

Investigation of subclinical caries risk parameters

PROPHYLAXIS IN ORTHODONTICS

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Caries is a multi-causal disease. Quality assurance in prevention and during orthodontic treatment means a regular re-evaluation of the caries risk with a corresponding reformulation of the preventive goals or the therapeutic consequences resulting from the risk diagnostics. The examination of subclinical caries risk parameters and thus the determination of cariogenic bacteria as well as other functional saliva parameters have a high predictive value for health and are therefore considered important diagnostic criteria for the success of preventive treatment.

Orthodontic appliances - especially fixed appliances - inevitably lead to increased retention niches for plaque bacteria and food residues. It does not matter whether the brackets are conventional or self-ligating. The same applies to the material differences between metal, plastic and ceramic [1-5]. Oral hygiene is significantly more difficult and even a moderate consumption of fermentable carbohydrates becomes a significant risk factor.

In addition, the nutritional situation can change during long-term fixed orthodontic treatment. This is especially true if the treatment continues into puberty or is only started during puberty. In this age group, the child or adolescent is tempted by experience to increase sugar intake through snacks or other cariogenic snacks. This increased sugar or carbohydrate intake leads to increased plaque growth and thus to an increased risk of caries.

Adhesive luting of the brackets can create additional retention opportunities for bacterial plaque due to excess luting material that has not been completely removed. At the

Roughness can often not be completely avoided at the transition to the tooth. Plaque finds ideal conditions on the tooth substance under additional hooks, metal coil springs and eyelets. Food debris also gets stuck here and forms a food reservoir for cariogenic germs. The region between the bracket and the gum as well as the interdental area are at the highest risk. When staining, the problem areas become apparent in many children despite oral hygiene instruction. If no countermeasures are taken, a pronounced demineralisation in the form of white spots is found after removal of the fixed appliance, often in clear contrast to the area "protected" by the luting composite under the bracket (Fig. 1). Gingival changes due to plaque accumulation are also more common, as are severely swollen papillae and thickened gingival margins, especially "congested papillae" when working with elastics or chains [6].

Impeded tooth cleaning promotes plaque accumulation

After the fixed appliances have been inserted, brushing the teeth as usual is less effective. Cleaning the teeth becomes more difficult and time-consuming. On the teeth fitted with braces

brackets, plaque often cannot be adequately removed with conventional toothbrushes and the brushing technique used until then (Fig. 2). The bracket and archwire inevitably increase the distance between the brush and the tooth and make it difficult or impossible for the bristle ends to come into contact with the tooth. The brush only "hovers" on the bracket or archwire. The bracket is cleaned, but not the deeper tooth surface. A cheek mucosa that is irritated or injured by brackets or protruding archwire ends can also make oral hygiene more difficult. The labial brackets also prevent the teeth from being "self-cleaning" of the buccal surfaces due to the lack of oral mucosal contact during cheek and lip movements.

Fixed appliances can also cause further discomfort. For example, especially in the first few days after an archwire change, pressure pain occurs when biting down, because the tooth movement changes the occlusal relationships in static occlusion. The teeth no longer fit together properly. This may result in further nutritional changes: Fibre-rich, chewy foods tend to be avoided and soft, pulpy food is preferred instead, which is often additionally disadvantageous due to a higher sugar content.



1 Condition after two years of fixed orthodontic treatment without prophylactic care. The localisation of the defects corresponds to the preferred plaque retention sites.

2 Stained plaque after removal of the archwire. Most of the plaque is found in the area of the brackets and in the shadow of the archwire.

