

Terminology of Dental Caries and Dental Caries Management: Consensus Report of a Workshop Organized by ORCA and Cariology Research Group of IADR.

Machiulskiene V^a, Campus G^b, Carvalho JC^c, Dige I^d, Ekstrand KR^e, Jablonski-Momeni A^f, Maltz M^g, Manton DJ^h, Martignon S^{i,j}, Martinez-Mier EA^k, Pitts NBⁱ, Schulte AG^l, Splieth CH^m, Tenuta Lⁿ, Ferreira Zandona A^o, Nyvad B^d.

^aClinic of Dental and Oral Pathology, Faculty of Odontology, Lithuanian University of Health Sciences, Kaunas, Lithuania;

^bKlinik für Zahnerhaltung, Präventiv- und Kinderzahnmedizin Zahnmedizinische Kliniken (ZMK) University of Bern, Switzerland; Department of Surgery, Microsurgery and Medicine Sciences, School of Dentistry, University of Sassari, Italy;

^cFaculty of Medicine and Dentistry, Catholic University of Louvain, Brussels, Belgium;

^dSection of Dental Pathology, Operative Dentistry and Endodontics, Department of Dentistry and Oral Health, University of Aarhus, Aarhus, Denmark;

^eSection of Cariology and Endodontics, Department of Odontology, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark;

^fDepartment of Orthodontics, Dental School, Philipps-University Marburg, Marburg, Germany;

^gDepartment of Preventive and Social Dentistry, Faculty Odontology, Federal University of Rio Grande do Sul, Brazil;

^hGrowth and Development Section, Melbourne Dental School, University of Melbourne, Victoria, Australia;

ⁱDental Innovation and Translation Hub, Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London, UK;

^jUNICA – Caries Research Unit, Research Vice-rectory, Universidad El Bosque, Bogotá, Colombia;

^kDepartment of Cariology, Operative Dentistry and Dental Public Health, Indiana University School of Dentistry, Indianapolis, Indiana, USA;

^lDepartment of Special Care Dentistry, Dental School, Witten/Herdecke University, Witten, Germany;

^mSection of Preventive & Pediatric Dentistry, University of Greifswald, Germany;

ⁿDepartment of Cariology, Restorative Sciences and Endodontics, School of Dentistry, University of Michigan, Ann Arbor, MI, United States;

^oDepartment of Comprehensive Care, School of Dental Medicine, Tufts University, Boston, MA, United States.

Corresponding author:

Vita Machiulskiene,
Clinic of Dental and Oral Pathology,
Faculty of Dentistry,
Lithuanian University of Health Sciences,
Eiveniu 2, 50009-LT
Kaunas, Lithuania.

E-mail: vita.machiulskiene@ismuni.lt

Key words: dental caries, dental caries management, dental caries terms, consensus

Abstract

A two-day workshop of ORCA and the IADR Cariology Research Group was organized to discuss and reach consensus on definitions of the most commonly used terms in cariology. The aims were to identify and to select the most commonly used terms of dental caries and dental caries management and to define them based on current concepts. Terms related to definition, diagnosis, risk assessment and monitoring of dental caries were included. The Delphi process was used to establish terms to be considered using the nominal group method favored by consensus. Of 222 terms originally suggested by six cariologists from different countries, a total of 59 terms were reviewed after removing duplicates and unnecessary words. Sixteen experts in cariology took part in the process of reaching consensus about the definitions of the selected caries terms. Decisions were made following thorough 'round table' discussions of each term, and confirmed by secret electronic voting. Full agreement [100%] was reached on 17 terms, while the definitions of 6 terms were below the agreed 80% threshold of consensus. The suggested terminology is recommended for use in research, in public health as well as in clinical practice.

Introduction

A joint workshop of ORCA and the IADR Cariology Research Group on the **Terminology of Dental Caries and Dental Caries Management** was organized on the 6-7th of February, 2019, in Frankfurt, Germany, in order to discuss and reach consensus on the definitions of the most commonly used terms in cariology. The inspiration to organize the present workshop was stimulated by continuous ongoing discussions among researchers, clinicians, public health professionals and policy makers regarding the most appropriate terms to describe conditions and characteristics of dental caries and related matters.

