planing can remove layers of protective cementum and dentin, causing sensitivity.\textsuperscript{26,27} When cementum or dentin is exposed these areas are more susceptible to caries, erosion, abrasion, and abfraction.\textsuperscript{28,29,30} Women are more prone to hypersensitivity, potentially due to a higher frequency of dental visits and more extensive oral hygiene than men.\textsuperscript{6,31}

In the general population prevalences for dentinal hypersensitivity of up to 57% have been reported, and more individuals report hypersensitivity after scaling and root planing than prior to scaling and root planing.

Hypersensitivity tends to be most prevalent on the bucal and cervical areas of the teeth.\textsuperscript{5,32,33} The most common sites are the cervical margins of the bucal and labial surfaces of teeth, with these sites accounting for 90% of sensitive surfaces.\textsuperscript{34} These areas of the teeth are a common site for recession and the enamel is also thinner in these areas. Canines and first premolars, followed by incisors, second premolars and molars are commonly affected by recession. Lastly, patients with moderate to severe sensitivity tend to have gingival recession predominantly on one side of their mouth compared to the contralateral side.\textsuperscript{4}

Ninety percent of sensitive surfaces are found at the cervical margins of the bucal and labial surfaces of teeth.

Diagnosis

A diagnosis of dentinal hypersensitivity can be a challenge for dental professionals since patients may not report it and it may not be obvious. A majority of patients do not deem it
to be a severe oral health condition and may not seek treatment or even report this condition to their practitioner. Conversely, patients with exposed dentin may or may not experience sensitivity. Exposed dentin may also be present but inconspicuous. One study used scanning electron microscopy of dental impressions to study the micromorphology of the bucco-cervical area of bicuspid teeth in dentally healthy young adults. Half the sites with gingival recession observed on the SEM were not evident clinically. The SEMs also showed areas of gingival inflammation with root exposure and an absence of cementum without clinical evidence of abrasion.

Patients with exposed dentin may or may not experience sensitivity.

Routine screening for this condition does not readily occur and many other oral conditions may present with similar symptoms. Definitively excluding these oral conditions first will then lead to the diagnosis of dentinal hypersensitivity. Fractured teeth, dental caries, pulpal pathologies, or leaking, fractured or failing restorations are conditions that present with similar signs and symptoms but require different treatment. Through the use of radiographs, conversations with the patient, and a thorough clinical exam, the dental practitioner must first exclude these conditions and then establish a diagnosis of hypersensitivity. Clinical signs and symptoms include sensitivity or pain when a stimulus is applied (such as hot/cold/sweet/sour/touch), exposed dentin at the site of sensitivity, and in the absence of dental caries, fracture lines, or failing restorations. The diagnosis is one of exclusion.

Patients may exhibit a variety of behaviors when receiving dental care if they have experienced hypersensitivity over the years. They may have anxiety with a routine dental cleaning, and can be so anxious about pain that they avoid examinations and routine dental care in general. Dental professionals may need to provide patients with desensitizers during treatment and post-operatively. Local anesthesia may be required for routine prophylaxis.

**Management and Treatment**

Educating the patient on the causes and management of dentinal hypersensitivity is a primary goal for dental professionals when creating a treatment plan for this condition. The first step is to identify the cause of the dentinal hypersensitivity. As listed above, there are multiple etiologies and once the main cause has been identified, education is the next step. This may entail behavior modifications, such as instructions on toothbrushing technique, using the correct type of bristled toothbrush (avoid using medium or hard toothbrushes) and avoid using too much toothpaste or repeated applications of toothpaste in the middle of brushing. Education on the appropriate way to brush, floss and use other interdental devices is necessary to avoid further loss of tooth structure and dentinal hypersensitivity. Other suggestions for behavior modifications focus on dietary choices; avoiding carbonated beverages, acidic foods and drinks to reduce the risk of erosion, and avoiding hot/cold beverages and food.

