DENTAL GUIDELINE

S2k Guideline (unabridged version)

Caries prevention in permanent teeth – basic recommendations*

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Leading professional associations:

German Association of Conservative Dentistry
Deutsche Gesellschaft für Zahnerhaltung (DGZ)

German Society of Dental, Oral and Craniomandibular Sciences
Deutsche Gesellschaft für Zahn-, Mund- und Kieferheilkunde (DGZMK)

Other AWMF professional associations involved:

German Society of Paediatric Dentistry
Deutsche Gesellschaft für Kinderzahnheilkunde (DGKiZ)

German Society of Prosthetic Dentistry and Biomaterials
Deutsche Gesellschaft für Prothetische Zahnmedizin und Biomaterialien e.V. (DGPro)

Other specialist associations/organisations involved:

German Federal Association of Paediatric Dentists
Bundesverband der Kinderzahnärzte (BUKiZ)

German Federal Association of Dentists in the Public Health Service
Bundesverband der Zahnärzte des Öffentlichen Gesundheitsdienstes e.V. (BZÖG)

German Dental Association
Bundeszahnärztekammer (BZÄK)

German Association of Aesthetic Dentistry
Deutsche Gesellschaft für Ästhetische Zahnheilkunde e.V. (DGÄZ)

German Association of Endodontics and Dental Traumatology
Deutsche Gesellschaft für Endodontologie und zahnärztliche Traumatologie (DGET)

German Nutrition Society
Deutsche Gesellschaft für Ernährung e.V. (DGE)

Free Association of German Dentists
Freier Verband Deutscher Zahnärzte e.V. (FVDZ)

German National Association of Statutory Health Insurance Dentists
Kassenzahnärztliche Bundesvereinigung (KZBV)

Association of German Certified Endodontists
Verband Deutscher Zertifizierter Endodontologen (VDZE)

German Association of Medical Professions (Qualified Dental Assistants Division)
Verband medizinischer Fachberufe e.V. (Referat Zahnmedizinische Fachangestellte)

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The "guidelines" of the Scientific Medical Professional Societies [Wissenschaftliche Medizinische Fachgesellschaften] are systematically developed aids for doctors/dentists in decision-making in specific situations. They are based on current scientific knowledge and practically established procedures and thus serve to provide more safety in medicine, while also taking economic aspects into consideration. The "guidelines" are not legally binding for doctors/ dentists and thus provide neither a basis for liability claims nor for freedom from liability.

*The English translation was critically reviewed for grammar and style by Dr. Gabriela Ibarra, DDS, MS, MPH, Associate Professor, Department of Restorative Dentistry, Oregon Health and Science University (OHSU), Portland, Oregon-USA, and Dr. Gerald E. Denehy, Professor emeritus, College of Denistry and Dental Clinics, The University of Iowa, Iowa City, Iowa, USA

CONTENTS

1 Preamble

The principal objective of conservative dentistry is the preservation of health of the natural or caries-free dentition, as well as that of the restored dentition. This guideline from the German Association of Conservative Dentistry [Deutsche Gesellschaft für Zahnerhaltung (DGZ)] and the German Society of Dental, Oral and Craniomandibular Sciences [Deutsche Gesellschaft für Zahn-, Mund- und Kieferheilkunde (DGZMK)] provides basic recommendations for caries prevention in permanent teeth.

Attention is paid to recommendations for cases where there is a high risk of caries in accordance with the definition of the American Dental Association (ADA) Council on Access, Prevention and Inter-professional Relations (CAPIR) (1995). No attention is paid to specific recommendations for children of pre-school age and for groups with an especially high risk of caries, e.g. patients who have undergone radiation therapy or with severely limited mobility.

Regarding fluoridation measures, the starting date for the literature search was in 2008, because the period before that year had already been covered for the guideline on fluoridation measures for caries prevention (AWMF Register No. 083-021, 2013).

This guideline does not address invasive caries treatment (surgical hard tissue intervention), which can also be understood as a measure of secondary prevention, nor the prevention of non-cariogenic loss of hard tooth tissue, such as dental erosion and/or abrasion. The recommendations on nutrition relate solely to caries prevention and are not intended to replace the general recommendations given by the appropriate professional associations. Furthermore, this guideline does not contain any information about the prevention of periodontal diseases.

Caries prevention can be carried out as part of an individual prevention program at home and/or in the dental office and also as part of group prevention or public health programs.

Accordingly, this guideline is directed to the majority of the population in the Federal Republic of Germany. It has been developed for dentists and other dental health care professionals as well as teachers, parents or other care providers for its implementation.

The aim, building on present knowledge about the etiology and pathogenesis of caries, is to provide scientifically sound statements about basic measures and recommendations for caries prevention in permanent teeth. The literature search for the present guideline (2003-2014) yielded only a few new findings from specific clinical studies (see appendix “Methodology and tables of studies”; the studies found are included in the references list).

The order in which the various methods for caries prevention are dealt with, is not intended to imply any order of priority, but is based solely on practical considerations.