The organizers of the workshop agreed that the benefits of a common terminology would include facilitating researchers to share concepts, to document conditions as well as to interpret them in the same way, and to ease communication with clinicians.

Thus the aims of the workshop were: i) to identify the available terms in the literature used to describe dental caries and related matters; ii) to select the most commonly used terms and review their definitions, based on the current concepts; and iii) to discuss and agree upon the most appropriate terms and definitions. Terms related to the definition, diagnosis, risk assessment and monitoring of dental caries were included.

Methods

The Delphi process was used to establish the terms or statements and definitions to be considered using the nominal group method favored by consensus. Prior to the workshop, a group of six experts suggested by the ORCA Board, independently provided commonly used terms related to dental caries. The total number of terms suggested was 222. After removing duplicates and unnecessary words (e.g., Ex-vivo, In-vitro, In-vivo, Magnification aid, Prognosis, Diet, Fluorapatite, Fluoride, Micronutrient, Saliva, Salivary flow, Starch, Sucrose, Sugar), 121 terms were taken forward by the Editor-in-Chief of 'Caries Research', the official journal of ORCA. This number was then revised by several working group members (VM, BN and JC) and further reduced to 60 by removing synonymous terms (e.g., "Caries", "Dental caries", "Caries disease") and the terms that do not relate directly to dental caries (e.g., "coding", "detection aid"). The provisional definitions of the selected terms were provided by the chairpersons of the working group (VM and BN), and circulated to the group of 17 experts who independently decided on the appropriateness of the definitions. In total, 16 researchers with considerable research expertise in cariology participated in the workshop and in the process of reaching consensus about the definitions of the selected caries terms. Following discussions at the workshop, the final number of terms ended up at 59.

A priori, consensus was established as 80% agreement among the participating experts on the definition of each term. The decisions were made following thorough 'round table' discussions of each term, and confirmed by secret voting using an electronic program [Mentimeter, 2019]. The consensus percentage agreement is presented in parentheses [...], next to each term.

Results

The definitions of 59 terms related to dental caries and dental caries management were reviewed. Full agreement [100%] was reached on 17 terms, while the definitions of six terms ("caries incidence", "rampant caries", "visual detection of caries lesion", "ultra-conservative caries treatment", "therapeutic sealing") were below the agreed 80% threshold of consensus.

Definitions of dental caries as a disease:

Dental caries [100 %]

is a biofilm-mediated, diet modulated, multifactorial, non-communicable, dynamic disease resulting in net mineral loss of dental hard tissues [Fejerskov 1997; Pitts et al, 2017]. It is determined by biological, behavioral, psycho-social and environmental factors. As a consequence of this process, a caries lesion develops.

Caries diagnosis [94%]

is the clinical judgement integrating available information, including the detection and assessment of caries signs (lesions), to determine presence of the disease.

The main purpose of clinical caries diagnosis is to achieve the best health outcome for the patient by selecting the best management option for each lesion type, to inform the patient, and to monitor the clinical course of the disease [Nyvad et al, 2015].

Caries activity [100%]

is a concept that reflects the mineral balance, in terms of net mineral loss, net mineral gain or stasis over time. Caries active implies caries initiation/progression; caries inactive implies caries arrest/regression [Thylstrup et al, 1994].

Prognosis of caries [94%]

is the likely or expected course of dental caries.

"Caries free" [94%]

implies that there are no detectable signs of dental caries. It is a label that often leads to misunderstanding. This term should not be used without clearly indicating the threshold level.

“Cavity free” [81%]

implies that there are no detected cavities in dentine. However, thorough clinical examination may reveal the presence of non-cavitated and/or micro-cavitated carious lesions.

Caries care/management/control [100%]

are actions taken to interfere with mineral loss at all stages of the caries disease [Nyvad & Fejerskov, 2015], including non-operative and operative interventions/treatments. Because of the continuous de/remineralization processes, caries control needs to be continued throughout the life course.

The terms caries care/management/control may be more appropriate than the term “caries prevention”.