**Patients should also be educated on when to brush i.e., to avoid brushing immediately after ingesting acidic foods and drinks (or immediately after exposure to gastric acid); instead it is better to rinse with water and wait at least two to three hours before brushing. Patients may also need education on the effect of tooth whitening on the occurrence and severity of dentinal hypersensitivity. Tooth whitening can contribute to dentinal hypersensitivity, by opening up the dentinal tubules during tooth whitening treatments. Patients who have sensitive teeth should have the sensitivity addressed prior to tooth whitening and should also be given specific instructions regarding tooth whitening and the management of associated hypersensitivity.**

**Table 5. Patient education**

<table>
<thead>
<tr>
<th>Causes of dentinal hypersensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructions on toothbrushing technique and when to brush</td>
</tr>
<tr>
<td>Advice on toothbrush type - avoid medium and hard bristles</td>
</tr>
<tr>
<td>Advice on appropriate use of toothpaste</td>
</tr>
<tr>
<td>Advice on technique for interdental cleaning</td>
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<tr>
<td>Dietary advice</td>
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<tr>
<td>Hypersensitivity associated with tooth whitening</td>
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**Patients should be educated to avoid brushing immediately after ingesting acidic foods and drinks.**
Treatment Options

Treatment options for hypersensitivity include self-applied, at home desensitizing agents and professional in-office desensitizing procedures. These treatment options can be categorized into two groups by their mode of action. Agents used to occlude the dentinal tubules include oxalate compounds, strontium chloride, hydroxethyl methacrylate (HEMA), and fluorides. Precipitates other than fluoride compounds that have been used to treat sensitivity include calcium phosphate compounds, calcium hydroxide, amorphous calcium phosphate, casein phosphopeptide amorphous calcium phosphate (CPP-ACP) and calcium sodium phosphosilicate. Recent approaches have focused on remineralizing tooth structure by increasing salivary calcium and phosphate levels as well as increasing the salivary pH, stimulating the formation of calcium phosphate or hydroxyapatite. Calcium phosphate compounds occlude the tubules by forming a calcium phosphate precipitate, while calcium hydroxide occludes the tubules and promotes peritubular dentin formation.

Figure 9. Tubule occlusion

Note the occlusion of the dentinal tubules, preventing the outward flow of fluid and subsequent stimulation of nerve fibers.

Products that interfere with the transmission of the nerve impulse work by raising the extracellular potassium ion concentrations and affecting polarization. When this is sustained for a period of time, nerve excitation is reduced and the nerve becomes less sensitive to the stimuli. Potassium nitrate is the most common agent used for this method.

Figure 10. Blocking neural transmission

Note the outward flow of fluid is still present in response to a stimulus; however, neural transmission in response to this is prevented by the presence of extracellular potassium.

In-office treatments for tubule occlusion

Treatments provided professionally include varnishes and precipitates, primers containing glutaraldehyde and hydroxyethylmethacrylate (HEMA), and polymerizing agents. In severe cases where there is a loss of cervical tooth structure, restorations such as composite resin-based materials or restorations with glass ionomer may be used and have been reported to effectively reduce dentinal hypersensitivity. There are several paint on products that work by occluding and sealing the dentinal tubules. Glutaraldehyde/HEMA-based agents have been found to significantly relieve hypersensitivity immediately after treatment and at six months, and to reduce dentin permeability. Oxalate based treatment is also effective and found to reduce dentin permeability. A third option, 5% sodium fluoride varnish, is applied topically to occlude the dentinal tubules. Initially this forms a barrier over the exposed dentin, and once the varnish has been removed relief from hypersensitivity is obtained by calcium fluoride deposits that occlude the dentinal tubules. This is effective for up to 6 months. Laser therapy is now also used for the treatment of dentinal hypersensitivity. Severe cases may require the use of resin or glass ionomer restorations for deeper abrasive lesions. Grafting may be necessary to treat some cases of gingival recession. The World Health Organization recommends that mild dentinal hypersensitivity be managed by less complex treatments i.e., use of at home desensitizers, and that in-office treatment (and follow-up home care) be provided for more severe, recal-
citrant cases and for patients who have ongoing moderate dentinal hypersensitivity.20

Periodontal patients without sensitivity prior to treatment may experience hypersensitivity following treatment due to scaling and root planing or other periodontal procedures resulting in exposure of open dentinal tubules.15,26 Prophylaxis can also result in hypersensitive dentin. In these situations, it is ideal if the patient can receive in-office treatment prior to leaving the office. In addition, the patient may have only very localized hypersensitivity that can be easily treated in-office.

An in-office product used prior to or after scaling and root planing contains the amino acid, arginine, a bicarbonate pH buffer and a calcium source in the form of calcium carbonate. The product is applied with a low speed handpiece, burnishing the paste into the teeth to occlude the dentinal tubules. Using this product either before or after dental procedures has been found to provide immediate and lasting relief. Specifically, when this product is applied immediately after scaling, the relief of hypersensitivity may last for up to four weeks when used as the final polishing step during a professional cleaning.39,16,57 It should be noted that this paste is not a prophylaxis paste and is not intended for the removal of stain.

