

Dentinal sensitivity: Concept and methodology for its objective evaluation

José Martínez Ricarte ¹, Vicente Faus Matoses ², Vicente José Faus Llácer ³, Antonio Juan Flichy Fernández ⁴, Bibiana Mateos Moreno ⁵

(1) Degree in Dental Surgery, Murcia University. Resident of the Master in Oral Surgery and Implantology. Faculty of Medicine and Dentistry, Valencia University

(2) Degree in Dental Surgery. Master in Dental Pathology and Therapeutics. Faculty of Medicine and Dentistry, Valencia University

(3) Assistant Professor of Dental Pathology and Therapeutics. Faculty of Medicine and Dentistry, Valencia University

(4) Degree in Dental Surgery, Barcelona University. Resident of the Master in Oral Surgery and Implantology. Faculty of Medicine and Dentistry, Valencia University

(5) Associate Professor of Adult Integrated Clinical Management. Faculty of Medicine and Dentistry, Murcia University (Spain)

Correspondence:

Dr. José Martínez Ricarte

Clinica Odontológica

Gascó Oliag 1

46021 – Valencia, Spain

E-mail: jmr64087@yahoo.es

Received: 04/05/2007

Accepted: 16/11/2007

Martínez-Ricarte J, Faus-Matoses V, Faus-Llácer VJ, Flichy-Fernández AJ, Mateos-Moreno B. Dentinal sensitivity: Concept and methodology for its objective evaluation. Med Oral Patol Oral Cir Bucal. 2008 Mar;13(3):E201-6.

© Medicina Oral S. L. C.I.F. B 96689336 - ISSN 1698-6946

<http://www.medicinaoral.com/medoralfree01/v13i3/medoralv13i3p201.pdf>

Indexed in:

-Index Medicus / MEDLINE / PubMed
-EMBASE, Excerpta Medica
-SCOPUS
-Índice Médico Español
-IBECs

Abstract

Dentinal sensitivity is a clinical condition of some importance, particularly in periodontal patients. Symptoms appear on applying a triggering stimulus to the exposed dentine - the particularity being that the pain is similar to that of other dental disorders of different etiology and treatment. Hence the importance of a correct differential diagnosis. The main problem not only in clinical practice when treating the disorder, but also in designing studies for the objective evaluation of dentinal sensitivity, is the difficulty of standardizing, evaluating and interpreting the clinical condition in its different degrees. Thus, consensus in designing and evaluating studies of dentinal sensitivity would facilitate our understanding of its etiology, and the assessment of possible treatments. Such studies may center their methodology on individual patient response or on the nature of the triggering stimulus. The present study provides an updated and global view of the disorder, and reviews the basic protocol for the objective assessment of dentinal sensitivity.

Key words: Dentinal sensitivity, study design, objective evaluation.

Concept and importance of objective evaluation

Dentinal sensitivity (DS) arises from the application of a stimulus to exposed dentine, regardless of its location, and constitutes a chronic disorder characterized by the appearance of acute episodes (1). A number of causal factors are implicated, and variations in prevalence are moreover observed (2). DS manifests as brief and acute pain that cannot be attributed to any other form of dental pathology or defect (1). In clinical practice, the importance of its presentation determines both understanding of the underlying etiology and the management approach by the dental specialist.

The literature describes a number of methods for the cli-

nic management of DS. However, problems are found when evaluating and comparing such treatments, due to the diversity of data published. Such contradictions in the literature are probably attributable to differences in the designing of the clinical trials, and in the types of procedures used (1). Traditionally, DS has been evaluated subjectively, based on the patient response elicited on applying a triggering stimulus. Such stimuli can be classified into four categories (mechanical, chemical, electrical and thermal), though evaluation and interpretation of the pain produced by them is more complicated to standardize (3) - thus explaining the difficulty of contrasting treatments. Different terms are applied in reference to the disorder,

including not only dentinal sensitivity but also dentinal hypersensitivity, or cervical sensitivity or hypersensitivity (4). However, considering that hypersensitive dentine macroscopically appears to be no different from normal dentine, the term “hypersensitive” appears inexact - since dentine as such cannot exhibit hypersensitivity. Rather, application of a stimulus to the dentinal surface elicits a response on the part of the nerves within the pulp cavity. Thus, the term “sensitivity” appears to be more correct (5).

