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Contemporary Approaches to Managing Dental Hypersensitivity: An Innovative Approaches for Treatment and Future Directions

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Abstracts

DH is a very common condition presenting as a short, sharp pain arising from exposed dentin that results from external stimuli in the form of thermal, tactile, or chemical triggers. It has a wide range of people affected, predominantly in the age group between 20 and 40 years and is challenging in terms of diagnosis and management. The condition not only compromises the oral health but also profoundly decreases the quality of life, often along with avoidance behaviors and anxieties towards dental care. This paper is going to discuss etiology, clinical presentation, and modern management strategies for DH. Common causes include enamel erosion, gingival recession, and dentin abrasion, all of which expose dentinal tubules and activate nociceptive pathways. Most patients are treated with traditional methods such as fluoride varnishes, potassium nitrate, and dentin bonding agents. However, they provide only temporary relief. Laser treatments and bioactive materials, such as bioactive glasses and calcium phosphates, have emerged as new approaches and have promising results in occluding the dentinal tubules and promoting remineralization. The review also focuses on the psychological impact of DH, by looking at the interrelation between pain perception, anxiety, and oral hygiene practices. The most common vicious cycle among the patients with DH is how fear of pain leads to poor oral hygiene, therefore worsening the dental problems. New approaches, such as probiotics and photobiomodulation, are emerging in efforts to complement the existing therapies to modulate the oral microbiome and enhance healing. Despite such advances, long-term relief and individual variability in the treatment efficacy must be further achieved. It focuses on the personalization of treatment plans according to specific etiology and lifestyle factors for each patient. Future studies should be able to confirm the long-term effectiveness of these novel therapies and how they may be incorporated into the routine care practices. Its multifactorial nature is addressed via improvement in patient outcomes, as well as the dental provider's overall well-being.

Keywords: Dental hypersensitivity, Dentin exposure, Desensitizing agents, Bioactive materials, Laser therapy, Oral health, Quality of life.

1. Introduction

DH is defined as a transient, sharp pain due to exposed dentin that occurs in response to stimuli such as thermal, evaporative, tactile, osmotic, or chemical factors and cannot be associated with any other dental defect or pathology (Behera, 2021; Porto et al., 2009). The basic pathogenesis of this condition is the stimulation of nerve endings in the dentin through fluid flow within the dentinal tubules. This fluid movement is facilitated by many factors, among them the physiological pulpal pressure that activates the nociceptive pathways (Oh et al., 2015; Liu et al., 2015). Wide ranges, from 4% to 69%, are reported for the incidence of dental hypersensitivity. Its peak is reported among those in the age range of 20 to 40 years (Bhowmik et al., 2021). The clinical significance of the condition is reflected in the way it affects the quality of life of patients and their perception to seek dental care. Patients suffering from DH often experience discomfort that may deter them from consuming certain foods or beverages, particularly those that are cold or acidic (Zeb et al., 2022; Rao et al., 2019). In addition, hypersensitivity will disrupt the dental procedures as its presence may lead to an unsuccessful attempt to administer pain for procedures, leading to further anxiety and fear in the patients (Jälevik et al., 2021). In pediatric dentistry, the condition may exacerbate molar-incisor hypomineralization sensitivity and, subsequently, the anxiety of the child patient (Vicioni-Marques et al., 2023).

This requires rather complicated diagnosis usually through the process of ruling out the existence of some other dental or periodontal conditions characterized by this kind of pain (Gernhardt, 2012). The diagnostic approach applied includes mechanical stimulation as well as osmotic and thermal stimulation for the determination of the presence of DH (Cunha-Cruz et al., 2010; Kopycka-Kedzierawski et al., 2017). With regards to DH, there exists a plethora of treatment choices ranging from desensitizing agents, diet, and even the use of dental lasers as advanced treatment (F et al., 2016). Interestingly, no one-size-fits-all gold standard seems to be there for this particular disease, which simply resonates with personalized treatments based on an individual's situation (Kopycka-Kedzierawski et al., 2017). DH might affect general oral health or overall well-being of an individual profoundly. This is characterized by sharp, short-duration pain to multiple stimuli, which can be thermal, tactile, or chemical in nature, thus causing significant annoyance and avoidance behaviors in the patients Liu et al. (2020). DH may therefore have a dramatic impact on the patient's ability to practice good oral hygiene because the fear of pain could lead to lowered brushing and flossing, therefore increasing the patient's chances of dental caries and periodontal disease (Tonguç et al., 2011). Therefore, the interaction between DH and oral hygiene practices leads to a vicious cycle that worsens oral health problems, which in turn cause secondary complications like tooth decay and gum disease (Xia et al., 2016).

Dental hypersensitivity also has an extreme psychological effect on patients who are anxious and stressed about dental care. People with DH tend to be more afraid of their teeth, which can prevent them from receiving the dental care they need (Vicioni-Marques et al., 2023). This will leave dental issues untreated and make the primary issue of hypersensitivity worse while possibly leading to other oral health problems (Zeb et al., 2022). The psychological burden of living with DH also affects social interactions because a person may feel embarrassed or self-conscious about his or her condition, leading to a diminished quality of life (Nguyen et al., 2019). It is not just the immediate physical discomfort that DH influences quality of life.

The studies show that patients with DH have a lower score for OHRQoL, meaning that the condition affects the general well-being and day-to-day functioning of these patients (Lawal & Oke, 2020). For instance, children with MIH who is also often associated with DH, have been reportedly to experience severe pain and impairment in their quality of life due to the dental condition's associated agony and discomfort (Jälevik et al., 2021). Of interest is the fact that there is also a significant association between the condition under discussion and diet. Patients tend to abstain from taking certain foodstuffs and beverages that can trigger hypersensitivity, for example, hot or cold food and drinks or acidic beverages that, over time, can lead to malnutrition (Zeb et al., 2022). This dietary restriction may negatively impact general health because the human body relies on nutrient-rich food and drinks for various body functions and oral hygiene preservation (Boa et al., 2019). Food avoidance associated with DH may also make the person isolate when eating, therefore a way that may adversely influence the interaction relationship and lower the quality of life (Nguyen et al., 2019).

2. Etiology of Dental Hypersensitivity

The primary cause of dental hypersensitivity (DH) is dentin exposure. A lot of conditions may compromise the enamel or cementum layer surrounding the roots of the teeth and result in such hypersensitivity. The most common factors include enamel erosion, gingival recession, and dentin abrasion exposing the sensitive dentinal tubules. The condition is normally brought about by dietary acids which bring about the demineralization of the enamel, hence exposing the dentin Izhar et al. (2019). The intake of acidic foods and beverages accelerates the process, which may lead to a considerable weakening of the enamel structure, thus exposing the dentin (Sumana et al., 2021). The fluid contained in the dentinal tubules can flow, thus transmitting pain through the hydrodynamic mechanism when the dentin is exposed to thermal, tactile, or chemical stimuli (Cunha-Cruz et al., 2010). According to the hydrodynamic theory, the movement of dentinal fluid within such tubules stimulates nerve endings in the pulp, resulting in the sensation of pain due to this response (Maillard et al., 2023; Cunha-Cruz et al., 2010).

Gingival recession also accounts for one of the major causes of DH. The gums continue to recede, exposing cementum which otherwise covers the root surface. This has the adverse effect of showing dentin (Amarasena et al., 2010). It can result from natural aging, aggressive brushing habits, or disease conditions characterized by the destruction of gingival tissues (Amarasena et al., 2010). Denin abrasion results from incorrect habits in brushing and from cleaning of teeth using abrasive products; then this abrasion exposes some denin portions that it gradually wears out until exposed tiny pieces of dentin, these regions are so sensitive since the open tubules serve as channels to help move fluid and transmit signals for the nerve to become stimulated (Kim et al., 2013; Aeran et al., 2022).