To make the guideline easier to read, masculine and feminine language forms are not used together. All descriptions referencing people apply equally to both sexes. (This does not apply to the English translation of this guideline).

2 Caries – etiology and pathogenesis

Dental caries is a localized disease that affects the teeth, which results from the interaction of a cariogenic, microbial biofilm and certain components of the diet (especially low-molecular-weight carbohydrates). The biofilm develops dynamically and is influenced by microbial metabolic processes and interactions amongst the various microbial species and their interaction with the host. Both, the composition and the "dynamics" of the oral biofilm over time, have their own very different and particular characteristics with corresponding implications for the prevention and treatment of plaque-associated diseases (Filoche *et al.*, 2010). The transition from "healthy" to "diseased" is crucially determined by host factors and the "plaque dynamics". If the equilibrium between the host and microbial film is disturbed, the balance shifts towards disease (Sbordone and Bortolaia, 2003).

Caries develops when, due to the action of microbial acids, demineralization (i.e. the dissolution of minerals) on the tooth surface exceeds the protective and remineralizing influences (factors). During this process, co-factors such as a reduced saliva flow rate, play an additional role. Saliva influences the removal of cariogenic food from the oral cavity ("clearance") and the neutralization of the acids in the biofilm (Buchalla, 2012).

The onset of caries is highly dependent on behaviour. If appropriate preventive measures are taken, carious lesions can be prevented (primary prevention), arrested in their progression (secondary prevention) or remineralized (Longbottom *et al.*, 2009).

Primary caries prevention includes:

1. Elimination or monitoring of the microbial factors (cariogenic biofilm)
2. Motivation to adopt a diet that promotes dental health
3. Promotion of the protective mechanisms of the saliva
4. The use of different fluoridation measures, in order to counteract the demineralization of the hard dental tissue and to promote remineralization, when signs of demineralization first become evident.

3 Consensus-based and agreed statements and recommendations

3.1. Mechanical processes for reducing the biofilm

The term “oral hygiene measures” is used to denote methods for preventing the formation of a pathological plaque and for removing it. Caries results from the metabolic activity of a pathogenic, bacterial biofilm on the teeth. Therefore, it seems obvious and biologically plausible that caries can be prevented if this biofilm is removed mechanically or influenced chemically in an appropriate way.

There is a solid body of evidence confirming that brushing the teeth twice a day with a fluoride-containing toothpaste reduces caries prevalence, and that brushing with a fluoride-containing toothpaste more than once a day has shown a better caries-preventive effect than brushing only once a day (Hellwig *et al*., 2013; Marinho *et al*., 2003; Centers for Disease Control and Prevention, 2001). However, it is impossible to deduce from the relevant studies, what proportion of the caries-preventive effect is due to the action of the fluoride and what proportion is due to the mechanical removal of the biofilm. There are no appropriately carried-out clinical studies available that prove that caries can, in fact, be prevented solely by means of mechanical oral hygiene measures (Swedish Council on Technology Assessment in Health Care, 2002; Davies *et al*., 2003; National Oral Health Promotion Clearing House, 2011). In this context, during the present literature search, it was only possible to find one longitudinal cohort study in which data was collected regarding the correlation between the frequency of tooth brushing and the development of new carious lesions within the framework of a 5-year prospective study of children ages 6-10 years who were undergoing restorative treatment consisting of direct fillings (Maserejian *et al*., 2009).

Due to the lack of appropriate studies, the assumption that a reduction in the incidence of caries can result from the removal of plaque by an individual´s own initiative, can only be demonstrated by means of surrogate parameters. Toothbrushing once a day leads to an average plaque reduction of 42%. Depending on the plaque index used, the values vary between 30% and 53% (Slot *et al*., 2012). It is unclear whether a reduction in plaque on this scale is always linked to a reduction in the risk of caries. It is assumed, however, that the caries-inhibiting effect of toothbrushing probably depends on the quality, rather than on the frequency of toothbrushing (Brothwell *et al*., 1998). In this context, the time allotted to oral hygiene measures plays an important role in this caries-inhibiting effect. On average, a 27% reduction in plaque is achieved with 1 minute of toothbrushing and a 41% reduction is achieved with 2 minutes of toothbrushing (Slot *et al*., 2012). However, there is no clear data regarding the exact duration, frequency, timing and method of toothbrushing for optimal benefit (Attin and Hornecker, 2005).

Both, manual toothbrushes and electrically powered toothbrushes can be used to remove the biofilm. In short-term as well as in long-term studies, it was possible to remove more plaque with electrically powered toothbrushes than with manual toothbrushes. It is, however, unclear whether these results have any clinical relevance (Sicilia *et al*., 2002, Yaacob *et al*., 2014).

The teeth should be cleaned after meals to ensure the removal of any biofilm that is present, as well as of food debris, which could be available as a substrate for cariogenic bacteria. Nonetheless, there is no evidence for these recommendations from randomized clinical studies. As a general recommendation for oral hygiene, the individualized cleaning technique should be optimized and a systematic approach should be practiced.