Caries prevention [88%]

Traditionally meant inhibition of caries initiation, otherwise called primary prevention. Primary, together with secondary and tertiary prevention, comprising non-operative and operative treatments, are now summarized under “caries care/management/control”.

Demineralization [94%]

is the loss of tooth mineral, due to acids.

In dental caries, this process is biofilm-mediated while in erosion, the acid comes from other sources.

Remineralization [100%]

is the net gain of mineral in previously demineralized tissue.

The word “remineralization” can be misleading as it does not imply that the lesion has regained its original mineral content.

Dental biofilm [100%]

is a consortium of microorganisms that stick to a tooth surface. The microorganisms are embedded in an extracellular polymeric matrix [modified from Hall-Stoodley et al, 2004].

Dental plaque [94%]

is a clinical term used commonly when referring to the dental biofilm.

Cariogenic [100 %]

describes substrates or microorganisms capable of promoting dental caries.

Cariogenicity [100%]

is the potential of substrates or microorganisms to promote dental caries.

Cariostatic [88%]

describes substances or procedures capable of arresting dental caries.

Definitions of terms used in dental caries epidemiology:

Caries experience [94%]

is the number of teeth/surfaces that have caries lesions (at a specified threshold), restorations and/or are missing due to caries, accumulated by an individual, up to a designated point in time. Traditionally, it has been measured by means of DMFT/S (dmft/s) at varying detection levels. New models and indices are being explored internationally.

Caries prevalence [94%]

is, in a strict sense, the number/proportion of individuals with caries in a given population at a specified threshold, at a designated point in time.

Case definitions are often misunderstood and are necessary. In many studies the prevalence of caries experience has been reported. Other specific examples of case definitions include reporting of total (untreated and treated) caries lesions in primary and permanent teeth, or untreated caries which includes lesions in primary and permanent teeth that have not received appropriate treatment [Fleming and Afful, 2018].

Caries incidence [69%]

is, in a strict sense, the number/proportion of individuals with new or progressing caries at a specified threshold in a given population, detected during a given period.

Caries surveillance [100%]

is the ongoing, systematic collection, analysis and interpretation of caries data, essential to the planning, implementation and evaluation of public health practice, and the timely dissemination of these data to those who need to know so that action can be taken [modified from Last, 2001].

Caries risk [94%]

is the probability that caries lesions will appear or progress if conditions remain the same within a stated period of time [modified from Last, 2001]. Caries risk is a proxy for the true outcome (new caries lesions or progression) which can only be validated over time.

Caries risk factor/determinant [94%]

is an environmental, behavioral or biological factor confirmed by temporal sequence, usually in longitudinal studies, which, if present, directly increases the probability of caries occurrence. The risk factor is part of the causal chain [Burt, 2001].

Modifiable risk factor [94%]

is a determinant that can be modified by intervention, thereby reducing the probability of caries.

Caries risk indicator/marker [94%]

is a characteristic associated with increased probability of caries or, increased occurrence of caries [modified from Last, 2001]. A risk indicator is not causally associated with the disease.

Caries risk management [88%]

are the measures taken to reduce the caries risk to which an individual or population is subject [modified from Last, 2001].

Definitions of terms related to the dental caries lesion:**Caries lesion [88%]**

is the clinical sign of caries. Caries lesions can be categorized according to their anatomical location on the tooth (coronal or root/cementum surface), their severity (e.g., non-cavitated, cavitated), depth of penetration into the tissue (e.g., enamel, dentin, pulp), and their activity status (active, inactive).

Caries lesion detection [94%]

is the identification of the signs of dental caries. Caries lesions can be detected clinically at various detection thresholds and stages, e.g. non-cavitated, micro-cavitated and cavitated. Caries lesions can also be detected by supplementary detection tools, such as radiography, optical and electrical methods.

In vitro caries lesion detection includes histology, transmission and scanning electron microscopy as well as confocal laser scanning microscopy.

Caries lesion severity assessment [81%]

is the staging of the process of net mineral loss progressing from small lesions to increasing degrees of tooth destruction through to involvement of dental pulp.