Other contributing factors to dentin exposure include bruxism or tooth grinding and the presence of restorations in the dental structures. For instance, microleakage around restorations allows fluids to penetrate between the restoration and the structure and cause sensitivity (Kim et al., 2013). Gum recession is a significant contributing factor to the development of dental hypersensitivity. It occurs when the gingival tissue recedes from the tooth, exposing the root surface, which is usually covered by cementum (Que et al., 2010) López et al., 2016). This exposes the unprotected dentin to environmental stimuli, such as temperature changes and mechanical forces from brushing, hence triggering pain responses (Gernhardt, 2012). These patients had a greater incidence of sensitive teeth, which, in many studies, was observed in the setting of dental attachments, demonstrating that an evident relationship is present with dentine exposure from the destruction of periodontal attachments and DH (Que et al., 2010). Further, the root surface exposed is prone to acidic beverages and foods that tend to soften the dentin and increases further destruction by mechanical scrubbing that is usually present (Que et al., 2010; Gernhardt, 2012).

Enamel loss also contributes considerably to the loss of sensitivity. Enamel can wear away for several reasons that include abrasion due to harsh brushing, erosion related to diet acidity, and natural attrition with age (Mafla & Lopez-Moncayo, 2016; Fagundes-De-Souza et al., 2019). Acid beverages like soft drinks and juice tend to attack enamel and dissolve it out, leaving the dentine beneath (Mafla & Lopez-Moncayo, 2016; Awad et al., 2020). The loss of enamel compromises the protective barrier for the deeper dentin and, meanwhile, increases the permeability of tooth structure, which could easily be permeable for stimuli such as reaching the nerve ends easily (Fagundes-De-Souza et al., 2019). The erosion often becomes worse because of unhealthy eating habits, especially if many foods are acidic in their nature and eaten regularly within the mouth, which eventually leads to some cumulative damage over time (Awad et al., 2020).

Acidity in diets is the biggest risk factor for dental hypersensitivity since it causes enamel erosion and exposure of the dentin. Foodstuffs or beverages that contain acidic products can make the pH value in the oral cavity reduce and thus facilitate the formation of the acid that enhances the demineralization of the enamel and the dentin (Mafla & Lopez-Moncayo, 2016; Naidu, 2014). It has been observed that those who are more frequent consumers of acidic soft drinks have a greater prevalence of dental erosion and, consequently, dentin hypersensitivity (Awad et al., 2020; Farag & Awooda, 2016). Dentin is softened along with enamel by the acid environment, which in turn increases the vulnerability of dentin to further disturbances by mechanical forces and thermal stimuli (Fagundes-De-Souza et al., 2019). This will greatly increase the risk of developing DH due to acidic diets and poor oral hygiene practices because the protective mechanisms of saliva are compromised, thus increasing the chances of losing enamel and dentin (Netto et al., 2012).

The main mechanism is the hydrodynamic theory, which suggests that pain in DH is due to the fluid flow in the dentinal tubules because of an array of stimuli, which may include temperature changes and mechanical pressure (Gernhardt, 2012; Xia et al., 2016). As long as dentin is covered by enamel, fluid inside the tubules will remain static in response to any external stimuli. However, in the event of enamel erosion or gum recession, fluid within the tubules will shift in response to the stimuli, stimulating nerve endings within the pulp (Liu et al., 2015; Haneet & Vandana, 2016). Fluid flow is believed to stimulate the nociceptive pathways that lead to the sharp pain DH is characterized by (Gernhardt, 2012; Liu et al., 2015).

More so, new studies mention the involvement of adenosine triphosphate as a mediator in pain response. The ATP released by stimulation of dentin activates the purinergic receptors, one of which is the P2X3 receptors on sensory nerve fibers (Liu et al., 2015). The activation of these receptors leads to a response of pain as they have been involved in the mediation of nociceptive signals. In dental pulp, the presence of ATP increases the sensitivity of nerve fibers and can sensitize them to stimulation better (Liu et al., 2015). Another important aspect in the DH pain perception is psychological influence, especially anxiety and fear. Many studies have found that dental anxiety patients had a high level of sensitiveness of pain and discomfort that occurs at the time of dental procedures (Sanikop et al., 2011; Taheri et al., 2023). The interaction hypothesis suggests that the perception of pain is modified by the emotional state and the danger level of the situation, thus enhancing the experience of pain (Sanikop et al., 2011). Moreover, the CNS is critical in the modulation of perception and pain. Changes in the expression of some proteins were correlated with chronic pain conditions in relation to DH and a change was observed at the trigeminal caudal nucleus in the expression of the pERK protein (Worsley et al., 2014). These changes cause central sensitization, where the nervous system becomes supersensitive to pain signals that result in an exaggerated response to pain (Worsley et al., 2014; Lee et al., 2017).

3. Clinical Presentation and Diagnosis

The hallmark symptom of dental hypersensitivity is a short, stabbing pain which develops upon stimulation of exposed dentin. These pains are evoked by a variety of stimuli, namely thermal (hot and cold food or beverages), tactile (brushing or probing), osmotic (from sweet or acid foods), and chemical stimuli (by some dental products) (Sumana et al., 2021; Bhowmik et al., 2021; Fambrini et al., 2022). It is usually described as a sudden, sharp pain that is usually associated with discomfort, leading people to avoid eating some foods or practicing regular oral hygiene (Fagundes-De-Souza et al., 2019). Many patients with dental hypersensitivity describe increased sensitivity to thermal stimuli. Cold stimuli are more often described as the cause, and research has shown that cold air and cold food and drinks are among the major factors contributing to the pain in the mouth in DH (Naidu, 2014; Bekes et al., 2021). This tends to lead to the avoidance of cold beverages or foods, limiting the choice of food intake for the patient and, hence, the nutrition intake (Bhowmik et al., 2021).

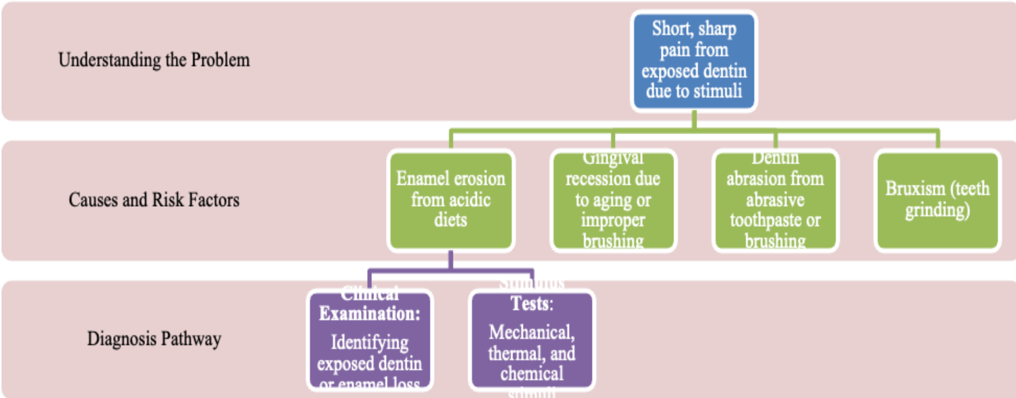

Figure 1. Overview of dental hypersensitivity.

Pain in the form of hypersensitivity is reported when oral hygiene practices, as routine practice, like brushing and flossing, cause pain. This pain could be one of the causes for failing to do adequate oral hygiene, which eventually leads to aggravation of caries and periodontal disease (Sumana et al., 2021; Naidu, 2014). The pain of brushing a hypersensitive tooth may lead to a vicious cycle of avoidance by the patient due to fear of pain, which worsens their dental health (Bhowmik et al., 2021). Some patients report pain without an obvious stimulus. Occasionally, this occurs because of environmental stimuli, such as cold air, or even normal activities, such as talking or breathing (Bardellini, 2024). A sting in the patient may be precipitated by particular foods, like sweet or acid ones, or very hot ones. This symptom is more common in patients who have undergone enamel erosion or gingival recession because conditions that result in exposure of dentine increase sensitivity (Taghat et al., 2019). The psychological effect caused by hypersensitivity leads to behavioral responses such as anxiety towards dental visits and avoidance of dental services when necessary. This leads to the hypersensitivity pain that is expected during dental procedures and, in a nutshell, contributes to the further degeneration of the oral health for the patient (Vicioni-Marques et al., 2023).