3 Even with removable braces, there are hygienic deficits - also due to the position of the teeth.

4 From homeostasis to dysbiosis: Ecological plaque hypothesis modified after Schoilew K., Wolff B., Staehle H. J. et al., Quintessenz 2016; 67 (2)135-144

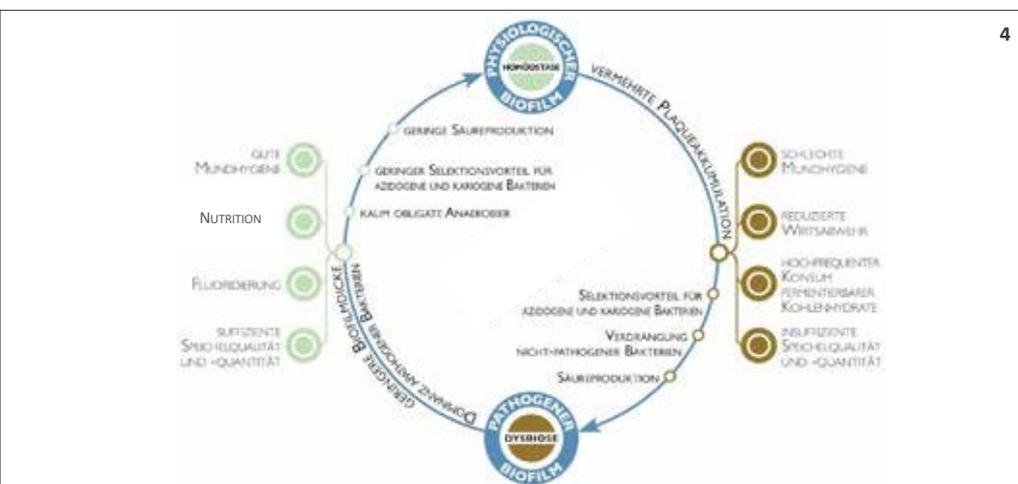


This means an increase in substrate for acidogenic bacteria. The increased intake of chewing-active food can also cause a reduction in the secretion rate, which in turn has a negative influence on the natural defence situation of the oral cavity (reduction in clearance, drop in saliva pH and buffer capacity).

The same applies to removable orthopaedic appliances, which also promote plaque accumulation under the attached retaining elements, especially if the appliances are not removed from the oral cavity when brushing the teeth (Fig. 3).



Higher caries risk due to changes in the biofilm



4 Due to the changing diet and hygiene deficits, the physiological biofilm also changes. The supply of high and low molecular weight carbon hydrates causes a selection advantage for acidogenic and cariogenic bacteria, which gradually displace the non-pathogenic bacteria from the physiological biofilm, as these are not able to survive in the long term due to the increased acid production and the resulting drop in pH. Thus, homeostasis slowly turns into dysbiosis and a corresponding pathogenic biofilm [7] (Fig. 4).



This change in the biofilm causes an increase in the caries risk. Clinically, however, there is always a longer time span between the establishment of the pathogenic biofilm and the appearance of a visible change in the tooth structure (demineralisation, cavitation). It is precisely this delay between cause (dysbiosis) and effect (demineralisation, cavitation) that can be used for preventive measures. However, the prerequisite is to diagnose this change in the oral cavity in good time [8].

Long-term studies have shown an increase in unstimulated secretion rates, but also an increase in the number of lactobacilli and a decrease in buffer capacity. Both indicate that the natural defence function of the oral biotope against food and plaque acids is reduced due to the increase in acidogenic bacteria [9]. To prove this, the functional and bacterial saliva parameters must be determined. This means determining the saliva pH, the secretion rate and buffer capacity as well as the number of *Streptococcus mutans* bacteria and lactobacilli [10].

Studies over the last 20 years have shown that fixed orthodontic treatments can have the following side effects on the oral biotope:

- There is a strong plaque development in the shadow of the arch and cervically (cf. Fig. 2).
- Both the papilla bleeding index (PBI) and the plaque index (PI) increase almost continuously and almost linearly [11].
- There is a constant increase in *Streptococcus mutans* numbers [12].
- Due to the individual situation, different risk areas arise in the oral cavity. For example, one study showed that there was less change in homeostasis in the central incisors than in posterior teeth [13].
- The increase in acidogenic bacteria leads to increased lactate production. This causes a drop in the saliva pH value [10].