It can be achieved using a range of classification methods and systems. Examples include clinical staging into non-cavitated, micro-cavitated and cavitated lesions [Ekstrand et al, 1998; Nyvad et al, 1999]; clinical and radiographic staging into initial, moderate and extensive lesions [Pitts et al, 2013], and clinical staging from non-cavitated lesions to pulpal sepsis [Frencken et al, 2011].

Caries lesion activity assessment [88%]

seeks to differentiate lesions deemed caries active from lesions deemed caries inactive in order to provide optimal care planning where there is a focus on arresting active lesions. Inactive lesions and sound surfaces should receive background level care and appropriate monitoring. Several systems have defined the process to assess activity.

Activity status of a caries lesion is defined by surface characteristics [Thylstrup et al, 1994]. Clinical surface features, such as change of texture, translucency, color, and other factors such as presence of thick plaque and plaque stagnation area as well as gingivitis discriminate the likelihood of a lesion progressing, or non-progressing/arrested [Carvalho et al, 1989; Ekstrand et al, 1998; Nyvad et al, 1999, Nyvad et al, 2003; Ekstrand et al, 2007; Ismail et al, 2015; Carvalho et al. 2017; Nyvad and Baelum, 2018; Drancourt et al, 2019]. Different systems include different combinations of these characteristics, with varying weight.

Initial caries lesion [100%]

is a frequently used term for non-cavitated caries lesion. Although the term implies an early-stage lesion, the lesion could have been present in the mouth for a lifetime. The term refers to the stage of severity and does not inform about lesion activity.

White-spot lesion = “white spot” [94%]

is a popular term for non-cavitated lesions in the past. The term refers solely to the color of the lesion, has no bearing on the activity of the lesion, and may be confused with other types of pathology such as dental fluorosis or, MIH.

Sound enamel/dentin [100%]

is tooth structure without clinically detectable alterations of the natural translucency, color or texture.

Primary caries [100%]

is a caries lesion on previously sound tooth surface.

Secondary caries/recurrent caries [88%]

is a caries lesion developed adjacent to a restoration.

Residual caries [94%]

is a demineralized carious tissue left in place before a restoration is placed.

“Hidden” caries [94%]

is a caries lesion in dentine missed on visual inspection, but detected radiographically or with other detection devices. In the context of present diagnostic knowledge, it is a historic and confusing term.

Rampant caries [69%]

is a historic term used to describe multiple caries lesions in the same patient, often used in association with early childhood caries, or radiation caries.

Early childhood caries (ECC) [94 %]

is the early onset of caries in young children with often fast progression which can finally result in complete destruction of the primary dentition.

An epidemiological definition of early childhood caries is the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled surfaces, in any primary tooth of a child under age of six [Drury et al, 1999; Pitts et al, 2019].

Due to the frequent consumption of carbohydrates, especially sugars, and inadequate to none oral hygiene in small children, ECC demonstrates an atypical pattern of caries attack, particularly on smooth surfaces of upper anterior teeth [Wyne, 1999].

Caries lesion transition [100%]

is a change in caries lesion severity and/or activity stage in response to changes of lesion environment, for example mediated by caries control measures or changes in life style.

Visual detection of caries lesion [69%]

is the identification of the presence of a lesion visually.

Tactile assessment [81%]

is the atraumatic tactile evaluation of the surface integrity and texture of a caries lesion by use of a dental manual instrument. It should not be confused with the historical practice of lesion detection by catching of the probe (no longer recommended).

Radiographic detection [100%]

is the identification of a radiolucency interpreted as a caries lesion, on a dental radiograph.

Definitions of terms related to management of caries or caries lesions:**Caries lesion monitoring** [100%]

is an episodic assessment of the effect of an intervention or, the natural behavior on the clinical and/or radiographic status of a caries lesion [modified from Last, 2001].

Non-operative caries treatment/management/control/care [81%]

are non-surgical measures interfering with the initiation of new caries lesion and the rate of caries lesion progression [Carvalho et al, 1992]. This treatment aims to keep the caries process at subclinical level and/or arrest caries lesion progression at the clinical/radiographic level [Carvalho et al, 2004]. The key elements can include brushing with fluoride toothpaste, other fluoride treatments, dietary modification, oral hygiene measures etc.*

*Sealing/infiltration are not unanimously recognized as non-operative treatment measures, but they are another non-surgical way of managing caries (see below).