A thorough patient history is the first step in the diagnosis of dental hypersensitivity. The patients describe the nature, timing, and causes of the pain (Izhar et al., 2019; Cunha-Cruz et al., 2013). The value of self-reporting is that the patients can give information about their reaction to stimuli, like temperature, sweet or sour food, and mechanical pressure due to brushing (Francisconi-dos-Rios et al., 2021). An essential tool in determining the diagnosis of DH is a detailed clinical examination. Dental practitioners check the affected teeth for any signs of enamel deceleration, gingival recession, and other dental abnormalities that contribute to hypersensitivity (Cunha-Cruz et al., 2010; Jena & Govind, 2015). During the examination, practitioners look for exposed dentin and assess the overall oral health of a patient to establish potential causes of sensitivity (Izhar et al., 2019; Cunha-Cruz et al., 2013). Moreover, the examination may include other dental conditions, including caries or fractured teeth, that could be causing symptoms similar to those of DH (Pathan et al., 2016; Bansal & Mahajan, 2017).

The majority technique of diagnosis is through a mechanical and thermal stimulus delivered onto the affected teeth. Other techniques include an air blast, dental explorer, and cold stimuli to provoke the pain response (Izhar et al., 2019; Cunha-Cruz et al., 2010). The response to those stimuli assures the existence of hypersensitivity condition or simply evaluates its severity. For example, an acute sensitivity reaction to cold air or a dental explorer may be said to be exposed dentin with hypersensitivity (Gillam, 2013). In addition to mechanical and thermal testing, sensitivity testing can be through osmotic and chemical stimuli. This would entail application of either sweet or acidic substances at the surface of the tooth for patient reaction to the stimulus (Cunha-Cruz et al., 2010; Gillam, 2013). It follows that a differential diagnosis should be conducted to eliminate the other causes of tooth pain, such as dental caries, cracked teeth, and periodontal disease (Pathan et al., 2016; Bansal & Mahajan, 2017). This may also need additional diagnostic tools, like radiographs or vitality testing, to evaluate the pulp health and that of adjacent structures (Francisconi-dos-Rios et al., 2021; Cunha-Cruz et al., 2010). Some clinicians will use some diagnostic assistants, such as electric pulp testers, in setting up the viability of the tooth and to also confirm a diagnosis of DH (Cunha-Cruz et al., 2010). Yet this is not commonly carried out, as most practitioners mostly rely on the history that the patient gives and also the clinical findings (Izhar et al., 2019; Cunha-Cruz et al., 2010).

4. Traditional Treatment Approaches

Table 1. Traditional Treatment Approaches

Aspect	Fluoride Varnishes	Bonding Agents and Sealants	References
Mechanism of Action	Promotes remineralization and occludes dentin tubules by forming fluorapatite, reducing fluid movement and pain.	Creates an adhesive layer that seals tubules, reduces fluid movement, and forms a hybrid layer for long-term bond strength.	Petersson (2012); Aeran et al. (2022); Camilotti et al. (2012); Clark & Levin (2016); elgohary (2024); Mazur et al. (2021).
Clinical Efficacy	Demonstrated significant reduction in hypersensitivity scores, providing immediate relief lasting several weeks.	Provides immediate and long-term relief, with superior performance in some cases compared to fluoride varnishes.	Aeran et al. (2022); Camilotti et al. (2012); elgohary (2024); Mazur et al. (2021); Ahmed et al. (2018).
Comparison with Other Treatments	Easier to apply and less invasive but may be less effective than bonding agents for long-term management.	Often outperforms fluoride varnishes in long-term management, especially for high-sensitivity cases. Sealants complement bonding agents for enhanced effectiveness.	Mazur et al. (2021); Aeran et al. (2022); Tabatabaei et al. (2018).
Application Frequency	Recommended every 3–6 months, especially for high-risk patients.	Application success depends on technique, tooth condition, and other dental issues.	Mangi et al. (2021); Dholam et al. (2013); Basudan et al. (2022); Jeetendra et al. (2018).
Safety and Side Effects	Generally safe with minimal risk; systemic fluoride	Safe and effective when applied correctly; effectiveness enhanced with proper technique.	García et al. (2017); Basudan et al. (2022).

	exposure is minimal due to topical application.		
Long-Term Relief	Provides sustained sensitivity relief through tubule occlusion and remineralization.	Significantly reduces recurrence of sensitivity symptoms by forming a durable protective layer.	Mazur et al. (2021).

5. Contemporary Management Strategies

Table 2. Contemporary Management Strategies

Aspect	Potassium Nitrate	Calcium Phosphates	Laser Therapy	References
Mechanism of Action	Increases extracellular potassium ion concentration, depolarizing nerve membranes and reducing pain signal transmission. Approved by ADA for over-the-counter use in 5% formulations.	Enhances remineralization, occludes dentinal tubules, deposits calcium and phosphate ions, and reduces dentin permeability.	Occludes dentinal tubules via thermal effects, modulates nerve activity by depressing nerve transmission, and promotes healing through cellular regeneration and pulp cell repair.	Dabhadkar & Kulkarni (2022); Vajrabhaya et al. (2019); Sen (2018); Cunha-Cruz et al. (2010); Acharya et al. (2013); Ghiorghe et al. (2018); Yarita (2024); Hashim et al. (2014).
Clinical Efficacy	Proven to significantly reduce sensitivity scores in patients over various time periods. Provides effective pain relief when used regularly.	Decreases sensitivity by occluding tubules and offers additional benefits in enamel remineralization compared to potassium nitrate.	Provides both short-term and long-term relief, with rapid results after a single session. Outperforms topical agents in pain reduction but may be cost-prohibitive for some patients.	West et al. (2015); Purra et al. (2014); Sen (2018); Satyapal et al. (2014); Zhou et al. (2020); Sgolastra et al. (2011); Cattoni et al. (2023); Pion et al. (2023).
Application and Recommendations	Administered as toothpaste or mouthwash, safe for long-term use, and recommended for daily oral hygiene routines.	Commonly used for patients with tooth erosion or high caries risk, incorporated into professional and home treatments for general mineral fortification.	Requires specialized equipment, making it less accessible. Typically used in professional dental settings and recommended for patients seeking immediate and effective relief.	Dabhadkar & Kulkarni (2022); West et al. (2015); Vajrabhaya et al. (2019); Acharya et al. (2013); Morsi et al. (2020); Gojkov-Vukelić et al. (2016).
Cost Considerations	Affordable and widely available in over-the-counter products.	Relatively cost-effective and commonly included in both professional and over-the-counter dental products.	Higher cost due to expensive equipment and session fees, limiting accessibility for some patients.	Zhou et al. (2020); Cattoni et al. (2023); Pion et al. (2023).

6. Innovative Approaches and Future Directions

Bioactive glasses, in particular those with the composition of silica, calcium, and phosphate, have shown to be promising for dentin hypersensitivity treatment. The materials form hydroxycarbonate apatite in the presence of saliva that closes the dentinal tubules and encourages remineralization. Research studies indicated that bioactive glasses may significantly reduce the sensitivity through the sealing of the exposed dentin and through natural repair processes activated in dental tissues (Juraski et al., 2021; Raszewski, 2024). Calcium phosphates, including the calcium sodium phosphosilicate, sold under several brand names, such as Novamin®, are effective in the management of dentin hypersensitivity. They work by releasing calcium and phosphate ions, which will help in the remineralization of enamel and dentin. They may occlude dentinal tubules, thus reducing sensitivity (Maillard et al., 2023; Aziz, 2024). Studies have revealed that calcium phosphates may reduce the DH symptoms while encouraging the overall health of dental tissues by great extents (Maillard et al., 2023; Aziz, 2024).