- Even after intensive tooth cleaning, vital bacteria remain on the tooth surface [14,15].
- Due to the changes in tooth position and the supragingival biofilm situation, the sulcus flora can change and thus favour the growth of periodontal pathogens [14,15].
- Toothpastes containing chlorhexidine or other antimicrobial agents cause only a slight to non-existent reduction of *Streptococcus mutans*. This is due to rapid recolonisation of the tooth surfaces due to the increased number of retention sites [16].
- For the same reason, the effect of fluoride-containing rinses is time-limited [17].

Due to the totality of these parameters, an oral biotope in homeostasis slowly but inexorably changes into a dysbiotic situation. Ultimately, this modification is caused by behavioural changes (poor oral hygiene, high-frequency consumption of fermentable carbohydrates, ingestion of soft and thus less chewing-active food), which subsequently cause a change in the subclinical situation (insufficient saliva quality and quantity, reduced host defence, increase in acidogenic germs). The treatment appliances inserted during orthodontic treatment increase the formation of plaque due to the numerous retention sites that are created.

Examination of the subclinical risk parameters

A regular, therapy-accompanying examination with determination of the subclinical risk parameters is able to detect the change of the physiological to the pathogenic biofilm already before the occurrence of a possible hard substance damage [10].

The selection advantage of acidogenic bacteria inevitably leads to a proliferation, especially of the known and easily determined cariogenic germs. A high number of *Streptococcus mutans* creates

a selection advantage for aciduric bacteria, lactobacilli provide information about the patient's sugar intake. The polysaccharides massively produced by mutans streptococci protect the biofilm from external influences (fluorides, CHX) or even from mechanical effects [18,19].

The examination of subclinical risk parameters includes:

- Determination of bacterial parameters: Number of *Streptococcus mutans* as well as the number of lactobacilli. Here it is possible to determine the amount of acidogenic bacteria not only in saliva but also in plaque. To do this, a soft brush is used to remove plaque.

The test sample is taken from the area to be examined (Fig. 5) and then spread on a nutrient medium. Figure 6 shows the results after incubation of the test for 24 hours (here: ^{CariesScreenTest1}).

- Determination of functional parameters: Secretion rate, saliva pH value, buffer capacity (for instructions on how to perform this test, see www.kariesscreentest.de). The determination of functional parameters can be done by saliva tests (e.g. caries screen test) and detected pathological changes can then be treated at an early stage [10,20-22]. Knowledge of these subclinical risk parameters is therefore important detailed information in the overall clinical assessment of a patient's health (homeostasis) or disease (dysbiosis). With the help of this information, diagnosis-based individual prophylaxis (DIP) can be carried out.

Exemplary patient case

Figures 7 to 10 on the following pages document an exemplary

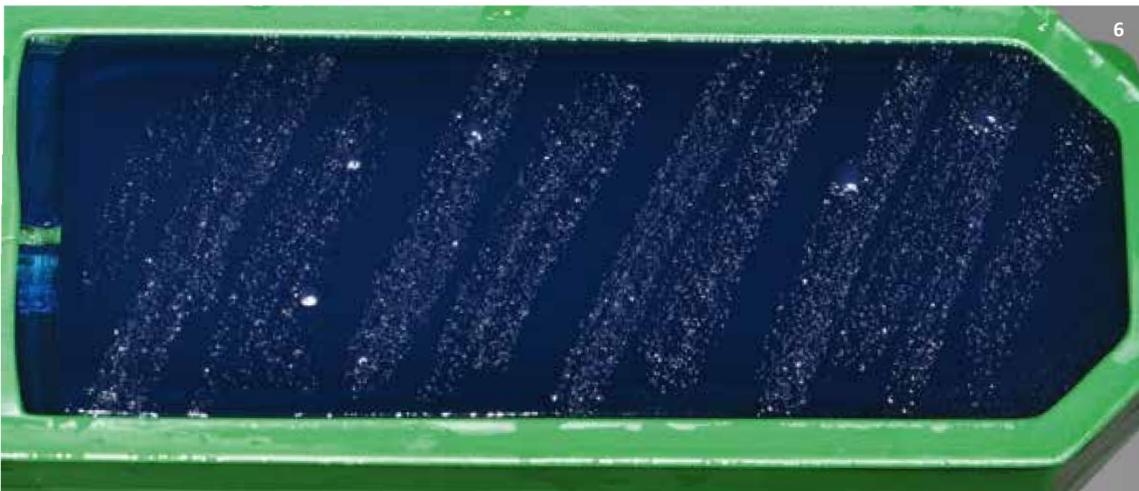
¹ The CariesScreenTest is the successor product to the former CRT Bacteria. The previous manufacturer Ivoclar Vivadent discontinued production and distribution on 31.12.2018. The detection method based on the same patent is now produced by the company Aurosan under the name KariesScreenTest (distributed by www.minilu.de).