In clinical practice, the dental professional must establish a differential diagnosis with other disorders characterized by pain similar to that found in patients with DS. Such disorders moreover generally require a management approach different from that used in DS. Thus, other causes of brief and acute dentinal pain include pain secondary to caries, fractured restorations, marginal leakage around restorations, certain materials used in dental treatment, and dental fractures and fissures (6).

Epidemiology

The existing literature is highly varied. In effect, the reported prevalence of DS ranges from 3-57% (2,7). In periodontal patients, the percentage increases, reaching 72-98% (8,9). In turn, most affected patients are in the 20-50 years of age interval, with a peak between 30-40 years of age. As regards the sex distribution, DS affects women more often than men (10).

Most studies describe a preferential order of pain location according to the type of teeth involved. Thus, the canines and first premolars are the most affected teeth, followed by the incisors and second premolars. The molars are the teeth least affected by DS. As regards the anatomical location of DS, most cases are circumscribed to the buccocervical region of permanent teeth (11).

Etiopathogenesis

The hydrodynamic theory is the most widely demonstrated and accepted physiopathological theory of DS (12). According to this theory, most pain-inducing stimuli increase centrifugal fluid flow within the dentinal tubules, giving rise to a pressure change throughout the entire dentine. This in turn activates the A δ intradentinal nerves (of medium conduction velocity) at the pulp-dentinal interface, or within the dentinal tubules - thereby generating pain. Two phases must coincide in order to produce DS. In effect, dentinal exposure (location of the lesion) must occur (Figures 1 and 2), and the dentinal tubular system must open or become permeable towards the pulp compartment (start of the lesion)(Figure 3)(4). Dentinal exposure may be secondary to loss of enamel or periodontal tissue (gingival recession). Enamel loss or dental wear is due to attrition, abrasion and erosion, and although dental erosion is the most important single factor to be taken into account, increased dentine wear and tubular aperture occurs when it acts in synergy with abrasion.



Fig. 1. Dentinal exposure (location of the lesion) secondary to periodontal tissue loss due to: 1) bruxism; 2) abrasion through traumatic brushing; and 3) erosion in a bulimic patient.



Fig. 2. Dentinal exposure (location of the lesion) secondary to periodontal tissue loss

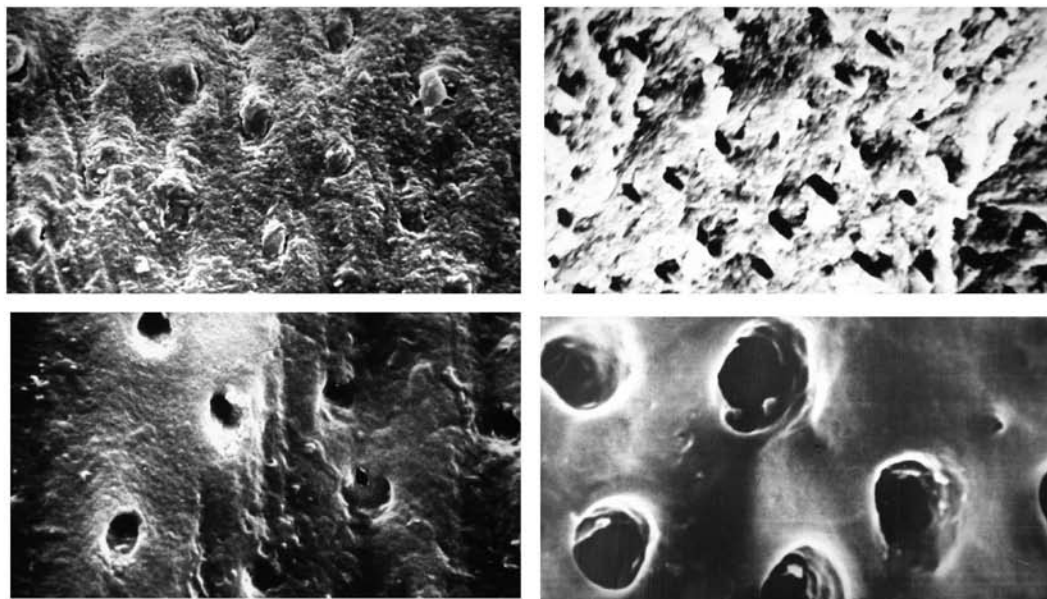


Fig. 3. Sequence of tubular aperture (start of the lesion).