Nano-hydroxyapatite is another biomaterial that shares the same composition as the mineral component of the normal dental structure. nHAp has been shown to produce effective occlusion of dentinal tubules. Hydroxyapatite toothpastes have been proven to decrease sensitivity by facilitating remineralization and cementing the exposed dentin (Febriani et al., 2021; Polyakova et al., 2022). Scientific literature shows that nHAp may enhance the remineralization of teeth and produces a long-term desensitizing effect (Izzetti et al., 2022). Strontium has been suggested to be an auxiliary beneficial element in dental materials. It is believed to decrease dentin sensitivity and aid the process of remineralization. The mechanical properties of dental materials are improved by strontium compounds because they favor the process of dentin remineralization (Abdalla, 2024). Mesoporous bioactive glass nanoparticles have been studied as a result of their promise to make available therapeutic ions and provide remineralizing ability. These materials should prove to be efficient in occluding dentinal tubules and thereby providing the scope for mineralization, thus providing a new approach towards the management of DH (Son et al., 2020).

Bioactive-glass-containing gels and sealers are also currently being considered as the new treatments for hypersensitive dentin. These materials are designed to penetrate the dentinal tubules and then proceed to release bioactive ions for a long time after entering the dentinal tubules thus initiating remineralization (Raszewski, 2024). Although not a biomaterial, photobiomodulation is a new technique that utilizes low-level laser therapy to enhance the effects of the biomaterials used in the treatment of DH. PBM has been shown to enhance healing and diminish sensitivity by modulating nerve activity and enhancing the efficacy of remineralizing agents (Kim, 2024; Fossati et al., 2023).

7.1 Probiotics

Table 3. Role of probiotics in Dental hypersensitivity.

Aspect	Probiotics	References
Mechanism of Action	Probiotics balance the oral microbiome by promoting beneficial bacteria and inhibiting pathogenic species. Mechanisms include:	Shenbagam et al. (2021); Vedam (2023); Liu et al. (2021).
	- Competitive Inhibition: Compete with harmful bacteria like Streptococcus mutansfor adhesion sites.	

	- Production of Antimicrobial Substances: Produce bacteriocins and antimicrobial compounds to inhibit pathogens.	
	- Immune Modulation: Enhance the immune response to combat infections and reduce inflammation.	
Clinical Evidence and Effectiveness	Limited direct evidence on managing hypersensitivity, but positive impacts on oral health are noted. Probiotics can prevent caries and improve periodontal health, indirectly alleviating hypersensitivity. Lactobacillus salivarius reduces cariogenic bacteria.	Seminario-Amez et al. (2017); Vedam (2023).
Probiotics in Oral Health Products	Incorporated into toothpaste and mouth rinses to promote a healthier oral microbiome. Challenges include selecting effective strains and optimizing formulations for delivery and efficacy.	Shenbagam et al. (2021).
Future Directions	Further research is needed to determine specific effects on hypersensitivity, identify effective strains, and develop targeted interventions. Longitudinal studies and clinical trials are essential for validating their complementary role in treatment.	Shenbagam et al. (2021); Seminario-Amez et al. (2017).

8. Comparison of Current Treatment Modalities

The most used interventions for DH are fluoride treatments, especially in the form of varnishes and gels. They tend to promote remineralization of the enamel and occlude the dentinal tubules, thus reducing sensitivity. Kopycka-Kedzierawski et al showed that practitioners most frequently recommended fluoride products, which indicated wide acceptance in clinical practice Kopycka-Kedzierawski et al. (2017). Potassium nitrate is another desensitizing agent that is commonly applied, which works by making the nerve endings in the dental pulp depolarized so that the perception of pain is reduced. According to studies, potassium nitrate is effective in DH management, with reports that show significant reductions in scores of sensitivities among patients using potassium nitrate-containing products (West et al., 2015; Purra et al., 2014).

Dentin bonding agents are the sealing of open dentinal tubules with a protection against stimuli. A clinical study comparing the efficacy of Nd:YAG laser with diode laser and dentin bonding agent concluded that the use of a bonding agent is effective in preventing sensitivity with a greater immediate effect of lasers (Tabatabaei et al., 2018). Laser therapy, especially with Nd:YAG and diode lasers, has been of interest because of its potential to provide rapid relief from DH. It has been shown that laser treatments can effectively occlude dentinal tubules and modulate nerve activity, leading to a significant reduction in pain (Tabatabaei et al., 2018).

Some of the recently developed materials include calcium phosphates: calcium sodium phosphosilicate, which enhance dentin remineralization and occlusion of dentinal tubules. In real life, clinical studies have verified the effectiveness of these materials in reducing sensitivity and enhancing general health of dental tissues (Maillard et al., 2023; Aziz, 2024). Some recent studies have assessed the efficacy of herbal dentifrices and natural desensitizers, including propolis, in DH treatment. While such treatments have more holistic approaches, further studies of their efficacy as compared with conventional methods like potassium nitrate and fluoride varnishes are required (Purra et al., 2014; Kaur et al., 2020). A review by West et al. conducted a systematic review that compared several desensitizing agents to determine their efficacy. According to the conclusion, though several treatment modalities have been proven to have achieved clinical success, no one treatment modality dominated all the studies (West et al., 2015).

This has posed significant challenges in treatment as one of the significant issues concerning DH treatment. There exists a high difference in terms of treatment effectiveness among treatments. In numerous studies, it is clear that, although treatments such as potassium nitrate and fluoride varnishes are very effective for many patients, the effectiveness percentage may differ highly between the two regarding the specific factors of an individual patient, for instance, on hypersensitivity levels and causes of Sadiasa et al., 2013) Oh et al. (2015). For instance, whereas potassium nitrate is always highly effective for most patients, it may not be quite effective for some patients who need further treatment (Kopycka-Kedzierawski et al., 2017). The vast majority of the conventional treatments for dentine hypersensitivity-which include topical desensitizing agents and fluoride varnishes-typically only provide short term relief. Patients often present with recurrence of symptoms just after a few weeks or months thus requiring repeated applications or more treatments (Mazur et al., 2021; Kopycka-Kedzierawski et al., 2017).

Some of the most effective treatments, such as dentin bonding agents and laser therapy, require a professional to administer them, which can be more invasive and time-consuming than the at-home options, such as desensitizing toothpaste (Assis et al., 2011). This could impact the compliance of the patient as patients might want less invasive, self-administered treatment options. Professional treatments are also very expensive, and this might also prevent the patients from using such treatment options if not covered by insurance (Assis et al., 2011). Dental hypersensitivity etiology is multifactorial and includes enamel erosion, gingival recession, and exposure of dentin, among others. The precise mechanisms of DH are still unknown, and this complicates the development of targeted treatments (Menoncin et al., 2019; Tonguç et al., 2011). Dental anxiety and fear will strongly influence perception of pain and willingness to seek treatment for DH. In a study, it has been identified that in patients with higher levels of anxiety, more sensitivity and discomfort are encountered that may not make the treatment of such a condition possible (Mujahid, 2023; Vicioni-Marques et al., 2023).

Most of the research studies regarding the effectiveness of DH treatments are short-term, and they do not provide any insight into long-term effectiveness and safety of the interventions. For instance, some treatments may appear to work immediately, but sustainability and their effects on oral health over time are unknown (Shitsuka et al., 2015; Alqahtani et al., 2021). Although the new therapies, such as probiotics and biomaterials, including bioactive glasses and calcium phosphates, seem to hold a lot of promise toward the management of DH, there is not enough clinical evidence to consider their widespread use (Vicioni-Marques et al., 2023; Belgin, 2024).