Due to the fact that toothbrushes are unable to penetrate completely into the interdental space, aids such as dental floss or interdental brushes are often recommended. It seems plausible that the risk of interproximal caries is reduced through regular use of dental floss or interdental brushes. However, a considerable reduction in interproximal caries has only been demonstrated in one study involving small children with poor oral hygiene habits and low fluoride intake (Wright *et al*., 1979). In all other studies, there is no proof of a reduction in caries through the regular use of dental floss (Hujoel *et al*., 2006). Even in the Cochrane Review of Sambunjak *et al*. (2011) on the effectiveness of flossing in addition to teeth-cleaning to prevent gum disease and tooth decay in adults, the authors came to the conclusion that no studies exist regarding the caries-preventive effect of dental floss in adults. There is also only weak, unreliable evidence that a slight reduction in interproximal plaque is achieved through the additional use of dental floss (Berchier *et al*., 2008; Sambunjak *et al*., 2011). Good mechanical removal of the biofilm with the toothbrush with simultaneous use of fluoride seems to

obscure the caries-inhibiting effect of the regular use of dental floss. No studies are available on the correlations between the use of interdental brushes and caries. In the Cochrane Review of Poklepovic *et al*. (2013), the effectiveness of the use of interdental brushes in addition to toothbrushing was compared with toothbrushing alone or toothbrushing and flossing, regarding the prevention of periodontal disease, dental plaque formation and caries development in adults. In none of the studies included in this review, was there any data collected on the parametercaries.

Thus the use of dental floss, just like the use of interdental brushes for interproximal hygiene, is based first and foremost on the conclusion that plaque can be removed more effectively with these aids than with the toothbrush alone and that consequently, there is also a resulting caries-inhibiting effect.

There is insufficient evidence, based on well-designed clinical trials, about the effectiveness of mechanical biofilm removal by means of toothbrushing alone to prevent caries. However, the caries-prevention effectiveness of toothbrushing with fluoride toothpaste has been proven.

There is insufficient evidence, based on well-designed clinical trials, about the effectiveness of interproximal mechanical biofilm removal alone regarding caries prevention. However, through the incorporation of methods to clean the interdental spaces, food debris and perhaps cariogenic microorganisms are removed.

Consented recommendation:

As basic prevention, patients should clean their teeth at least twice a day with a fluoride toothpaste using a method which eliminates as much of the biofilm as possible. Depending on the patient, different toothbrushes may be used. If food debris and biofilm cannot be adequately removed through toothbrushing alone, hygiene aids in the interproximal spaces (dental floss, interdental brushes) should be used in addition.

3.2 Influencing the biofilm by the use of chemical compounds

Apart from mechanical aids, different chemical compounds in toothpastes as well as in mouthwashes, gels and varnishes are used to influence the metabolism and to prevent the growth of cariogenic microorganisms. Reviews show that the use of such products leads to a reduction in bacteria. The available data regarding the caries-reducing effect is, however, weak and inconsistent (Van Rijkom *et al.*, 1996; Bader *et al.*, 2001; Anderson, 2003; Derks *et al.*, 2004; Zhang *et al.*, 2006 a, b; Autio-Gold, 2008; James *et al.*, 2010; Marsh, 2010; Rethmann *et al.*, 2011; Rodrigues *et al.*, 2011; Gluzman *et al.*, 2013, Simon-Soro and Mira, 2015). No additional caries-preventive effect is detectable when chemical plaque inhibitors are used, especially in patients who practice appropriate care with fluoride products. Nevertheless, a caries-reducing effect in pit and fissures in erupting molars and in root caries can be established for chlorhexidine varnishes (Twetman, 2004; Slot *et al.*, 2011).

It is evident from a systematic review of toothpastes containing triclosan/copolymer that its addition leads to a slight reduction in caries (DMF-S) in the coronal area of the teeth (Riley and Lamont, 2013). There is also weak evidence of the effectiveness of triclosan/copolymer with respect to root surface caries. However, it is questionable whether this slight reduction is clinically relevant. The question of oral microorganisms possibly developing resistance following the use of triclosan-containing oral hygiene products has not yet been resolved conclusively (Bundesinstitut für Risikobewertung, 2006 and 2009).

The addition of arginine to toothpastes also leads to a reduction in caries in the coronal and root areas, which can be interpreted as being additional to the effect of fluoride (Hu *et al.*, 2013; Kraivaphan *et al.*, 2013; Souza *et al.*, 2013; Srisilapanan *et al.*, 2013). Here, as well, the evidence from studies is yet not sufficient to make a clear clinical recommendation regarding its use for basic prevention.

No recommendation can be made regarding the use of other chemical compounds (e.g. essential oils, cetylpyridinium chloride, phenols) for caries prevention.

Influencing the biofilm by the use of chemical compounds

Consented recommendation:

The professional use of CHX varnishes containing at least 1% CHX can be recommended for caries prevention in erupting permanent teeth or in the exposed root area.