Operative (restorative) caries treatment (care) [94%]

is a surgical intervention to place a restoration to control caries, to aid biofilm control, and typically to restore form and function.

Non-restorative/non-operative cavity treatment [88%]

is the approach to make the cavitated caries lesions accessible to tooth cleaning by removal of overhanging enamel margins [Hansen & Nyvad, 2017; Santamaria et al, 2017].

Topical fluoride [100%]

are all methods of fluoride applied locally to teeth. They can be divided into self-applied (toothpaste, rinses, gels) or professionally applied (gels, varnishes, foams, solutions).

Systemic fluorides [94%]

are ingested fluorides. Historically this term referred to a supposed systemic effect. Currently, these methods of fluoride delivery such as fluoridated water and salt are used as public health measures that act through a topical effect when in contact with teeth.

Minimal intervention dentistry [81%]

is a holistic caries management philosophy that integrates caries lesion control and minimal operative intervention. The main objective is tissue preservation, including early caries detection and non-operative treatment, combined with minimally invasive restorative procedures [Frencken et al, 2012].

Preventive sealant/sealing [94%]

is the application of a thin physical barrier over a clinically sound caries predilection site, in order to prevent the initiation of a caries lesion. These can be applied to pits, fissures and fossae using resin composite or glass ionomer cement.

Therapeutic sealant/sealing [75%]

is the application of a thin physical barrier over a caries lesion in order to prevent its progression. These can be applied to pits, fissures, fossae and smooth surfaces [Martignon et al, 2006; Alkizy et al, 2009] using resin composite or glass ionomer cement.

Caries infiltration [94%]

is a micro-invasive intervention by which the pores of a non-cavitated caries lesion are infiltrated with low-viscosity resin after treating the surface with hydrochloric acid [Paris et al, 2007].

Atraumatic restorative treatment (ART) [88%]

is the tissue-saving caries management approach that uses hand instruments for opening caries cavities and removing decomposed carious dentine, followed by restoration with a high-viscosity glass-ionomer. The technique does not require access to electrically driven equipment and running water [Frencken et al, 1996].

Ultraconservative caries treatment [75%]

is a term used to define the method of bonded and sealed restorations placed directly over frank cavitated carious lesions extending into dentine [Mertz-Fairhurst et al, 1998].

Caries removal [88%]

is removal of carious tissue by the use of burs, hand excavators or other techniques.

Complete caries removal/non-selective caries removal to hard dentine [81%]

is excavation to hard dentine in the entire cavity. This technique is no longer recommended. [Innes et al, 2016].

Partial caries removal [100%]

is an excavation method by which carious dentine is removed from the peripheral walls of a deep cavitated caries lesion (excavated to hard dentine), followed by partial removal of soft dentine from the pulpal wall with hand excavator [Bjørndal et al, 1997; Maltz et al, 2018] or, round bur. Treatment is indicated for deep dentine lesions to avoid pulp exposure.

Selective caries removal to soft dentine [100%]

is an alternative term for **partial caries removal** [Innes et al, 2016].

Selective caries removal to firm/leathery dentine [94%]

is the excavation to firm/leathery dentine (physically resistant to hand excavation) in the pulpal aspect of the cavity. Periphery of the cavity should be excavated to hard dentine [Innes et al, 2016].

Stepwise caries removal [94%]

is the caries excavation in two (or more) steps, with a time interval between the steps, to stimulate mineral deposition in the dentine prior to final excavation [Bjørndal et al, 1997]. The first step is partial caries excavation followed by additional caries removal to firm dentine at a later date. [Innes et al, 2016].

Conclusion

In this consensus workshop the definitions of the most commonly used terms related to dental caries and dental caries management were discussed, updated and agreed on. The revised terms were based on current concepts published in the international scientific literature and on experts' opinions. The suggested terminology is recommended for the use in research, in the public health field as well as in clinical practice. A regular update of the terms is advisable in order to reflect up-to-date scientific standard.