In certain teeth, abfraction, in the same way as gingival recession, may act as predisposing factor. Bone and dental anatomical anomalies, and iatrogenic lesions in dental and periodontal treatments, also must be taken into account as possible etiological factors. As regards the start or initiation of the lesion, it is believed that loss of the thin (or smear) layer coating the dentine leads to tubule aperture (4).

Therapeutic considerations

Up to 90% of all patients with DS claim cold to be the principal triggering stimulus, while tactile stimuli are clearly seen to induce pain in 10% of cases (8).

Two types of therapeutic products can be considered: professional use and self-applied products. In patients with low or mild sensitivity, adequate counseling on foods, and the prescription of desensitizing toothpastes and/or oral rinses containing substances capable of occluding the dentinal tubules (strontium salts, oxalates or fluoridated agents), or agents capable of modulating nerve excitability (potassium salts), are of great help (13,14). In cases of moderate intensity DS, high-concentration fluoridated varnish or lacquer can offer good results (15). The above described treatment options can be classified as “reversible or noninvasive” (16). If such management measures prove ineffective, more complex but also more effective therapy can be decided on a stepwise basis. Such treatment is warranted in cases of severe DS, particularly if the disorder affects patient life style in some way. In such

situations treatment is “semi-invasive”, and includes the use of agents that can polymerize (dental adhesives) or set (glass ionomer) within the dentinal tubules, thereby occluding the latter. In extreme cases characterized by material or substance loss, “invasive” treatment can be decided, with the placement of crowns, periodontal surgery, or tooth extraction (16-20).

More sophisticated treatment, successfully used to deal with sensitivity, includes laser irradiation (CO₂, Nd:YAG) as desensitizing technique (21-23).

As regards the designing of studies to assess patient response to possible future management strategies, or to contrast the therapeutic effects of treatments that are already available, it is important to consider placebo effects, as well as spontaneous remission of the disorder, since both of these factors can limit the statistical power of the study (24).

Methodology for the objective evaluation of dentinal sensitivity

The study of DS is based on the stimuli applied to the exposed dentin, producing pain. A decisive requirement is the control, measurement, reproducibility and predictability of these stimuli, in order to compare the results of different studies in relation to the diagnosis and management of DS.

- Study design (1)

Ideally, a double-blind, randomized parallel group design (control and study group) is indicated, though cross-over

designs can be used for screening and initial selection of subjects to be included in the study. Patient assignment to one group or other should be made on a randomized basis, and stratification of the study components can be made, based on common characteristics.

The subjects forming part of the study - in both the placebo and study groups - are to be duly informed of the nature of the study, though individual counseling on treatments and etiological factors of DS are to be omitted, in order to avoid altering the natural course of the study.

A time period should be introduced before starting the study, during which the subjects are to avoid the use of desensitizing agents. This period also serves for training and the adoption of habits once the study begins.

- Study group

The study group selection criterion comprises dental maturity and the diagnosis of DS. The dental anatomical zones destined for study are the buccocervical surfaces of permanent teeth, since this is where DS is most often observed. The tooth or patient exclusion criteria are reported in Table 1.

- Control group

The use of a control group parallel to the study group allows us to evaluate the efficacy, equivalence or superiority of the study treatment. The negative control employed should involve omission of the study treatment or product.

- Study duration

The duration of the study will depend on whether the effects of the treatment or product are to be assessed over the short, middle or long term. Nevertheless, the time contemplated should be sufficient to express the maximum efficacy of the drug product used. A mean duration of 8 weeks is recommended (1). Once completed, follow-up over time is required to evaluate the persistence or reduction of the therapeutic effect found under the conditions of the study.