5 Plaque sampling to determine its composition

6 Condition after incubation of the test for 24 hours: greatly increased proportion of Streptococcus mutans, high caries risk at this site.

7 The series of pictures shows the initial clinical situation with a progenous forced bite in the primary dentition, the tendency towards a progenous forced bite in the mixed dentition, the condition after completed orthodontic treatment and the recall pictures over 26 years. The

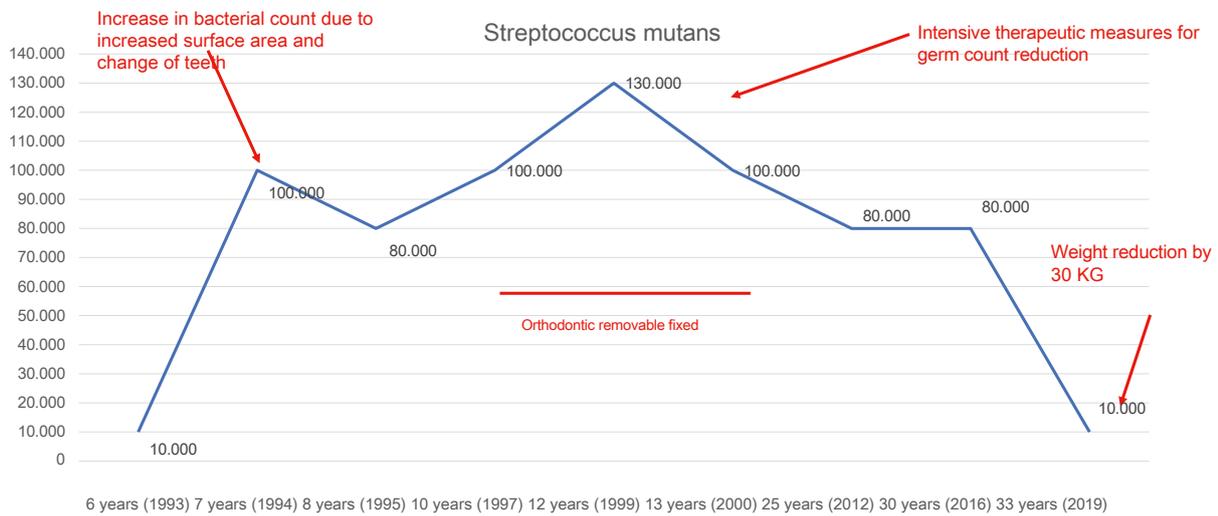


dentition is caries-free.