9. Conclusion

Dental hypersensitivity: a multifactorial phenomenon with critical implications for oral health as well as quality of life. This condition has severe etiologies, such as multifactorial factors, especially enamel erosion, gingival recession, and dentin exposure. Thus, full diagnostic approaches should be devised with individualized treatment management. Traditional approaches, such as fluoride varnishes and potassium nitrate, remain effective for most patients but only provide temporary relief. Emerging treatments are promising, not least among which are bioactive materials, laser treatment, and probiotics that can deal with both DH symptoms and, indeed, the cause. The methods involved would include dentinal tubule occlusion, remineralization, and dampening pain sensitivity. They all, however, need to be absorbed into everyday practice by testing their stability through long-term studies and cost-benefit analyses. The psychological effects of DH, such as anxiety and avoidance behaviors, even make treatment more challenging. Patient education and tailored care, therefore, help break the cycle of pain and poor oral hygiene. Thus, the treatment using the old and new methods together in an integrated way, combined with preventive care is necessary to manage DH in the most effective way. More research will also continue to make these materials and technologies even better for more effective, more durable, and accessible outcomes to patients all over the world.

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Author contributions

Although the initial text was written by the first author, all authors made substantial contributions by gathering information and searching the literature. Each author approved the final draft, participated in the book's critical revision, and assumed full responsibility for the work.

Conflict of Interest

Authors declare they don’t have any conflict of interest.

Ethical Approval

Not Applicable

WORKS CITED

1. Abdalla, M. (2024). Applications of bioactive strontium compounds in dentistry. Journal of Functional Biomaterials, 15(8), 216. https://doi.org/10.3390/jfb15080216
2. Acharya, A., Surve, S., & Thakur, S. (2013). A clinical study of the effect of calcium sodium phosphosilicate on dentin hypersensitivity. Journal of Clinical and Experimental Dentistry, e18-22. https://doi.org/10.4317/jced.50955
3. Aeran, H., Tuli, A., & Paul, S. (2022). Evaluation of the efficacy of sodium fluoride varnish, dentine bonding agent and diode laser in the treatment of dentine hypersensitivity: a clinical and scanning electron microscopic study. International Journal of Oral Health Dentistry, 8(2), 170-175. https://doi.org/10.18231/j.ijohd.2022.033

4. Ahmed, J., Ali, S., Jouhar, R., & Shah, H. (2018). Clinical assessment of bonding agent v/s fluoride varnish in dentinal hypersensitivity. Journal of Bahria University Medical and Dental College, 09(01), 53-56. https://doi.org/10.51985/jbumdc2018022
5. Alqahtani, A., Gufran, K., Silva, F., Rocha, M., & Chang, J. (2021). A clinical case report of a potential acute allergic reaction with titanium dental implant. Case Reports in Dentistry, 2021, 1-7. https://doi.org/10.1155/2021/5592934
6. Amarasena, N., Spencer, J., Ou, Y., & Brennan, D. (2010). Dentine hypersensitivity – australian dentists' perspective. Australian Dental Journal, 55(2), 181-187. https://doi.org/10.1111/j.1834-7819.2010.01223.x
7. Assis, J., Rodrigues, L., Fonteles, C., Colares, R., Souza, A., & Santiago, S. (2011). Dentin hypersensitivity after treatment with desensitizing agents: a randomized, double-blind, split-mouth clinical trial. Brazilian Dental Journal, 22(2), 157-161. https://doi.org/10.1590/s0103-64402011000200012
8. Awad, M., Kassas, D., Harthi, L., Abraham, S., Al-Khalifa, K., Khalaf, M., … & Bartlett, D. (2020). Dentine hypersensitivity and dentine exposure in arab patient populations. Journal of Oral Rehabilitation, 47(4), 473-479. https://doi.org/10.1111/joor.12927
9. Aziz, S. (2024). Remineralization potential of dentifrices with calcium sodium phosphosilicate and functionalized tri-calcium phosphate in the deeper incipient carious lesions: an in vitro study. Clinical and Experimental Dental Research, 10(2). https://doi.org/10.1002/cre2.876
10. Bansal, D. and Mahajan, M. (2017). Comparative evaluation of effectiveness of three desensitizing toothpastes for relief in the dentinal hypersensitivity. Contemporary Clinical Dentistry, 8(2), 195. https://doi.org/10.4103/ccd.ccd_135_17
11. Bardellini, E. (2024). Molar incisor hypomineralization: optimizing treatment protocols for hypersensitivity: a randomized clinical trial. Dentistry Journal, 12(6), 186. https://doi.org/10.3390/dj12060186
12. Basudan, T., Neyaz, A., Alnasser, N., Alabdali, A., Alqahtan, W., Asiri, G., … & Alshaeri, A. (2022). Improvement of quality of life through nanoparticles in restorative dentistry. Journal of Healthcare Sciences, 02(12), 560-567. https://doi.org/10.52533/johs.2022.21209
13. Behera, R. (2021). Nanotechnology: a new strategy to treat dental hypersensitivity. Indian Journal of Forensic Medicine & Toxicology, 15(2), 668-675. https://doi.org/10.37506/ijfmt.v15i2.14388
14. Bekes, K., Amend, S., Priller, J., Zamek, C., Stamm, T., & Krämer, N. (2021). Hypersensitivity relief of mih-affected molars using two sealing techniques: a 12-week follow-up. Clinical Oral Investigations, 26(2), 1879-1888. https://doi.org/10.1007/s00784-021-04163-5
15. Belgin, E. (2024). Anti-inflammatory effect of dental pulpa mesenchymal stem cell exosomes loaded mucoadhesive hydrogel on mice with dental nickel hypersensitivity. Macromolecular Bioscience, 24(6). https://doi.org/10.1002/mabi.202300352
16. Bhowmik, E., Deepika, P., & Sharma, H. (2021). Comparative evaluation of fluorinol and calcium sodium phosphosilicate-containing toothpastes in the treatment of dentin hypersensitivity. International Journal of Dental Hygiene, 19(4), 421-428. https://doi.org/10.1111/idh.12495
17. Boa, J., Ribeiro, A., Beumer, M., Reckziegel, J., & Santos, V. (2019). The deleterious impacts of bariatric surgery on oral health: a review article. International Journal of Advanced Engineering Research and Science, 6(7), 586-590. https://doi.org/10.22161/ijaers.6765
18. Camilotti, V., Zilly, J., Busato, P., Nassar, C., & Nassar, P. (2012). Desensitizing treatments for dentin hypersensitivity: a randomized, split-mouth clinical trial. Brazilian Oral Research, 26(3), 263-268. https://doi.org/10.1590/s1806-83242012000300013
19. Cattoni, F., Ferrante, L., Mandile, S., Tetè, G., Polizzi, E., & Gastaldi, G. (2023). Comparison of lasers and desensitizing agents in dentinal hypersensitivity therapy. Dentistry Journal, 11(3), 63. https://doi.org/10.3390/dj11030063
20. Clark, D. and Levin, L. (2016). Non-surgical management of tooth hypersensitivity. International Dental Journal, 66(5), 249-256. https://doi.org/10.1111/idj.12247
21. Cunha-Cruz, J., Stout, J., Heaton, L., & Wataha, J. (2010). Dentin hypersensitivity and oxalates. Journal of Dental Research, 90(3), 304-310. https://doi.org/10.1177/0022034510389179
22. Cunha-Cruz, J., Wataha, J., Heaton, L., Rothen, M., Sobieraj, M., Scott, J., … & Berg, J. (2013). The prevalence of dentin hypersensitivity in general dental practices in the northwest united states. The