Methods for inducing dentinal sensitivity

Many stimuli are able to cause dentinal pain, though not all are adequate for assessing DS (25). Since the sensation produced by the stimulus may differ according to the method employed, it is advisable to use at least two hydrodynamic stimuli. The interval between the stimuli should be long enough to minimize interaction between them. The operators in charge of producing the stimuli should be calibrated - ideally only one investigator being in charge of performing stimulation. The initial intensity of the stimulus should be as low as possible, followed by gradual escalation to the threshold level (i.e., the minimum stimulus capable of eliciting pain). This procedure is to be repeated after some time, in order to obtain an average of values or a threshold range.

- Mechanical (tactile) stimuli (25)

Such stimuli include the following: scratching of the dentinal surface with a sharp-tipped probe; mechanical pressure stimulators; or use of the so-called Yeaple probe. Periodontal probes have been criticized on the grounds that they produce variability in the pressure applied.

These stimulators are applied perpendicular to the surface of the tooth, and the pressure in grams is gradually increased until the pain threshold is reached. In the case of the Yeaple probe, force variation is controlled by an electromagnetic device.

In general terms, if a force equivalent to 70 g is reached without eliciting pain sensation, the tooth is classified as non-sensitive. Normally, the applied force is increased in 5-g steps, taking care not to cause excessive tooth scratching that could give rise to further problems.

- Chemical (osmotic) stimuli (3)

Use is made of hypertonic solutions of glucose and sucrose, among others. Acid solutions have been discarded, since low pH values produce tubular demineralization that can worsen the symptoms. These solutions exert their effect through osmotic pressures that induce intratubular fluid

Table 1. Factors excluding teeth or subjects from the study group (1).

1. Current desensitizing therapy.
2. Medical treatment (including psychiatric treatment) and pharmacological therapy - including chronic antiinflammatory and analgesic use.
3. Pregnancy or nursing.
4. Allergies and idiosyncratic responses to any of the components used.
5. Eating disorders.
6. Systemic disorders causing or predisposing to dentinal sensitivity.
7. Prolonged environmental or dietary exposure to acids.
8. Dental restoration, periodontal surgery and/or orthodontics in the three months prior to selection.
9. Teeth or supporting structures with any other painful pathology or defect.
10. Teeth used as posts or abutments in fixed and removable dentures.
11. Dental crowns.
12. Extensive dental restorations and reconstructions affecting the study zone.

movement. The solution is applied with a cotton stick during 10 seconds, or until the subject reports discomfort. The use of stimuli of this kind for evaluating DS is not advised, however, due to the difficulty of controlling the response obtained.

- Cold air currents

An air current from the dental chair is applied for one second at a pressure of 45 psi, and at an environmental temperature of 19-24°C. The air current is applied at a distance of 1 cm, and perpendicular to the surface of the tooth (26,27). Application of the air current for more than one second leads to temperature variations. Due to the difficulty of localizing the sensitive dentine with the air current technique, the procedure is usually used for the screening and initial selection of teeth and subjects destined for study.

If tactile and thermal stimuli are jointly employed in one same individual, the tactile stimulus generally should be applied first to avoid doubts as to whether the pain produced after thermal stimulation is due to the low temperature or to dehydration induced by the air current (3).

- Cold water stimulation

Water at a temperature of 7°C is ideal for the identification of DS and for minimizing the incidence of false-positive results (3), though for identification of the pain threshold it is better to use a battery of syringes containing water at different temperatures (between 0-20°C) - beginning with the warmest water and gradually lowering the temperature. Application to the tooth should not exceed three seconds, and if no response is obtained, three minutes should be allowed to elapse before continuing with the next test at a lower temperature. The temperature of the water is lowered in steps of 5°C, and testing is stopped when a painful response is recorded, or when 0°C is reached (non-sensitive tooth).

- Thermoelectric systems

These techniques involve continuous heat or cold application, and allow quantification of the applied stimulus. The instrument used consists of a fine-tipped thermal probe placed on the surface of the tooth. The temperature range of the probe depends on the type of instrument used. Testing begins at a temperature of 25°C, followed by stepwise 5°C decrements until the study subject reports pain (26).

The probe must be correctly placed in contact with the surface of the tooth, in order to ensure that the adequate temperature is transmitted in each moment. As an inconvenience of this procedure, it must be taken into account that the main etiopathogenic factor of DS is exposure or stimulation with cold air or liquid - not solid elements - since the former induce intratubular fluid movements, indirect pressure changes, or direct thermoreceptor stimulation (5).