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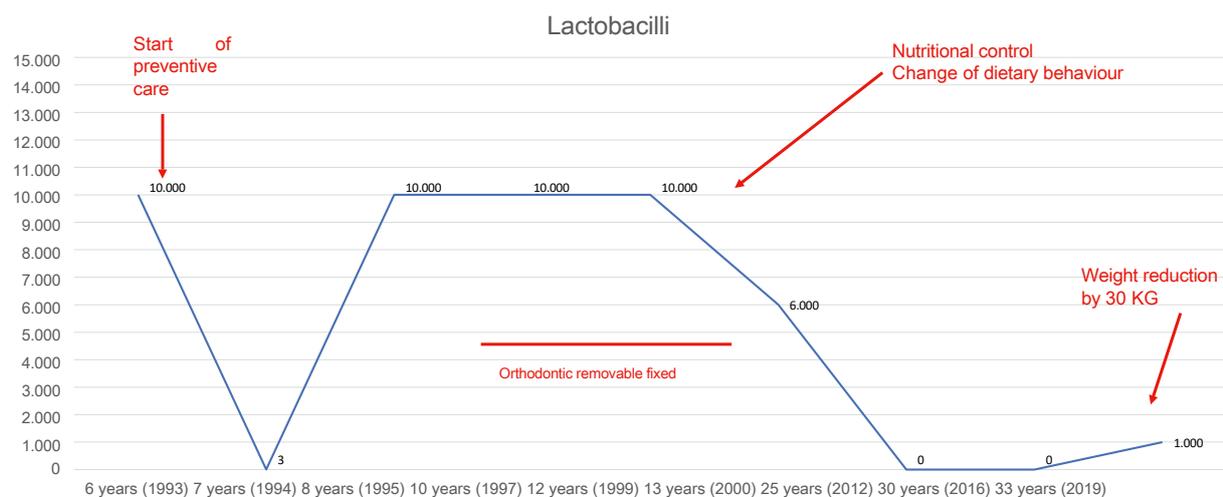


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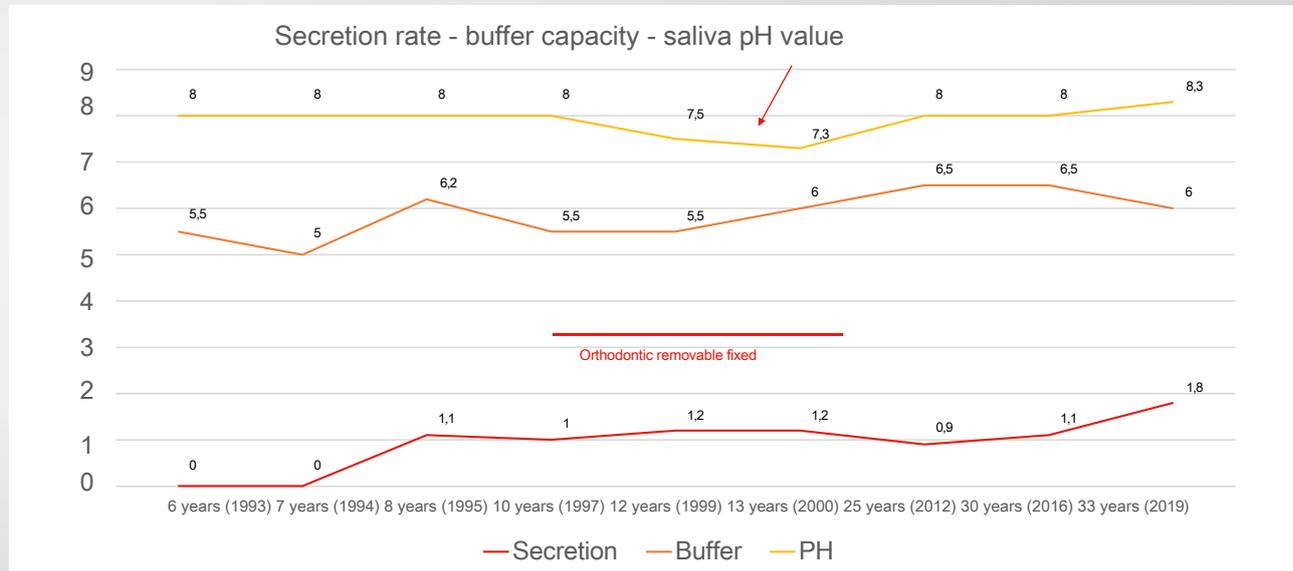


8 Continuous monitoring of Streptococcus mutans counts showed an increase in the mixed dentition (increase in tooth surface due to the number of teeth erupting from the permanent teeth) as well as an increased number of retention niches in the eruption phase. During the fixed orthodontic treatment, there was a further increase in Streptococcus mutans counts. After completion of the orthodontic treatment and intensive therapy to reduce the germ count in conjunction with nutritional counselling, the Streptococcus mutans counts decreased again.