3.3 Prevention programs

With an overall approach, including the use of different preventive measures, it is possible to reduce caries significantly. This has been shown in carefully carried out clinical studies for all age groups (Hamp *et al*., 1978, 1984; Axelsson and Lindhe, 1974, 1978; Axelsson *et al*., 2004). However, these studies do not allow any statement about the relative effectiveness of individual measures to be made.

Preventive programs often involve a combination of information, motivation and instruction at various time intervals as well as various types of fluoride applications. Hugoson *et al*. (2007) compared the effect of various programs on plaque and gingivitis in young adults. All programs led to a reduction in the plaque and gingival indexes. Most programs in which fluoridation measures were also carried out resulted in a 30-70% reduction in caries. It was not possible to show that a certain combination of measures or certain fluoride products were more effective than others (The Swedish Council on Technology Assessment in Health Care, 2002).

Prevention programs

Consented recommendation:

By combining various prevention measures, it is possible to reduce caries considerably. Participation in structured prevention programs should be recommended especially to patients with a high risk of caries.

3.4 Fluoridation measures

One of the most important cornerstones of individual and group-based caries prevention is the use of different fluoride-containing products. Numerous meta-analyses and systematic reviews (Gluzman *et al*., 2013; Heijnsbroek *et al*., 2007 Marinho *et al*., 2002 a,b, 2003 a,b, 2004; SCTAHC, 2002) have come to the conclusion that the use of fluoride-containing products leads to different, but significant, caries reduction rates. In 2005, the AWMF published a guideline on fluoridation measures for caries prevention, which was updated in 2013 (AWMF Register No. 083- 001, Hellwig *et al.,* 2013). The recommendations below are based on the AWMF guideline. The publications mentioned in the various chapters and in the tables of studies in this guideline, which relate to studies available after the completion of the AWMF guideline, confirm the recommendations given in the latter guideline. However, statements concerning fluoridation measures regarding children of pre-school age have not been taken into consideration in the present guideline. As a basic rule, when fluoridation measures are employed, the total intake of fluoride that is swallowed from the products used and the intake of fluoride from food and drink should not exceed a value of 0.05 mg fluoride per kg of body weight per day (EFSA, 2013). With regard to recommendations for fluoridation measures, attention must be paid to the fluoride content in drinking water. The 2013 fluoride guideline was based on a literature search up to the year 2008. Consequently, for the present guideline the literature search was limited to the years 2009-2013.

Fluoride-containing toothpaste

Both, systematic reviews as well as fluoride recommendations from different professional associations, arrive consistently to the conclusion that the daily use of fluoride toothpaste (1000 to 1500 ppm fluoride) represents an effective method for caries prevention in children and adolescents (Marinho *et al*., 2003; American Academy of Pediatrics, 2008; Canadian Dental Association, 2012; European Academy of Paediatric Dentistry, 2009; Scottish Intercollegiate Guidelines Networks, 2005; The Swedish Council on Technology Assessment in Health Care, 2002; Walsh *et al*., 2010). In this context, it is evident that the effectiveness is dependent on dose and that in addition, there is a direct relation to the frequency of use. There is little scientific evidence for the cariostatic effectiveness of fluoride toothpaste in older adults. However, nothing indicates that the preventive effect differs significantly from that in younger people (McGrath *et al*, 2009; Davies, 2004; Griffin *et al*., 2007; Heijnsbrock *et al*., 2007). Moreover, the use of a high-concentration fluoride toothpaste (5000 ppm F) seems to play an important role in the prevention of root surface caries (Baysan *et al*., 2001; Ekstrand *et al*., 2013; Gluzman *et al*., 2013).

In the systematic literature search for this guideline, six new original articles were identified (see tables; the publications are contained in the list of references) which met the criteria for a clinical study. In addition, numerous reviews were identified as well that did not lead to any new knowledge from the one compiled in the original guideline on fluoridation measures. Consequently, they have not been taken into consideration. In the studies in which fluoride toothpaste was used to prevent caries, other prevention measures were carried out simultaneously, therefore the caries-preventive effectiveness of fluoride toothpaste alone could not be assessed. In summary, it is possible to refer to the statement from the 2013 guideline on fluoridation measures for caries prevention ["Fluoridierungsmaßnahmen zur Kariesprophylaxe"]:

"The use of fluoride toothpaste containing at least 1000 ppm fluoride is a widespread and effective caries-preventive measure; the effectiveness of which has been proven beginning at school age. Therefore, it is recommended that the teeth be cleaned with a toothpaste that contains at least 1000 ppm fluoride from the moment the permanent teeth erupt. The effectiveness increases if the frequency of toothbrushing is increased from once to twice daily and if the toothpaste has a higher concentration of fluoride."

Fluoride varnish

In most of the clinical studies identified in the literature search (see tables in the Appendix; the relevant publications are included in the list of references) and the reviews, it was evident that fluoride varnishes have a caries-preventive effect.