- Electric stimulation (3)

Electric stimulation (measured in volts) applied gradually

to the dentinal surface also can be used to evaluate DS. The risk posed by this method is the possibility of extending the stimulus to neighboring zones, due to current loss through the periodontium and subsequent stimulation of the periodontal nerves - thereby generating false-positive results.

Methods for evaluating response after stimulation (3)

Pain is a subjective experience in which perception is based on a range of variables, including: individual personality, psychological factors, degree of fear or anxiety, cultural factors, and social influences.

In view of the broad range of different expressions in response to one same stimulus, objective methodology is needed to quantify subjective patient response as far as possible.

- Verbal rating scale (VRS)

The patient uses a numerical code from 0 to 3 to rate perceived sensation (0 = no discomfort, 1 = mild discomfort, 2 = important discomfort, 3 = important discomfort lasting more than 10 seconds).

The main inconvenience of this scale is the limitation of the choice to only these few options - no detailed description of pain sensation being possible.

- Visual analog scale (VAS)

The patient scores pain intensity on a 10-cm straight line scale traced on a piece of paper. Specifically, 0 = no pain and 10 = extreme, unbearable pain (27).

Although this instrument does not allow us to distinguish between the sensory and affective components of pain, it is very practical and useful for assessing DS. The combination of this scale with a list of verbal pain descriptors serves to lessen the problem commented above.

- Global evaluation of dentinal sensitivity

Dentinal sensitivity can be evaluated in terms of both the "intensity of stimulus needed to produce pain (stimulus-based techniques)" and the "subjective evaluation of pain induced by a stimulus (response-based techniques)". At least two evaluations (one at the start and another at the end of the study) are required in order to determine testing effectiveness. In the first case pain threshold is the measurement used, while in the second case the intensity of pain is assessed (1).

In the response-based techniques (air current), the stimulus is constant, the study variable is based on the patient response, and the latter in turn is assessed by means of visual analog or verbal rating scales. However, in the case of stimulus-based techniques (thermoelectric systems, electric stimulation, mechanical stimulation, or water baths), subject response remains constant, while the study variable is based on increments or decrements in the intensity of the applied stimulus (1).

Conclusion

Dentinal sensitivity in periodontal patients is a factor to be taken into account by dental professionals, in view of the high prevalence of DS in this population. Correct management of the disorder requires a precise diagnosis - hence the importance of adequate knowledge of the underlying etiology and a correct differential diagnosis with respect to other dental processes that can be accompanied by brief and acute pain.

When designing studies to evaluate the nature and intensity of the stimuli that trigger DS, it must be taken into account that of all the etiopathogenic factors, stimulation with cold liquid or air is the main inducing cause. The mean duration of such studies should be 8 weeks, with subsequent follow-up to evaluate the persistence or reduction of the therapeutic effect. Depending on the design involved, both individual patient response and the nature of the triggering stimulus may be used as study variables.