9



9 Follow-up of lactobacilli counts: The high lactobacilli count due to the unfavourable nutritional situation at the beginning of preventive treatment was reduced by appropriate compliance. It increased again in the course of the fixed orthodontic treatment. Due to the acid formation, ideal conditions were created for the proliferation of acidogenic bacteria (Streptococcus mutans). After completion of the treatment measures, the lactobacilli numbers could be reduced again through dietary control, education and remotivation (sugar reduction) [10].



10 The functional parameters show the effects of the change in homeostasis towards dysbiosis. Due to the increased acid production, there was a decrease in salivary pH. The secretion rate increased slightly during orthodontic treatment. However, due to preventive measures, the secretion rate and thus also the buffer capacity could be kept constant or improved somewhat [9].

patient case. Overall, the effects of orthodontic treatment could be detected in time by regular monitoring of subclinical parameters and treated by preventive measures. Figures 11 and 12 show both the diagnostic and the resulting therapeutic measures before, during and after orthodontic treatment [23].

Below are explanatory notes on some of the diagnostic measures listed in Figure 11 [24,25]:

- The control of subclinical parameters with the help of a saliva test provides information about the condition of the oral environment (homeostasis/dysbiosis). The values obtained represent the initial situation before the start of orthodontic treatment. Ideally, the subclinical findings should be restored or improved at the end of treatment or at the first recall appointments. The latter is

This is quite possible, especially if the orthodontic treatment has eliminated potential cariogenic microbiotopes [26].

- In the case of changing lactobacilli counts and an increasing number of *Streptococcus mutans*, a nutritional analysis and counselling with the aim of sugar substitution is indicated. Hygiene in the critical zones is to be checked, furthermore professional measures are necessary that have an influence on the colonisation parameters. Changes in the secretion rate (1 ml/min) and the buffer capacity (between pH 5 and pH 6) indicate a reduction in clearance and a reduced defence potential of the oral cavity against food and plaque acids. A chewing diet (possibly including sugar-free chewing gum) to influence the secretion rate is indicated. In principle, a deterioration of the clinical and subclinical risk parameters results in a

increased prophylactic effort.

- Adequate oral hygiene is a prerequisite for being able to take responsibility for fixed orthodontic treatment. The oral hygiene status is to be determined by plaque and bleeding index in order to identify deficits already determined in advance and to inform the patient in detail about the associated risks (plaque gingivitis) or to motivate him to improve his oral hygiene. Insufficient oral hygiene with the associated increased risk of caries is a contraindication for orthodontic treatment measures. Inadequate oral hygiene cannot be compensated for by increased fluoride intake.
- Based on the clinical and subclinical parameters determined, an individualised care programme can be
The aim is to create a system that is carried out both in the dental practice and at home in order to avoid adverse effects on tooth substance and gingiva caused by the wearing of



DIAGNOSTIC MEASURES

11



Before starting treatment

- Determination of subclinical parameters (homeostasis/dysbiosis), saliva test
- Assessment of the current oral hygiene situation (API)
- Periodontitis risk assessment (SBI)
- Check for demineralisation of the smooth surfaces
- X-ray check of the approximal spaces (bite wing radiograph, no panoramic slice radiograph)
- Knowledge about oral hygiene and a healthy dental diet
- in adult patients: PSI

during treatment (once a year, more often if there is a risk)

- Control of subclinical parameters (changes in biofilm), saliva test
- Control of the colonisation parameters (API)
- Periodontitis risk and gingival changes (SBI, "compressive papillae")
- Nutritional situation, control of sugar substitution (lactobacilli counts)
- Review of adequate cleaning techniques (e.g. single tuft brush) on brackets.
- Checking for incipient demineralisation in the area of the brackets
- Checking the approximal spaces (laser fluorescence, transillumination, etc.)
- Checking existing fissure sealants

at the end of treatment

- Determination of subclinical parameters (changes in the biofilm), saliva test
- Control of the colonisation parameters (API)
- Checking the risk of periodontitis and gingival changes in the approximal space (SBI, "compressive papillae")
- Checking for incipient or existing demineralisation in the area of the brackets
- Checking the approximal spaces (bite wing radiograph, transillumination, laser fluorescence, etc.)
- Nutritional care (sugar substitution)
- Checking existing fissure sealants