Acknowledgements

The consensus workshop was sponsored by The European Organization for Caries Research (ORCA). Additional financial support was provided by Karger Publishers, the Cariology Research Group of the International Association for Dental Research (IADR), Procter and Gamble, and Colgate Palmolive.

Disclosure statement:

the authors declare that they have no conflicts of interest to disclose.

References:

Alkilzy M, Berndt C, Schidlowski M, Splieth CH: Sealing of proximal surfaces with polyurethane tape: a two-year clinical and radiographic feasibility study. *J Adhes Dent* 2009;11: 91-94.

Bjørndal L, Larsen T, Thylstrup A: A clinical and microbiological study of deep carious lesions during stepwise excavation using long treatment intervals. *Caries Res* 1997;31:411-417.

Burt BA: Definitions of risk. *J Dent Educ* 2001;65:1007-1008.

Carvalho JC, Ekstrand KR, Thylstrup A: Dental plaque and caries on occlusal surfaces of first permanent molars in relation to stage of eruption. *J Dent Res* 1989;68:773-779.

Carvalho JC, Thylstrup A, Ekstrand KR: Results after 3 years of non-operative occlusal caries treatment of erupting permanent first molars. *Community Dent Oral Epidemiol* 1992;20:187-192.

Carvalho JC, Van Nieuwenhuysen, JP, Maltz M. Traitement non-opératoire de la carie dentaire: Réalités cliniques : revue européenne d'odontologie 2004 ; 15 : 235-248.

Carvalho JC, Mestrinho HD, Oliveira LS, Varjão MM, Aimée N, Qvist V: Validation of the Visible Occlusal Plaque Index (VOPI) in estimating caries lesion activity. *J Dent* 2017;64:37-44.

Drancourt N, Roger-Leroi V, Martignon S, Jablonski-Momeni A, Pitts N, Doméjean S. Carious lesion activity assessment in clinical practice: a systematic review. *Clin Oral Investig* 2019;23:1513-1524.

Drury TF, Horowitz AM, Ismail AI, Maertens MP, Rozier RG, Selwitz RH: Diagnosing and reporting early childhood caries for research purposes. A report of a workshop sponsored by the National Institute of Dental and Craniofacial Research, the Health Resources and Services Administration, and the Health Care Financing Administration. *J Public Health Dent* 1999; 59:192-197.

Ekstrand KR, Ricketts DN, Kidd EA, Qvist V, Schou S: Detection, diagnosing, monitoring and logical treatment of occlusal caries in relation to lesion activity and severity: an in vivo examination with histological validation. *Caries Res* 1998;32:247-254.

Ekstrand KR, Martignon S, Ricketts DJ, Qvist V: Detection and activity assessment of primary coronal caries lesions: a methodologic study. *Oper Dent* 2007;32: 225-35.

Fejerskov O. Concepts of dental caries and their consequences for understanding the disease. *Community Dent Oral Epidemiol* 1997;25:5-12.

Fleming E, Afful J: Prevalence of total and untreated dental caries among youth: United States 2015-2016. NCHS Data Brief, no 307. Hyattsville, MD: National Center for Health Statistics. 2018.

Frencken JE, Pilot T, Songpaisan Y, Phantimvanit P: Atraumatic restorative treatment (ART): Rationale, technique and development. *J Publ Health Dent* 1996;56:135-240.

Frencken JE, de Amorim RG, Faber J, Leal SC: The Caries Assessment Spectrum and Treatment (CAST) index: rationale and development. *Int Dent J* 2011;61:117-123.

Frencken JE, Peters MC, Manton DJ, Leal SC, Gordan VV, Eden E: Minimal intervention dentistry (MID) for managing dental caries – a review: report of a FDI task group. *Int Dent J* 2012;62:223-243.

Hall-Stoodley L, Costerton JW, Stoodley P: Bacterial biofilms: from the natural environment to infectious diseases. *Nat Rev Microbiol* 2004;2:95-108.

Hansen NV, Nyvad B: Non-operative control of cavitated approximal caries lesions in primary molars: a prospective evaluation of cases. *J Oral Rehabil* 2017;44:537-544.