A prophylaxis paste containing bioactive glass is available that is indicated for immediate desensitization. It is used to desensitize exposed dentin during prophylaxis or to prevent hypersensitivity associated with prophylaxis and the removal of the smear layer, or post-procedurally following scaling and root planing. This bioactive glass contains calcium sodium phosphosilicate, marketed under the name NovaMin®, and has been investigated for hypersensitivity relief.38,59 Calcium sodium phosphosilicate (CSPS) is an inorganic, amorphous melt-derived glass compound that contains only calcium, sodium, phosphate, and silica. This ingredient has been incorporated into oral healthcare products for the alleviation of dental hypersensitivity for nearly 10 years and can be found in a range of products including dentifrices and prophylaxis paste.60,61 In recent studies, NovaMin® has been shown to rapidly release calcium, sodium, and phosphorous ions which form hydroxyapatate apatite (HCA) that is similar in composition to the minerals found in teeth and bones. These particles have the ability to adhere to the dentin surface and continue releasing calcium and phosphate ions once they are deposited onto the tooth surface.62

The crystalline hydroxyapatite apatite that is precipitated relieves hypersensitivity through occlusion of the dentinal tubules63 and is also resistant to acid challenges. A 2012 study64 evaluated the ability of NovaMin® to reduce dentin hypersensitivity immediately after a single application following scaling and root planing and 28 days post-application. In this study, 2 NovaMin® containing prophylatic pastes were used, one containing fluoride, one without fluoride. The control prophylactic paste contained neither NovaMin® nor fluoride. Following scaling and root planing both NovaMin® containing prophylactic pastes resulted in significantly better dentinal hypersensitivity reduction compared to the control immediately and 28 days post-application. Furthermore, there was no statistical difference between the NovaMin® containing pastes with and without fluoride, demonstrating that fluoride was not the primary agent responsible for the reduction in hypersensitivity. Prophylactic paste with NovaMin® is indicated for polishing procedures before and after scaling and root planing. Given that prophylaxis is typically the last step in a scaling and root planing procedure, and a routine treatment at recall, incorporating the desensitizing agent into the prophylaxis paste saves an extra step and makes relief of hypersensitivity a simultaneous event, while still ensuring that stain is removed.

Home use treatments
Mild, generalized dentinal hypersensitivity can usually be managed well with at home treatment.65 Home use treatments for dentinal hypersensitivity fall into the two categories defined by their mechanism of action. At home treatments for sensitivity relief are cost effective, safe, noninvasive and simple to use. These at home treatments come in a variety of applications including dentifrices, gels, or rinses and are incorporated into the daily oral home care regimen.

Home use treatments interfering with neural transmission
The most popular agent in over the counter dentifrices that affects neural transmission is 5% potassium nitrate, the concentration recognized by the FDA for this ingredient. Potassium ions work by penetrating the length of the dentinal tubule and block the repolarization of the myelinated A-fibers. This increase in extracellular potassium allows for a sufficient concentration to depolarize the nerve fibers and does not allow repolarization to occur. As a result, neural transmission will not occur following exposure to the stimuluses and the patient will have no sensation of sensitivity or pain.4,66,67,68 For these dentifrices to work, frequent and regular application is needed. These dentifrices have demonstrated a significant reduction in hypersensitivity within a two week time frame when used twice daily to maintain a high level of extracellular potassium.4,69 There are a number of dentifrices containing 5% potassium nitrate. All of these products contain fluoride ions as well for protection against caries (Sensodyne®, Crest Sensitivity®, Colgate Sensitive Maximum Strength®, BioTene Sensitive Toothpaste with Dry Mouth Protection®). Potassium nitrate has also been used in whitening trays to relieve hypersensitivity between whitening treatments.70