However, the studies investigated different groups of patients. In addition, the varnishes containing fluoride were applied at different frequencies. In patients with a risk of root caries there is substantial evidence that quarterly treatments with fluoride varnish lead to a reduction in caries. This is also confirmed in a recent literature review by Gluzman *et al*. (2013) and in another review by Petersson (2013). Overall, no new information in addition to the one already contained in the guideline on fluoridation measures (Hellwig *et al*., 2013) was found during the review of these clinical studies.

It follows that the recommendations of the 2013 guideline on fluoridation measures still apply without restriction:

"In the case of children and young people a fluoride varnish should be applied twice a year. The local application of a fluoride varnish can be carried out regardless of any other general fluoridation measures already in use. Regarding patients with a very high risk of caries, the frequency of fluoride applications should be more than twice (normally four times) a year, because then an enhanced caries-reducing effect can be expected."

The varnishes are to be applied by the dentist or delegated to trained dental personal (e.g. dental hygienist, qualified dental assistant). The use of fluoride varnish should also be considered as an additional caries-preventive measure for adults (Marinho *et al*., 2002, 2004).

Fluoride gel

Seven recently identified studies (see tables and references) confirm the statement made in the guideline on fluoridation measures (Hellwig, et al. 2014), that fluoride gels have a caries-preventive effect. This also applies to preventing and arresting root surface caries (Leake, 2001). The application of fluoride gels (in Germany gels with a fluoride concentration of 1.25 % are used for the most part) leads to the inactivation and remineralization of initial carious lesions, especially in caries-active patients. However, the results are very heterogeneous.

Fluoride tablets

Three studies were identified that demonstrated a caries-reducing effect of fluoride tablets. However, the evidence in the study published by Meyer-Lückel *et al*. (2010) is lessened by numerous confounding variables. In the investigation by Liu *et al*. (2013), mentally disabled children were studied in a special program. Here, the fluoride tablets were dissolved slowly in the mouth and led to a 30.4% reduction in caries (DMFT). The investigation by Stecksen-Blicks *et al*. (2008) concluded that the use of xylitol-containing fluoride tablets for dissolution in the mouth (sucking) does not represent a suitable preventive measure for children with a high risk of caries because compliance is poor. There is still a lack of recent randomized studies on the use of fluoride tablets (Espelid, 2009). It can be concluded from this, that fluoride tablets are effective for preventing caries under certain conditions (see also 2013 guideline on fluoridation measures), but that its effectiveness is linked to good patient compliance. The recommendation from the guideline on fluoridation measures is as follows:

"Fluoride tablets are effective for preventing caries. They should be dissolved in the mouth (sucked) after the eruption of teeth in order to maximize the topical active component. If a relevant amount of fluoridated table salt is consumed regularly, the administration of fluoride tablets should be discontinued."

This also applies if the teeth are brushed twice a day with a fluoride-containing toothpaste.

Fluoridated table salt

The use of fluoridated table salt can be recommended as a further basic fluoridation measure. The scientific evidence for the cariostatic effect of fluoridated table salt is, however, weak in countries in which other fluoridation measures (fluoride toothpaste, fluoride varnish, etc.) are already in use. In a review by Espelid (2009) it is concluded that there are no randomized clinical studies on the caries-reducing effect of fluoridated table salt.

During the literature search for the present guideline, no new clinical studies concerning the fluoridation of table salt were found. However, in a meta-analysis by Yengopal *et al*. in 2010, they concluded that the fluoridation of table salt contributes to a reduction in caries in children and adolescents (age group 6-15 years). Therefore, this guideline must refer to the information contained in the AMWF guideline on fluoridation measures (Hellwig *et al*., 2013):

"It has been reported that the fluoridation of table salt has a caries-preventive effect. In countries where there is already a high level of caries prevention, an additional beneficial effect of the use of fluoridated table salt cannot be quantitatively demonstrated."

Fluoride-containing mouthwashes

The use of fluoride-containing mouthwashes has a caries-preventive effect.

With regard to fluoride-containing mouthwashes, a total of five clinical studies were identified for the present guideline. However, due to the design of the trials, they provide relatively little information (see tables and references). Therefore, regarding the use of fluoride mouthwashes, reference must be made again to the AMWF guideline on fluoridation measures (Hellwig *et al*., 2013):

"In children with a high risk of caries, the daily supervised use of mouthwashes (with a concentration of 0.05 % NaF) or the once weekly supervised use of a mouthwash (0.2 % NaF), leads to a significant reduction in the caries incidence. Due to the fact that this effect is not dependent on the use of other fluoride-containing products, e.g. toothpastes, the use of a fluoride mouthwash is recommended for children and young people with a high caries risk. On the basis of the available evidence from studies it can be assumed that fluoride-containing mouthwashes contribute to the prevention of caries in young people (especially if orthodontic treatment is carried out with fixed appliances)."

Fluoride-containing mouthwashes should also be used to prevent root caries. This is confirmed in a systematic review from 2003 by Marinho *et al*.