Innes NP, Frencken JE, Bjørndal L, Maltz M, Manton DJ, Ricketts D, Van Landuyt K, Banerjee A, Campus G, Doméjean S, Fontana M, Leal S, Lo E, Machiulskiene V, Schulte A, Splieth C, Zandona A, Schwendicke FP, Frencken JE, Bjorndal L et al: Managing carious lesions: consensus recommendations on terminology. *Adv Dent Res* 2016;28:49-57.

Ismail AI, Pitts NB Tellez M: The International Caries Classification and Management System (ICCMS™) An Example of a Caries Management Pathway. *BMC Oral Health* 2015;15 Suppl 1:S9.

Last JM: *A Dictionary of Epidemiology*. 4th Ed.. Oxford University press, New York, 2001.

Maltz M, Koppe B, Jardim JJ, Alves LS, de Paula LM, Yamaguti PM, Almeida JCF, Moura MS, Mestrinho HD: Partial caries removal in deep caries lesions: a 5-year multicenter randomized controlled trial. *Clin Oral Invest* 2018;22:1337-1343.

Martignon S, Ekstrand KR, Elwood R: Efficacy of sealing proximal early active lesions: an 18-month clinical study evaluated by conventional and subtraction radiography. *Caries Res* 2006;40:382-388.

Mentimeter. *Interactive presentation software*. [online] Available at: <https://www.mentimeter.com/> [Accessed 6-7 February, 2019].

Mertz-Fairhurst EJ, Curtis JR, JW, Ergle JW, Rueggeberg FA, Adair SM: Ultraconservative and cariostatic sealed restorations: Results at year 10. *JADA* 1998;129:55-66.

Nyvad B, Baelum V: Nyvad criteria for caries lesion activity and severity assessment: a validated approach for clinical management and research. *Caries Res* 2018;52:397-405.

Nyvad B, Fejerskov O: The caries control concept; in: Fejerskov O, Nyvad B and Kidd E (eds): *Dental Caries: The disease and its clinical management*, 3rd Edn. Oxford, Wiley Blackwell, 2015, pp 235-243.

Nyvad B, Machiulskiene V, Baelum V: Reliability of a new caries diagnostic system differentiating between active and inactive caries lesions. *Caries Res* 1999;33:52–260.

Nyvad B, Machiulskiene V, Baelum V: Construct and predictive validity of clinical caries diagnostic criteria assessing lesion activity. *J Dent Res* 2003;82:117-122.

Nyvad B, Machiulskiene V, Soviero VM, Baelum V: Visual-tactile caries diagnosis; in: Fejerskov O, Nyvad B and Kidd EAM (eds): *Dental Caries: The Disease and Its Clinical Management*, 3rd Edn. Oxford, Wiley Blackwell, 2015, pp 191-210.

Paris S, Meyer-Lueckel H, Colfen H, Kielbassa AM: Resin infiltration of artificial enamel caries lesions with experimental light curing resins. *Dent Mater J* 2007;26:582–588.

Pitts NB, Ekstrand KR, ICDAS Foundation: International Caries Detection and Assessment System (ICDAS) and it's International Caries Classification and Management System (ICCMS) -

methods for staging of the caries process and enabling dentists to manage caries. *Community Dent Oral Epidemiol.* 2013;41:e41-52.

Pitts NB, Zero D, Marsh P, Ekstrand K, Weintraub J, Ramos-Gomez J, Tagami J, Twetman S, Tsakos G and Ismail A. Dental caries. *Nat Rev Dis Primers* 2017;3:e17030.

Pitts N, Baez R, Diaz-Guallory C, et al. Early Childhood Caries: IAPD Bangkok Declaration. *Int J Paediatr Dent* 2019; 29: 384-386.

Santamaria RM, Innes NPT, Machiulskiene V, Schmoeckel J, Alkilzy M, Splieth CH: Alternative management options for primary molars: 2.5-year outcomes of a randomized clinical trial. *Caries Res* 2018;51:605-614.

Thylstrup A, Bruun C, Holmen L: In vivo caries models – mechanisms for caries initiation and arrestment. *Adv Dent Res* 1994;8:144-157.

Wyne AH: Early Childhood Caries: nomenclature and case definition. *Community Dent Oral Epidemiol* 1999;27:313-315.