Home use treatments for tubule occlusion
Home use over the counter desensitizing agents that occlude the dentinal tubules are found in toothpastes, gels, and mouthrinses. One of the primary active ingredients used in this manner is fluoride. Stannous fluoride (0.4%) in particular has a long history of use for relief of dentinal hypersensitivity,71 and is found in dentifrices (Crest Pro-Health®) and gels, as well
as at other concentrations in mouthrinses. When fluoride is applied to exposed dentin, precipitates form which block the dentinal tubules. Long term relief requires continued use of the product. Stannous fluoride dentifrices have been shown to relieve dentinal hypersensitivity in clinical trials. It has been reported that other fluoride dentifrices effectively relieve dentinal hypersensitivity by occluding the dentinal tubules, including prescription level 5,000 ppm sodium fluoride dentifrice. Calcium and phosphate precipitates formed following use of dentifrices containing calcium and phosphate technologies have also been found to relieve hypersensitivity, including CPP-ACP, ACP and calcium sodium phosphosilicate. Studies have been conducted on dentifrice formulations containing 5% and 7.5% calcium sodium phosphosilicate. The research has indicated that using calcium sodium phosphosilicate delivered by brushing twice daily with a dentifrice has a beneficial effect, reducing the sensitivity caused by exposed cervical dentin surfaces. Both concentrations of calcium sodium phosphosilicate (5% and 7.5%) demonstrated effective relief f and the 7.5% concentration was even more favorable for relief compared to the 5% concentration. One study found 7.5% calcium sodium phosphosilicate, 5% potassium nitrate and 0.4% stannous fluoride dentifrices all to be effective for relief of hypersensitivity. An in vitro study found that both casein phosphopeptide amorphous calcium phosphate and calcium sodium phosphosilicate occluded dentinal tubules and resisted acid challenges.

Additional considerations
Exposed dentin is more susceptible to root caries than enamel, and many patients with exposed dentin are also at a higher risk for caries beyond the risk posed by exposed dentin.

It is therefore desirable if the active agent for hypersensitivity relief also helps prevent caries. Thus, in-office treatments incorporating high concentrations of fluoride in fluoride varnish can help prevent caries and are recommended by the American Dental Association for patients at risk for caries. Home use of CPP-ACP-containing dentifrice has been found to help inhibit demineralization and to promote remineralization. Home use dentifrices containing fluoride are effective anti-caries agents. Their use for sensitivity relief either through the action of fluoride occluding the dentinal tubules or in combination with 5% potassium nitrate provides both sensitivity relief and protection against coronal and root caries. Prescription level 5,000 ppm sodium fluoride dentifrices provide extra protection against dental caries and have been found to reduce root caries. These higher fluoride level dentifrices are used for patients at higher risk for caries. Recently, a prescription level 5,000 ppm sodium fluoride dentifrice that also contains calcium sodium phosphosilicate has been introduced to offer a remineralizing effect with a high level of protection against acid challenges. This is indicated for caries prevention.

Figure 11. Patient with hypersensitive dentin and root caries

Courtesy of Dr. Keerthana Satheesh

Conclusion
Dentinal hypersensitivity can be a challenging condition for dental practitioners to diagnose and treat effectively. With the advancement in dental products, options for providing relief from pain and sensitivity are great and vary according to the severity of the condition. Dental practitioners should be more aware and proactively ask patients about sensitivity. With practitioners being more proactive with this condition, patients may not need to experience the pain associated with hypersensitivity and receive treatment that can provide relief from pain.

References


Author Profiles

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1. Dentinal hypersensitivity:
   a. Consists of short, sharp pain in response to a stimulus
   b. May or may not be reported
   c. Occurs when a stimulus reaches exposed dentin
   d. All of the above

2. Dentin contains:
   a. Collagen fibers
   b. An inorganic component
   c. Hydroxyapatite crystals
   d. All of the above

3. Which of the following is the correct number of tubules there may be in a square millimeter of dentin?
   a. 10,000
   b. 20,000
   c. 30,000
   d. 40,000

4. Which of the following communicate with the pulp?
   a. Odontoblasts
   b. Tomes’ fibers
   c. Dentine tubules
   d. None of the above

5. Which of the following is a characteristic of hypsersensitive dentin?
   a. Dentine tubules open to the oral cavity
   b. Large and numerous dentinal tubules
   c. A thin, poorly calcified (or absent) smear layer
   d. All of the above

6. The smear layer:
   a. Helps protect the cementum and dentin
   b. Covers the openings of the dentinal tubules
   c. Reduces the risk that a stimulus for hypersensitivity reaches the dentinal tubules
   d. All of the above

7. The A-delta fibers:
   a. Are stimulated by fluid movement in the dentinal tubules
   b. Transmit to the brain
   c. Are myelinated
   d. All of the above