Journal of the American Dental Association, 144(3), 288-296. https://doi.org/10.14219/jada.archive.2013.0116
23. Cunha-Cruz, J., Wataha, J., Zhou, L., Manning, W., Trantow, M., Bettendorf, M., … & Berg, J. (2010). Treating dentin hypersensitivity. The Journal of the American Dental Association, 141(9), 1097-1105. https://doi.org/10.14219/jada.archive.2010.0340
24. DABHADKAR, M. and KULKARNI, M. (2022). In situ gel formulation of potassium nitrate: a novel approach to treat dentin hypersensitivity. International Journal of Applied Pharmaceutics, 83-90. https://doi.org/10.22159/ijap.2022v14i6.44999
25. Dholam, K., Somani, P., Prabhu, S., & Ambre, S. (2013). Effectiveness of fluoride varnish application as cariostatic and desensitizing agent in irradiated head and neck cancer patients. International Journal of Dentistry, 2013, 1-5. https://doi.org/10.1155/2013/824982
26. F, L., Niang, S., Faye, B., Sarr, M., Seck, A., Ndiaye, D., … & Touré, B. (2016). Treatment of dentin hypersensitivity: a systematic review of randomized clinical trials. Journal of Dentistry and Oral Care Medicine. https://doi.org/10.15744/2454-3276.2.204
27. Fagundes-De-Souza, D., Napimoga, M., Soares, A., Araújo, V., & Turssi, C. (2019). Does hypersensitive teeth show pulp inflammation? Rgo - Revista Gaúcha De Odontologia, 67. https://doi.org/10.1590/1981-86372019000113580
28. Fambrini, E., Miceli, M., Pasini, M., & Giuca, M. (2022). Clinical evaluation of the use of desensitizing agents in the management of dentinal hypersensitivity. Applied Sciences, 12(21), 11238. https://doi.org/10.3390/app122111238
29. Farag, Z. and Awooda, E. (2016). Dental erosion and dentin hypersensitivity among adult asthmatics and non-asthmatics hospital-based: a preliminary study. The Open Dentistry Journal, 10(1), 587-593. https://doi.org/10.2174/1874210601610010587
30. Febriani, M., Amelia, H., Alawiyah, T., & Rachmawati, E. (2021). The potential of hydroxyapatite toothpaste towards the hypersensitive tooth. International Journal of Medical Science and Clinical Invention, 8(12), 5849-5857. https://doi.org/10.18535/ijmsci/v8i12.03
31. Fossati, A., Sobral, A., Bruno, M., Viarengo, N., Sertaje, M., Santos, E., … & Bussadori, S. (2023). Photobiomodulation and glass ionomer sealant as complementary treatment for hypersensitivity in molar incisor hypomineralisation in children: protocol for a blinded randomised clinical trial. BMJ Open, 13(6), e068102. https://doi.org/10.1136/bmjopen-2022-068102
32. Francisconi-dos-Rios, L., Calabria, M., Pereira, J., Hatton, J., Honório, H., Wang, L., … & Gillam, D. (2021). Knowledge of brazilian dentists and students in treating dentine hypersensitivity. Research Society and Development, 10(9), e28010917194. https://doi.org/10.33448/rsd-v10i9.17194
33. García, R., Gregorich, S., Ramos-Gomez, F., Braun, P., Wilson, A., Albino, J., … & Gansky, S. (2017). Absence of fluoride varnish–related adverse events in caries prevention trials in young children, united states. Preventing Chronic Disease, 14. https://doi.org/10.5888/pcd14.160372
34. Gernhardt, C. (2012). How valid and applicable are current diagnostic criteria and assessment methods for dentin hypersensitivity? an overview. Clinical Oral Investigations, 17(S1), 31-40. https://doi.org/10.1007/s00784-012-0891-1
35. Ghiorghe, C., Dimbu, E., Tirca, T., Andrian, S., Topoliceanu, C., Iovan, G., … & Salceanu, M. (2018). The assessment of the effectiveness of remineralization and laser therapy in cervical dentine hypersensitivity. Revista De Chimie, 69(6), 1489-1492. https://doi.org/10.37358/rc.18.6.6352
36. Gillam, D. (2013). Current diagnosis of dentin hypersensitivity in the dental office: an overview. Clinical Oral Investigations, 17(S1), 21-29. https://doi.org/10.1007/s00784-012-0911-1
37. Gojkov-Vukelić, M., Hadzic, S., Zukanović, A., Pašić, E., & Pavlić, V. (2016). Application of diode laser in the treatment of dentine hypersensitivity. Medical Archives, 70(6), 466. https://doi.org/10.5455/medarh.2016.70.466-469
38. Gümüştaş, B., Gürbüz, Ö., & Efes, B. (2017). Effects of bleaching agents, neutral fluoride gels, and surface sealants on enamel surface roughness. Journal of Operative Dentistry & Endodontics, 2(2), 74-78. https://doi.org/10.5005/jp-journals-10047-0041
39. Haneet, R. and Vandana, L. (2016). Prevalence of dentinal hypersensitivity and study of associated factors: a cross-sectional study based on the general dental population of davangere, karnataka, india. International Dental Journal, 66(1), 49-57. https://doi.org/10.1111/idj.12206

40. Hashim, N., Gasmalla, B., Sabahelkheir, A., & Awooda, A. (2014). Effect of the clinical application of the diode laser (810 nm) in the treatment of dentine hypersensitivity. BMC Research Notes, 7(1). https://doi.org/10.1186/1756-0500-7-31
41. Izhar, F., Nazir, M., Majeed, A., & Almas, K. (2019). A study of dentists about their knowledge and practice of dentine hypersensitivity. European Journal of Dentistry, 13(04), 540-546. https://doi.org/10.1055/s-0039-1697110
42. Izzetti, R., Gennai, S., Nisi, M., Gulia, F., Miceli, M., & Giuca, M. (2022). Clinical applications of nano-hydroxyapatite in dentistry. Applied Sciences, 12(21), 10762. https://doi.org/10.3390/app122110762
43. Jeetendra, S., Rangappa, A., Naganathan, M., & Lakshminarasimhaiah, V. (2018). Influence of dentin desensitizers on the bond strength of self-etch adhesive to dentin: anin vitrostudy. Journal of Operative Dentistry & Endodontics, 3(1), 18-21. https://doi.org/10.5005/jp-journals-10047-0050
44. Jena, A. and Govind, S. (2015). Comparison of efficacy of three different desensitizing agents for in-office relief of dentin hypersensitivity: a 4 week clinical study. Journal of Conservative Dentistry, 18(5), 389. https://doi.org/10.4103/0972-0707.164052
45. Juraski, A., Figueredo, D., Daghastanli, N., Santos, C., Fernandes, M., Ana, P., … & Daguano, J. (2021). Effect of a whitlockite glass-ceramic on the occlusion of dentinal tubules for dentin hypersensitivity treatment. Research Society and Development, 10(3), e19610313161. https://doi.org/10.33448/rsd-v10i3.13161
46. Jälevik, B., Sabel, N., & Robertson, A. (2021). Can molar incisor hypomineralization cause dental fear and anxiety or influence the oral health-related quality of life in children and adolescents? —a systematic review. European Archives of Paediatric Dentistry, 23(1), 65-78. https://doi.org/10.1007/s40368-021-00631-4
47. Kaur, J., Paul, R., Blaggana, V., Upadhyay, P., & Arora, G. (2020). Evaluation of efficacy of a herbal dentifrice on dentinal hypersensitivity: a clinical study. International Journal of Oral Health Dentistry, 6(2), 126-130. https://doi.org/10.18231/j.ijohd.2020.028
48. Kim, H. (2024). Effects of photobiomodulation using near-infrared light on the dentin and periodontal ligament in a beagle model. Applied Sciences, 14(2), 724. https://doi.org/10.3390/app14020724
49. Kim, S., Kim, E., Kim, D., & Lee, I. (2013). The evaluation of dentinal tubule occlusion by desensitizing agents: a real-time measurement of dentinal fluid flow rate and scanning electron microscopy. Operative Dentistry, 38(4), 419-428. https://doi.org/10.2341/11-504-l
50. Kopycka-Kedzierawski, D., Meyerowitz, C., Litaker, M., Heft, M., Tasgaonkar, N., Day, M., … & Gilbert, G. (2017). Management of dentin hypersensitivity by practitioners in the national dental practice-based research network. The Journal of the American Dental Association, 148(10), 728-736. https://doi.org/10.1016/j.adaj.2017.05.003
51. Lawal, F. and Oke, G. (2020). Oral health related quality of life and satisfaction with dental condition of school age children with dental pain in ibadan, nigeria.. https://doi.org/10.21203/rs.3.rs-21413/v1
52. Lee, C., Ramsey, A., Brito-Gariepy, H., Michot, B., Podborits, E., Melnyk, J., … & Gibbs, J. (2017). Molecular, cellular, and behavioral changes associated with pathological pain signaling occur after dental pulp injury. Molecular Pain, 13. https://doi.org/10.1177/1744806917715173
53. Liu, X., Tenenbaum, H., Wilder, R., Quock, R., Hewlett, E., & Ren, Y. (2020). Pathogenesis, diagnosis and management of dentin hypersensitivity: an evidence-based overview for dental practitioners. BMC Oral Health, 20(1). https://doi.org/10.1186/s12903-020-01199-z
54. Liu, X., Tong, X., Zhu, J., Liang, T., Jie, Z., Zou, Y., … & Zhang, T. (2021). Metagenome-genome-wide association studies reveal human genetic impact on the oral microbiome. Cell Discovery, 7(1). https://doi.org/10.1038/s41421-021-00356-0
55. Liu, X., Wang, C., Fujita, T., Malmström, H., Nedergaard, M., Ren, Y., … & Dirksen, R. (2015). External dentin stimulation induces atp release in human teeth. Journal of Dental Research, 94(9), 1259-1266. https://doi.org/10.1177/0022034515592858
56. López, L., España, P., Bastidas, R., Fuelagan, J., & Mafla, A. (2016). Factors associated with dentine hypersensitivity severity in colombian dental patients.. Journal of Oral Research, 5(2), 63-70. https://doi.org/10.17126/joralres.2016.014