References

- Holland GR, Narhi MN, Addy M, Gangarosa L, Orchardson R. Guidelines for the design and conduct of clinical trials on dentine hypersensitivity. *J Clin Periodontol.* 1997 Nov;24(11):808-13.
- Rees JS. The prevalence of dentine hypersensitivity in general dental practice in the UK. *J Clin Periodontol.* 2000 Nov;27(11):860-5.
- Gillam DG, Newman HN. Assessment of pain in cervical dentinal sensitivity studies. A review. *J Clin Periodontol.* 1993 Jul;20(6):383-94.
- Addy M. Dentine hypersensitivity: new perspectives on an old problem. *Int Dent J* 2002;52 Suppl 5/02:367-75.
- Pashley DH. Mechanisms of dentin sensitivity. *Dent Clin North Am.* 1990 Jul;34(3):449-73.
- Dowell P, Addy M, Dummer P. Dentine hypersensitivity: aetiology, differential diagnosis and management. *Br Dent J.* 1985 Feb 9;158(3):92-6.
- Rees JS, Addy M. A cross-sectional study of dentine hypersensitivity. *J Clin Periodontol.* 2002 Nov;29(11):997-1003.
- Chabanski MB, Gillam DG, Bulman JS, Newman HN. Prevalence of cervical dentine sensitivity in a population of patients referred to a specialist Periodontology Department. *J Clin Periodontol.* 1996 Nov;23(11):989-92.
- Chabanski MB, Gillam DG, Bulman JS, Newman HN. Clinical evaluation of cervical dentine sensitivity in a population of patients referred to a specialist periodontology department: a pilot study. *J Oral Rehabil.* 1997 Sep;24(9):666-72.
- Gillam DG, Seo HS, Bulman JS, Newman HN. Perceptions of dentine hypersensitivity in a general practice population. *J Oral Rehabil.* 1999 Sep;26(9):710-4.
- Addy M, Mostafa P, Newcombe RG. Dentine hypersensitivity: the distribution of recession, sensitivity and plaque. *J Dent.* 1987 Dec;15(6):242-8.
- Brännström M. Sensitivity of dentine. *Oral Surg Oral Med Oral Pathol.* 1966 Apr;21(4):517-26.
- Haywood VB. Dentine hypersensitivity: bleaching and restorative considerations for successful management. *Int Dent J* 2002;52 Suppl 5/02:376-84.
- Wara-aswapati N, Krongnawakul D, Jiraviboon D, Adulyanon S, Karimbux N, Pitiphat W. The effect of a new toothpaste containing potassium nitrate and triclosan on gingival health, plaque formation and dentine hypersensitivity. *J Clin Periodontol.* 2005 Jan;32(1):53-8.
- Pamir T, Ozyazici M, Balolu E, Onal B. The efficacy of three desensitizing agents in treatment of dentine hypersensitivity. *J Clin Pharm Ther.* 2005 Feb;30(1):73-6.
- Kielbassa AM. Dentine hypersensitivity: simple steps for everyday diagnosis and management. *Int Dent J* 2002;52 Suppl 5/02:394-6.
- Dababneh RH, Khouri AT, Addy M. Dentine hypersensitivity - an enigma? A review of terminology, mechanisms, aetiology and management. *Br Dent J.* 1999 Dec 11;187(11):606-11.
- Pandurić V, Knezević A, Tarle Z, Sutalo J. The efficiency of dentine adhesives in treating non-carious cervical lesions. *J Oral Rehabil.* 2001 Dec;28(12):1168-74.
- Polderman RN, Frencken JE. Comparison between effectiveness of a low-viscosity glass ionomer and a resin-based glutaraldehyde containing primer in treating dentine hypersensitivity--a 25.2-month evaluation. *J Dent.* 2007 Feb;35(2):144-9.
- Drisko CH. Dentine hypersensitivity - dental hygiene and periodontal considerations. *Int Dent J* 2002;52 Suppl 5/02:385-93.
- Zhang C, Matsumoto K, Kimura Y, Harashima T, Takeda FH, Zhou H. Effects of CO₂ laser in treatment of cervical dentinal hypersensitivity. *J Endod.* 1998 Sep;24(9):595-7.
- Lier BB, Rösing CK, Aass AM, Gjermo P. Treatment of dentin hypersensitivity by Nd:YAG laser. *J Clin Periodontol.* 2002 Jun;29(6):501-6.
- Sipahi C, Berk N, Ozen J, Atay A, Beydemir B. Tubule-occluding effect of desensitizing laser treatment on prepared dentin surfaces: an environmental SEM study. *Int J Prosthodont.* 2006 Jan-Feb;19(1):37-9.
- Yates RJ, Newcombe RG, Addy M. Dentine hypersensitivity: a randomised, double-blind placebo-controlled study of the efficacy of a fluoride-sensitive teeth mouthrinse. *J Clin Periodontol.* 2004 Oct;31(10):885-9.
- Orchardson R, Collins WJ. Thresholds of hypersensitive teeth to 2 forms of controlled stimulation. *J Clin Periodontol.* 1987 Feb;14(2):68-73.
- Gillam DG, Newman HN, Davies EH, Bulman JS, Troullos ES, Curro FA. Clinical evaluation of ferric oxalate in relieving dentine hypersensitivity. *J Oral Rehabil.* 2004 Mar;31(3):245-50.
- Addy M, West NX, Barlow A, Smith S. Dentine hypersensitivity: is there both stimulus and placebo responses in clinical trials. *Int J Dent Hyg.* 2007 Feb;5(1):53-9.