Fluoride application in prevention programs

Four clinical studies (Featherstone *et al*., 2012; Hadler-Olsen *et al*, 2012; Monse *et al*., 2013; Nakamura *et al*., 2009) were identified in which different fluoride preparations were used. However, they were used within the framework of complex prevention programs, so the relative caries-preventive effectiveness of fluoridation could not be assessed in itself.

Summary:

Fluoride-containing toothpastes:

The daily use of fluoride toothpaste is an effective method of caries prevention. The effectiveness depends on the fluoride concentration and the frequency of use. This applies both to children and young people and to adults.

Fluoridated table salt:

The caries-inhibiting action of fluoridated table salt has been proven. However, the isolated effect is difficult to prove in countries in which other fluoridation measures (fluoride toothpaste, fluoride varnish etc.) are already carried out.

Fluoride varnishes and gels:

There is evidence of the caries-preventive effect of fluoride varnishes and fluoride gels. In this context the varnishes or gels are applied professionally. Gels can also be used by the patients themselves (brushing). If there is high caries activity the preventive effect is improved when the frequency of application is increased.

This applies also to the prevention and arresting of root surface caries (Leake, 2001). Here, a quarterly application of fluoride varnish or the use of fluoride gels is recommended.

Fluoride-containing mouthwashes:

The use of fluoride-containing mouthwashes has a caries-preventive effect, especially in patients with a high caries risk (e.g. orthodontic treatment).
The daily use of fluoride-containing mouthwashes is recommended for patients with root caries risk.

Fluoridation measures

Consented recommendation:

Patients should brush their teeth with a fluoride-containing toothpaste. In addition to this, fluoridated table salt should always be used in the home. Also, the use of a toothpaste with a high fluoride concentration and fluoride varnishes, gels or mouthwashes may be indicated (especially in relation to caries-active patients).

3.5 Nutrition recommendations

There is convincing evidence available from animal studies and from epidemiological and experimental studies in humans that a correlation exists between the quantity and frequency of the intake of free sugars and the onset of caries. Up until about 1970, it was possible to find a very positive correlation between sugar consumption and the prevalence of caries in a number of countries (Sreebny, 1982). Following the introduction of fluoridation measures, however, only a weak correlation is detectable (Burt and Pai, 2001).

Sugars, in this sense, are all mono- and disaccharides. Free sugars are all sugars that are added to foods by either manufacturers or consumers, as well as the sugars that are present naturally in honey, fruit juices, syrup etc. Other fermentable carbohydrates are also cariogenic, but epidemiological studies have shown that starchy basic foods and fresh fruits are only weakly associated with caries. The cariogenicity of uncooked starch is very low; that of finely-ground and heat-treated starch is higher, but not as high as that of sugars (Moynihan and Petersen 2004; Sheiham, 2001).

There are very few randomized clinical studies in the literature that address the question of the correlation between sugar consumption and caries. The reason for this is that it is very difficult to entirely eliminate the consumption of sugar and sugar-containing foods and drinks. Previously, in the Turku sugar study, sucrose was entirely replaced with xylitol and fructose in a strictly controlled manner (Scheinin *et al*., 1976). On behalf of the WHO, Moynihan and Kelly (2014) examined all the available data related to the correlation between the quantity of sugar consumption (per day or year or as a percentage of the total energy intake) and the prevalence of caries. In 5 out of 8 cohort studies that were included, more caries was found where sugar consumption was >10%, as opposed to <10%, of the total energy requirement. The effect of a further reduction in the quantity of sugar to below 5% of the total energy requirement has not been adequately demonstrated. Anderson *et al*. (2009) found a significant correlation between the total quantity of sugar consumption and caries in only 6 out of 15 of the studies included in their review. However, in a different set of studies, 19 out of 31 showed a significant correlation between the frequency of sugar consumption and caries. Examples that can be mentioned in this regard are two studies in children, which concluded that the risk of caries increases considerably as a result of more than four or five sugar-containing snacks between meals (sweet foods and/or sweet drinks in addition to three main meals) (Holbrook *et al*., 1989, 1995; Kalsbeek and Verrips, 1994).

In the current literature search, cohort studies, cross-sectional studies and population studies were used. In six studies the correlation between the total sugar consumption and the consumption of NME sugars (non-milk extrinsic sugars) and caries in children or young people was investigated (Ruottinen *et al*., 2004; Masson *et al*., 2010; Marshall *et al*., 2007; McIntyre *et al*., 2006; Jamel *et al*., 2004; Downer *et al*., 2008). The results of these studies are inconsistent. Viewed as a whole, however, a correlation between sugar consumption and caries is proven in most cases. In three studies involving pre-school children and schoolchildren the correlation between the frequency of sugar consumption and caries was investigated (Johansson *et al*., 2010; Lee and Messer, 2010; Marshall *et al*., 2005). Overall, in these studies the correlation between frequent consumption of sugar-containing foods and/or drinks between the main meals and caries was confirmed. Only in one study, the correlation between sugar intake and caries was studied in adults aged 30-89 years (Bernabe *et al*., 2016). In this longitudinal study, the total quantity but not the frequency of sugar intake, was associated with caries. Moreover, the association was weaker, if the adults used fluoride-containing toothpaste every day.