57. Mafla, A. and Lopez-Moncayo, L. (2016). Dentine sensitivity risk factors: a case–control study. European Journal of Dentistry, 10(01), 001-006. https://doi.org/10.4103/1305-7456.175678
58. Maillard, M., Bandiaky, O., Maunoury, S., Alliot, C., Alliot-Licht, B., Serisier, S., … & Renard, E. (2023). The effectiveness of calcium phosphates in the treatment of dentinal hypersensitivity: a systematic review. Bioengineering, 10(4), 447. https://doi.org/10.3390/bioengineering10040447
59. Mangi, N., Memon, A., Tasleem, F., Jakhrani, I., Banglani, M., & Shams, S. (2021). Effect of flouride varnish in prevention of dental caries. PJMHS, 15(12), 3533-3536. https://doi.org/10.53350/pjmhs2115123533
60. Mazur, M., Jedliński, M., Ndokaj, A., Ardan, R., Janiszewska-Olszowska, J., Nardi, G., … & Guerra, F. (2021). Long-term effectiveness of treating dentin hypersensitivity with bifluorid 10 and futurabond u: a split-mouth randomized double-blind clinical trial. Journal of Clinical Medicine, 10(10), 2085. https://doi.org/10.3390/jcm10102085
61. Menoncin, B., Portella, P., Ramos, B., Assunção, L., Souza, J., & Menezes, J. (2019). Dental anxiety in schoolchildren with molar incisor hypomineralization—a population-based cross-sectional study. International Journal of Paediatric Dentistry, 29(5), 615-623. https://doi.org/10.1111/ipd.12503
62. Morsi, A., Haidary, D., Franzen, R., & Gutknecht, N. (2020). Intra-pulpal temperature evaluation during diode laser (445 nm) irradiation for treatment of dentine hypersensitivity: in vitro a pilot study. Lasers in Dental Science, 4(3), 139-144. https://doi.org/10.1007/s41547-020-00085-9
63. Mujahid, A. (2023). Dentine hypersensitivity: a cross-sectional study in karachi. PJMHS, 17(5), 68-71. https://doi.org/10.53350/pjmhs202317568
64. Naidu, G. (2014). Prevalence of dentin hypersensitivity and related factors among adult patients visiting a dental school in andhra pradesh, southern india. Journal of Clinical and Diagnostic Research. https://doi.org/10.7860/jcdr/2014/9033.4859
65. Netto, B., Moreira, E., Patiño, J., Benincá, J., Jordão, A., & Fröde, T. (2012). Influence of roux-en-y gastric bypass surgery on vitamin c, myeloperoxidase, and oral clinical manifestations. Nutrition in Clinical Practice, 27(1), 114-121. https://doi.org/10.1177/0884533611431462
66. Nguyen, Q., Duverger, O., Mishra, R., Mitnik, G., Jani, P., Frischmeyer-Guerrerio, P., … & Lee, J. (2019). Oral health-related quality of life in loeys-dietz syndrome, a rare connective tissue disorder: an observational cohort study. Orphanet Journal of Rare Diseases, 14(1). https://doi.org/10.1186/s13023-019-1250-y
67. Oh, D., Prajatelistia, E., Ju, S., Kim, H., Baek, S., Joon, H., … & Hwang, D. (2015). A rapid, efficient and facile solution for dental hypersensitivity: the tannin–iron complex. Scientific Reports, 5(1). https://doi.org/10.1038/srep10884
68. Pathan, A., Bolla, N., Kavuri, S., Sunil, C., Damaraju, B., & Pattan, S. (2016). Ability of three desensitizing agents in dentinal tubule obliteration and durability: an in vitro study. Journal of Conservative Dentistry, 19(1), 31. https://doi.org/10.4103/0972-0707.173190
69. Petersson, L. (2012). The role of fluoride in the preventive management of dentin hypersensitivity and root caries. Clinical Oral Investigations, 17(S1), 63-71. https://doi.org/10.1007/s00784-012-0916-9
70. Pion, L., Matos, L., Gimenez, T., Palma-Dibb, R., & Faraoni, J. (2023). Treatment outcome for dentin hypersensitivity with laser therapy: systematic review and meta-analysis. Dental and Medical Problems, 60(1), 153-166. https://doi.org/10.17219/dmp/151482
71. Polyakova, M., Sokhova, I., Doroshina, V., Arakelyan, M., Novozhilova, N., & Babina, K. (2022). The effect of toothpastes containing hydroxyapatite, fluoroapatite, and zn-mg-hydroxyapatite nanocrystals on dentin hypersensitivity. Journal of International Society of Preventive and Community Dentistry, 12(2), 252-259. https://doi.org/10.4103/jispcd.jispcd_333_21
72. Porto, I., Andrade, A., & Montes, M. (2009). Diagnosis and treatment of dentinal hypersensitivity. Journal of Oral Science, 51(3), 323-332. https://doi.org/10.2334/josnusd.51.323
73. Purra, A., Mushtaq, M., Acharya, S., & Saraswati, V. (2014). A comparative evaluation of propolis and 5.0% potassium nitrate as a dentine desensitizer: a clinical study. Journal of Indian Society of Periodontology, 18(4), 466. https://doi.org/10.4103/0972-124x.138695
74. Que, K., Ruan, J., Xu, F., Liang, K., & Hu, D. (2010). A multi-centre and cross-sectional study of dentine hypersensitivity in china. Journal of Clinical Periodontology, 37(7), 631-637. https://doi.org/10.1111/j.1600-051x.2009.01513.x