8. Which of the following is a common cause of gingival recession?
   a. Occlusal trauma
   b. Frenum attachment
   c. Periodontal disease
   d. All of the above

9. Gingival recession can be the result of the alveolar bone being:
   a. Fenestrated
   b. Thin
   c. Absent
   d. All of the above

10. Which of the following is a less common cause of gingival recession?
    a. Aggressive scaling and root planing
    b. Inadequate attached gingiva
    c. Iatrogenic loss during restorative procedures
    d. All of the above

11. Which of the following is one of the conditions that can result in enamel loss?
    a. Abrasion
    b. Attrition
    c. Erosion
    d. All of the above

12. Which of the following is correct regarding the rate of dentin and cementum abrasion respectively compared to enamel?
    a. 35 times; 25 times
    b. 25 times; 45 times
    c. 25 times; 35 times
    d. None of the above

13. Which of the following can result in erosion of intrinsic origin?
    a. Acid reflux disease
    b. Swimming
    c. Bulimia
    d. a and c

14. Enamel demineralization occurs below a pH of:
    a. 3.0–3.7
    b. 4.0–4.7
    c. 5.0–5.7
    d. 6.0–6.7

15. Higher incidence of dentinal hypersensitivity occurs in which of the following age groups?
    a. 20- to 40-year-old
    b. 30- to 40-year-old
    c. 10- to 20-year-old
    d. 40- to 60-year-old

16. Which of the following is correct regarding the prevalence of dentinal hypersensitivity cited in publications?
    a. Up to 78%
    b. Up to 88%
    c. Up to 98%
    d. None of the above

17. Which of the following is correct regarding the number of patient reports of dentinal hypersensitivity after scaling and root planing compared to before?
    a. Fewer
    b. The same number of
    c. More
    d. None of the above

18. Which of the following is correct regarding the most common sites for dentinal hypersensitivity on the buccal and labial surfaces of teeth?
    a. Incisal margins
    b. Cervical margins
    c. Mid-facial
    d. a and b

19. Which of the following can present with signs and symptoms similar to those of dentinal hypersensitivity?
    a. Fractured teeth or restorations
    b. Pulpal pathologies
    c. Leaking or failing restorations
    d. All of the above

20. Patients who have dentinal hypersensitivity may:
    a. Have anxiety with a routine dental cleaning
    b. Be so anxious about pain that they avoid examinations and routine dental care in general
    c. Request local anesthesia even for routine prophylaxis
    d. All of the above

21. Which of the following is a primary goal for dental professionals?
    a. Educating the patient on the causes of dentinal hypersensitivity
    b. Educating the patient on the management of dentinal hypersensitivity
    c. Covering exposed dentin
    d. a and b

22. Behavior modification can include:
    a. Using proper oral hygiene techniques
    b. Making sound dietary choices
    c. Avoiding brushing after intake of acidic foods and drinks
    d. All of the above

23. Strontium chloride:
    a. Prevents neural transmission of a stimulus
    b. Occludes the dentinal tubules
    c. Is part of the normal smear layer
    d. a and c

24. Which of the following has been used to treat dentinal hypersensitivity?
    a. Fluoride
    b. Amorphous calcium phosphate
    c. Calcium sodium phosphosilicate
    d. All of the above

25. Calcium hydroxide:
    a. Occludes the tubules
    b. Precipitates calcium phosphate
    c. Promotes peritubular dentin formation
    d. a and c

26. Products that interfere with the transmission of the nerve impulse work by raising:
    a. Extracellular sodium ion concentrations
    b. Intracellular sodium ion concentrations
    c. Intracellular potassium ion concentrations
    d. Extracellular potassium ion concentrations

27. Glutaraldehyde/HEMA-based agents have been found to:
    a. Significantly relieve hypersensitivity immediately after treatment
    b. Significantly relieve hypersensitivity after six months
    c. Reduce dentin permeability
    d. All of the above
28. Restorations such as composite resins are used for which type of dentinal hypersensitivity cases?
   a. Mild cases
   b. All cases
   c. Severe cases
   d. None of the above

29. 5% sodium fluoride varnish:
   a. Initially forms a barrier over exposed dentin
   b. Occludes the dentinal tubules with calcium fluoride deposits
   c. Is effective in treating dentinal hypersensitivity
   d. All of the above

30. Based on a hierarchical model from the World Health Organization, it has been recommended that mild and responsive dentinal hypersensitivity be managed by:
   a. Less complex treatments
   b. More complex treatments
   c. In-office treatments only
   d. None of the above