As part of caries prevention, it is common in dental practice to recommend that patients reduce the amount and frequency of their sugar consumption, based on the previously described knowledge. The question of whether caries is in fact reduced as a result of these dental recommendations, has not been investigated to date (Lingström *et al*., 2003; Harris *et al*., 2010).

Sugar replacements (polyols) such as sorbitol and xylitol as well as sweeteners such as cyclamate and aspartame, cannot be metabolized by oral microorganisms, or can only be metabolized into acids to a very small extent and therefore, are not cariogenic (Matsukubo and Takazoe, 2006; Van Loveren, 2004). Although high-quality clinical studies in this area are not available in sufficient numbers, it is biologically plausible that the risk of caries can be reduced through complete or partial

replacement of sugar by sugar substitutes or sweeteners (Lingström *et al.*, 2003). In four reviews (Van Loveren, 2004; Antonio *et al.*, 2011; Fontana and Gonzales-Cabezas, 2012; Riley *et al.*, 2015) a possible caries-preventive effect of xylitol is examined independently of its use as xylitol chewing-gum. All four reviews come to the conclusion that up to this point, there has been no adequate proof that xylitol has a caries-preventive effect. In the current literature search, three clinical studies were identified in which similarly, no caries-inhibiting effect of xylitol could be established (Stecksen-Blicks *et al.*, 2008; Lenkkeri *et al.*, 2012; Bader *et al.*, 2013). In a secondary evaluation of the study by Bader *et al.* (2013) carried out by Ritter *et al.* (2013), a significant caries-preventive effect on root surface caries was found in adults with high caries risk. This result however, must be viewed with certain caution, because root surface caries was not the primary end point of the study. Overall, there is no adequate evidence that sugar replacements have a caries-preventive effect.

Nutrition

Consented recommendations:

The total quantity of daily sugar intake and the number of sugar-containing meals (main meals and snacks between meals) including sugary drinks should be kept to a minimum.

Foods and drinks without free sugars should be preferred.

3.6 Saliva stimulation through the use of chewing-gum

The onset and progression of caries are influenced in a variety of ways by protective salivary factors. In this context, the neutralization of acids by the buffering capacity of the saliva, the removal of food components from the oral cavity by its rinsing function (clearance) and its the remineralizing effect are especially important (Dawes, 2008). These effects become more evident, as the saliva production increases. A sufficient quantity of saliva (0.5 - 1 litre per day) is thus regarded as a cornerstone of oral health (Buchalla, 2012). Therefore, it seems biologically plausible that the act of chewing with the consequent increase in saliva flow rate, can reduce the incidence and progression of caries.

The action of chewing sugar-free gum can increase both, the saliva flow rate and the saliva pH, and can also lower the formation of plaque and the concentrations of mutant streptococci and lactobacilli in the saliva (Ship, 2004; Ribelles Lop *et al*., 2010). This has been demonstrated in various clinical experimental studies (Holgerson *et al*., 2007; Dawes and Kubieniec, 2004; Dawes and Macpherson, 1992; Edgar, 1998; Mäkinen *et al*., 2008; Morgan *et al*., 2008; Wang *et al*., 2012).

The caries-preventive effect of chewing sugar-free gum at least three times a day has been investigated in numerous clinical studies. As an example, studies of eight- to nine-year-old children and of eight- to thirteen-year-old children have shown a significantly lower progression of caries after 24 months in the group which chewed gum in comparison with the control group, which did not use the chewing-gum (Kandelman and Gagnon, 1990; Szöke *et al*., 2001). Peng *et al*. (2004) reported that after two years, there was significantly less caries formation in six- to seven-year-old children who received instruction on oral hygiene and also chewed gum for two years, than in the group that only received instruction on oral hygiene or in the control group who did not receive any instruction on oral hygiene nor chewed gum.

Accordingly, on the basis of a meta-analysis, the ADA Center for Evidence-Based Dentistry (2011) established that chewing sugar-free gum for 10 to 20 minutes after meals can reduce the caries incidence in children and adolescents between the ages of five and sixteen years.

In a systematic review the authors concluded, on the basis of six clinical studies, that there is objectively good to very good evidence that sugar-free gum can have an anti-cariogenic effect. According to them, this is due to the saliva stimulation effect especially after meals and perhaps also to the inability of the bacteria to metabolize the polyols within the chewing gum into acids (Mickenautsch *et al*., 2007).

Other systematic reviews also come to the conclusion that regular chewing of sugar-free gum has a caries-preventive effect and can therefore be recommended as part of the basic measures for caries prevention (Van Loveren, 2004; Deshpande and Jadad, 2008).

The saliva flow can also be increased significantly by means of other gustatory and masticatory stimuli. Possibilities here are, for example, the sucking of sugar-free sweets or drops, though they must not contain any acidic ingredients. Regarding these methods for stimulation of the salivary flow, there is no evidence of their effectiveness available from clinical studies.