75. Rao, K., Thomas, S., Kumar, J., & Narayan, V. (2019). Prevalence of dentinal hypersensitivity and dental erosion among competitive swimmers, kerala, india. Indian Journal of Community Medicine, 44(4), 390. https://doi.org/10.4103/ijcm.ijcm_213_19
76. Raszewski, Z. (2024). Investigating bioactive-glass-infused gels for enamel remineralization: an in vitro study. Journal of Functional Biomaterials, 15(5), 119. https://doi.org/10.3390/jfb15050119
77. Sadiasa, A., Franco, R., Seo, H., & Lee, B. (2013). Hydroxyapatite delivery to dentine tubules using carboxymethyl cellulose dental hydrogel for treatment of dentine hypersensitivity. Journal of Biomedical Science and Engineering, 06(10), 987-995. https://doi.org/10.4236/jbise.2013.610123
78. Sanikop, S., Agrawal, P., & Patil, S. (2011). Relationship between dental anxiety and pain perception during scaling. Journal of Oral Science, 53(3), 341-348. https://doi.org/10.2334/josnusd.53.341
79. Satyapal, T., Mali, R., Mali, A., & Patil, V. (2014). Comparative evaluation of a dentifrice containing calcium sodium phosphosilicate to a dentifrice containing potassium nitrate for dentinal hypersensitivity: a clinical study. Journal of Indian Society of Periodontology, 18(5), 581. https://doi.org/10.4103/0972-124x.142447
80. Seminario-Amez, M., López-López, J., Estrugo-Devesa, A., Ayuso-Montero, R., & Jané-Salas, E. (2017). Probiotics and oral health: a systematic review. Medicina Oral Patología Oral Y Cirugia Bucal, 0-0. https://doi.org/10.4317/medoral.21494
81. Sen, S. (2018). Comparative desensitizing effect of a toothpaste & mouthwash- containing potassium nitrate: an in vivo & in vitro scanning electron microscopic study. Advances in Dentistry & Oral Health, 8(5). https://doi.org/10.19080/adoh.2018.08.555749
82. Sgolastra, F., Petrucci, A., Gatto, R., & Monaco, A. (2011). Effectiveness of laser in dentinal hypersensitivity treatment: a systematic review. Journal of Endodontics, 37(3), 297-303. https://doi.org/10.1016/j.joen.2010.11.034
83. Shenbagam, R., Poorni, S., M.S., N., Srinivasan, M., Rakshagan, V., Jeevitha, M., … & Jeyaraman, S. (2021). Are probiotics effective in preventing dental caries? – a narrative review. Journal of Pharmaceutical Research International, 3442-3449. https://doi.org/10.9734/jpri/2021/v33i60b35031
84. Shitsuka, C., Mendes, F., Corrêa, M., & Leite, M. (2015). Exploring some aspects associated with dentine hypersensitivity in children. The Scientific World Journal, 2015(1). https://doi.org/10.1155/2015/764905
85. Son, S., Kim, D., Yoo, K., Yoon, S., & Kim, Y. (2020). Mesoporous bioactive glass combined with graphene oxide quantum dot as a new material for a new treatment option for dentin hypersensitivity. Nanomaterials, 10(4), 621. https://doi.org/10.3390/nano10040621
86. Sumana, N., Yshs, C., S, C., Harika, P., Bontu, S., & Ramya, D. (2021). Evaluation and comparision of the clinical effectiveness of diode laser and gluma as desensitizing agents in the treatment of dentinal hypersensitivity. Journal of Dental Panacea, 3(2), 69-72. https://doi.org/10.18231/j.jdp.2021.015
87. Tabatabaei, M., Chiniforush, N., Hashemi, G., & Valizadeh, S. (2018). Efficacy comparison of nd:yag laser, diode laser and dentine bonding agent in dentine hypersensitivity reduction: a clinical trial. Laser Therapy, 27(4), 265-270. https://doi.org/10.5978/islsm.27_18-or-24
88. Taghat, N., Werling, M., & Östberg, A. (2019). Oral health–related quality of life after gastric bypass surgery. Obesity Surgery, 30(1), 224-232. https://doi.org/10.1007/s11695-019-04172-0
89. Taheri, A., Parvizifard, A., Reisi, S., Jafari, M., Mohammadian, Y., Heshmati, K., … & Ghasemi, M. (2023). Associations between the perception of dental pain and pain anxiety, mental pain, and dental anxiety in iranian sample. The International Journal of Psychiatry in Medicine, 59(1), 34-49. https://doi.org/10.1177/00912174231180855
90. Tonguç, M., Özat, Y., Sert, T., Sönmez, Y., & Kırzıoğlu, F. (2011). Tooth sensitivity in fluorotic teeth. European Journal of Dentistry, 05(03), 273-280. https://doi.org/10.1055/s-0039-1698892
91. Vajrabhaya, L., Sappayatosok, K., Kulthanaamondhita, P., Korsuwannawong, S., & Sirikururat, P. (2019). Desensitizing efficacy of a herbal toothpaste: a clinical study. World Journal of Dentistry, 10(6), 408-412. https://doi.org/10.5005/jp-journals-10015-1681
92. Vedam, V. (2023). Biotherapeutic potential of lactobacillus probiotic strains on streptococcus mutans biofilm in dental caries–pathogenesis revisited. Indian Journal of Pharmaceutical Education and Research, 57(4), 956-964. https://doi.org/10.5530/ijper.57.4.117

93. Vicioni-Marques, F., Carvalho, M., Raposo, F., Paula-Silva, F., Queiroz, A., Leal, S., … & Carvalho, F. (2023). Association of dental hypersensitivity and anxiety in children with molar-incisor hypomineralisation (mih). European Archives of Paediatric Dentistry, 24(3), 313-319. https://doi.org/10.1007/s40368-023-00803-4
94. West, N., Seong, J., & Davies, M. (2015). Management of dentine hypersensitivity: efficacy of professionally and self-administered agents. Journal of Clinical Periodontology, 42(S16). https://doi.org/10.1111/jcpe.12336
95. Worsley, M., Allen, C., Billinton, A., King, A., & Boissonade, F. (2014). Chronic tooth pulp inflammation induces persistent expression of phosphorylated erk (perk) and phosphorylated p38 (pp38) in trigeminal subnucleus caudalis. Neuroscience, 269, 318-330. https://doi.org/10.1016/j.neuroscience.2014.03.056
96. Xia, W., Qin, T., Suska, F., & Engqvist, H. (2016). Bioactive spheres: the way of treating dentin hypersensitivity. Acs Biomaterials Science & Engineering, 2(5), 734-740. https://doi.org/10.1021/acsbiomaterials.5b00499
97. Yarita, M. (2024). Effects of semiconductor laser irradiation on differentiation of human dental pulp stem cells in co-culture with dentin. Dentistry Journal, 12(3), 67. https://doi.org/10.3390/dj12030067
98. Zeb, A., Amirzadah, S., Ahmad, F., Afridi, F., Ullah, N., & Akhtar, M. (2022). Frequency of dentine hypersensitivity and their associated risk factors amongst the patients visiting the dental outpatient department. PJMHS, 16(10), 578-580. https://doi.org/10.53350/pjmhs221610578
99. Zhou, K., Liu, Q., Yu, X., & Zeng, X. (2020). Laser therapy versus topical desensitising agents in the management of dentine hypersensitivity: a meta-analysis. Oral Diseases, 27(3), 422-430. https://doi.org/10.1111/odi.13309
100. elgohary, s. (2024). The effect of a resin-based desensitizer containing glutaraldehyde on cervical dentin hypersensitivity: a randomized controlled clinical trial. Alexandria Dental Journal, 0(0), 0-0. https://doi.org/10.21608/adjalexu.2023.214772.1383