31. The discomfort associated with dentinal hypersensitivity can:
   a. Increase the patient’s ability to tolerate treatment
   b. Reduce the patient’s ability to tolerate treatment
   c. Increase patient compliance
   d. Any of the above

32. Which of the following can result in dentinal hypersensitivity?
   a. Scaling and root planing
   b. Prophylaxis
   c. Radiographs
   d. a and b

33. Which of the following is correct regarding when to use of Pro-Argin® technology for immediate relief of hypersensitivity?
   a. Prior to
   b. Instead of
   c. After
   d. a and c

34. Which of the following is correct regarding the length of time Pro-Argin® technology may provide relief when used during a hygiene appointment?
   a. One week
   b. Two weeks
   c. Three weeks
   d. Four weeks

35. Calcium sodium phosphosilicate:
   a. Is an inorganic, amorphous melt-derived glass compound
   b. Contains only calcium, sodium, phosphate and silica
   c. Has been used to treat dentinal hypersensitivity and incorporated into oral products for nearly 10 years
   d. All of the above

36. NovaMin®:
   a. Is the brand name for calcium sodium phosphosilicate
   b. Is contained in prophylaxis paste
   c. Is contained in several professional products
   d. All of the above

37. Incorporating the desensitizing agent into prophylaxis paste:
   a. Saves an extra step
   b. Makes relief of hypersensitivity a simultaneous event with prophylaxis
   c. Still allows stain to be removed
   d. All of the above

38. Crystalline hydroxyl-carbonate apatite:
   a. Is precipitated when using calcium sodium phosphosilicate containing products
   b. Occludes the dentinal tubules
   c. Is resistant to acid challenges
   d. All of the above

39. At-home treatments for sensitivity relief are:
   a. Simple to use
   b. Noninvasive and safe
   c. Cost-effective
   d. All of the above

40. At-home treatments for dentinal hypersensitivity are available as:
   a. Dentifrices
   b. Gels
   c. Rinses
   d. All of the above

41. The most popular ingredient in over-the-counter dentifrices that affect neural transmission is:
   a. 5% potassium nitrate
   b. 3% potassium nitrate
   c. 5% potassium chloride
   d. a or b

42. Potassium ions work by blocking which of the following actions of myelinated A-fibers?
   a. Depolarization
   b. Hyperpolarization
   c. Repolarization
   d. All of the above

43. Stannous fluoride:
   a. Has a long history of use for relief of dentinal hypersensitivity
   b. Is found in dentifrices, gels and mouth rinses
   c. Has been shown in clinical trials to relieve dentinal hypersensitivity
   d. All of the above

44. Which of the following dentifrices have been found to be effective for relief of hypersensitivity?
   a. 5% potassium nitrate
   b. 7.5% sodium calcium phosphosilicate
   c. 0.4% stannous fluoride
   d. All of the above

45. An in vitro study found that both CPP-ACP and sodium calcium phosphosilicate:
   a. Occluded dentinal tubules
   b. Resisted acid challenges
   c. Prevented neural transmission
   d. a and b

46. Exposed dentin is susceptible to which of the following levels of root caries, compared to enamel?
   a. Less
   b. More
   c. Equally
   d. None of the above

47. Prescription-level 5,000 ppm sodium fluoride dentifrice incorporating a desensitizing agent:
   a. Relieves dentinal hypersensitivity
   b. Protects against acid challenges
   c. Can be recommended for patients at high-risk for caries
   d. All of the above

48. Dentinal hypersensitivity can be a challenging condition for dental practitioners to:
   a. Effectively diagnose
   b. Have
   c. Effectively treat
   d. a and c

49. Which of the following is true regarding the patient reporting of dentinal hypersensitivity?
   a. Always
   b. Sometimes
   c. Never
   d. Accurately

50. With practitioners being more proactive with dentinal hypersensitivity:
   a. Patients can receive treatment
   b. Patients may not need to experience the pain associated with this condition
   c. Treatments will be wasted
   d. a and b
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Educational Objectives
1. List and describe the anatomical features of dentin that predispose it to dentinal hypersensitivity.
2. List and describe the etiological factors in dentinal hypersensitivity.
3. List and describe the prevalence and most common sites for dentinal hypersensitivity.
4. List and describe the home treatment options and in-office options for the treatment of dentinal hypersensitivity.

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

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