Saliva stimulation through the use of chewing-gum

Consented recommendations:

Regular chewing of sugar-free gum can contribute additionally to caries prevention and therefore, can be recommended especially after meals.

3.7 Pit and fissure sealing

Pits and fissures on molars that are erupting or have just erupted are considered to be at a very high risk of developing caries in children and adolescents.

In the period between the years of 2003-2013, several systematic reviews were published on the topic of "sealing of pits and fissures". In addition, there is a guideline from the European Academy of Paediatric Dentistry (Welbury *et al*., 2004), a guideline from the AWMF (Kühnisch *et al*., 2010) and an evidence-based clinical recommendation from the American Dental Association Council on Scientific Affairs (Beauchamp *et al*., 2008) in respect to this topic. The Cochrane Collaboration systematic review of Ahovuo-Saloranta *et al*. (2013) summarizes the most relevant clinical articles on pit and fissure sealing and makes an assessment of them. No clinical data is available from the German-speaking areas in the period between 2003-2013, that can be considered for the guideline.

Incorporated into the systematic review of the Cochrane Collaboration were randomized and quasi-randomized clinical studies lasting at least 12 months, in which patient groups with and without pit and fissure sealants were compared. Studies were also included, in which various sealing materials for the prevention of occlusal caries in children and young people under the age of 20 years were compared.

The end point of the studies was the increase in the number of carious lesions on the occlusal surfaces of the premolars and molars. In total 34 studies were included; twelve studies compared groups with and without sealants and twenty one studies compared different sealing materials. In this context, it was shown that children and young people in whom the occlusal surfaces of molars had been sealed, developed less caries than those in whom sealants had not been used. An investigation from this review, which extended over nine years, was able to demonstrate that 27% of the sealed molars developed caries, whereas 77% of the unsealed molars developed caries (Bravo, 2005).

Accordingly, the sealing of pits and fissures is a recommended measure for preventing caries on the occlusal surfaces. This applies especially to children with a high risk of caries; there is insufficient information for other patient groups. The aforementioned publications can serve as the basis for the present chapters of this guideline. Accordingly, the basic recommendations published in the 2010 AWMF guideline on pit and fissure sealing (Register No. 083/002; Kühnisch *et al*.) continue to be valid:

"The sealing of pits and fissures is an effective prevention method that is tooth-surface specific for permanent teeth, which provides most benefit during the years of childhood and youth. The aim is to transform a plaque-retentive fissure topography into a tooth surface that is amenable to prevention.

"The indication for pit and fissure sealing should be determined after an examination to diagnose caries. The indication for pit and fissure sealing applies in the case of pits and fissures that are healthy, plaque-retentive and at risk for developing caries as well as in the case of pits and fissures that are affected by non-cavitated carious lesions.

"Priority for early sealing should be given to patients with a high risk of caries".

"Contraindications with respect of pit and fissure sealing are extensive occlusal dentine lesions and decidious molars whose exfoliation is imminent."

If an indication exists, pits and fissures with a high risk of caries in premolars, anterior teeth and permanent teeth can be sealed under an individualized dental care program (Beauchamp *et al*., 2008).

Pit and Fissure sealants

Consented recommendation:

As part of a preventive plan, pits and fissures at risk of developing caries should be sealed.

3.8 Basic recommendations on caries prevention in permanent teeth

	Basic recommendations on caries prevention in permanent teeth:
Chapter 1	**Mechanical methods for reducing the biofilm:** As basic prevention, patients should brush their teeth at least twice a day with a fluoride-containing toothpaste in a manner that removes as much of the biofilm as possible. Depending on the patient, different toothbrushes may be used. If food debris and biofilm cannot be adequately removed by toothbrushing alone, aids for the hygiene in the interproximal spaces (dental floss, interdental brushes) should be used in addition.
Chapter 2	**Influencing the biofilm by the use of chemical compounds:** The professional use of CHX varnishes containing at least 1% CHX can be recommended for caries prevention in erupting permanent teeth or in the exposed root area.
Chapter 3	**Prevention programs:** By combining various preventive measures, it is possible to considerably reduce caries. Participation in structured prevention programs should be recommended, especially to patients with a high risk of caries.
Chapter 4	**Fluoridation measures:** Patients should brush their teeth with a fluoride-containing toothpaste. In addition to this, fluoridated table salt should always be used at home. Moreover, the use of toothpaste with a high concentration of fluoride as well as fluoride varnishes, gels or mouthwashes may be indicated (in particular for caries-active patients).
Chapter 5	**Nutrition:** The total quantity of daily sugar intake and the number of sugar-containing meals (main meals and snacks between meals) including sugary drinks should be kept to a minimum. Foods and drinks without free sugars should be preferred.
Chapter 6	**Saliva stimulation through the use of chewing-gum:** Regular chewing of sugar-free gum can additionally contribute to caries prevention and can therefore, be recommended especially after meals.
Chapter 7	**Pit and Fissure sealing:** As part of a preventive plan, pits and fissures at risk of developing caries should be sealed.

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