11 Diagnostic measures before, during and after orthodontic treatment

THERAPEUTIC MEASURES

12



Before treatment

- Basic prophylaxis
 - Oral hygiene status
 - Education and motivation
 - Local fluoridation measures on risk areas
- Professional dental cleaning (PZR; for adults also UPT if required)
- Fissure sealing according to the findings of the subclinical diagnostics or in the case of food- and plaque-retentive occlusal surface systems
- Care of the approximal spaces (if necessary)
- Fluoridation concept (home/professional)
- Measures required based on the result of the determination of subclinical parameters

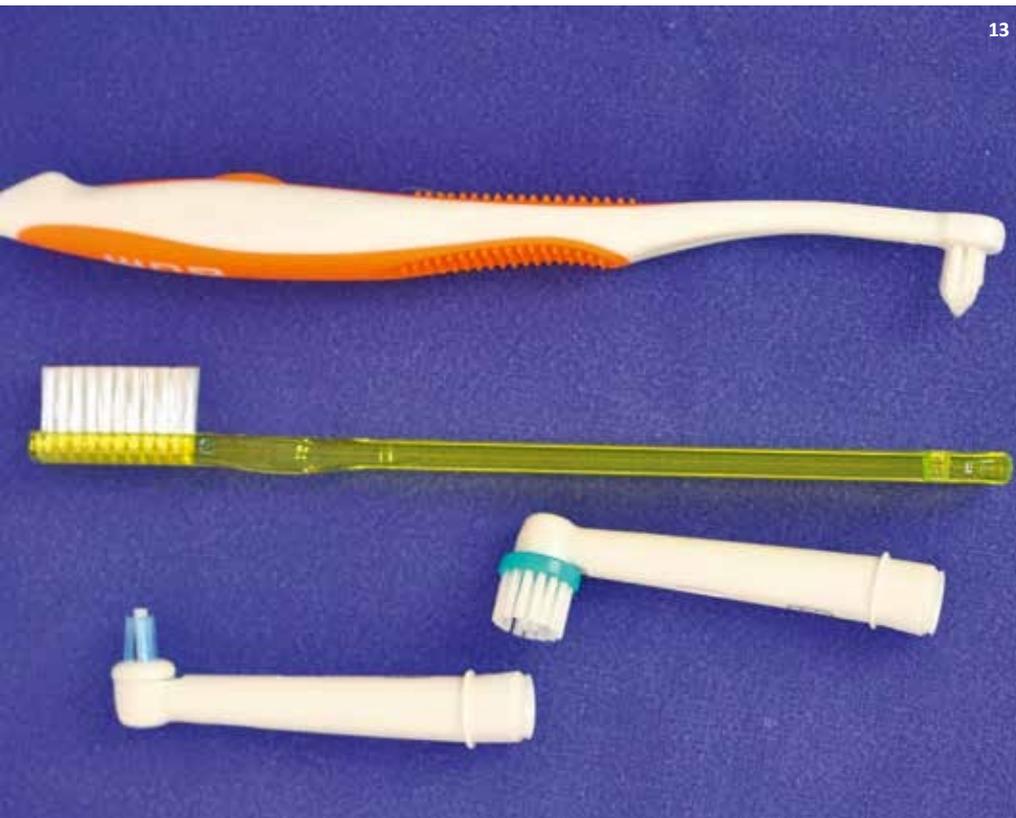
startsDuring

- Basic prophylaxis or intensive prophylaxis (depending on clinical and subclinical findings)
- Application of CHX-containing lacquers at the brackets and in problematic hygiene areas
- If necessary, intermittent intensive therapy (six times CHX gel in two days)
- Fluoridation concept: toothpaste recommendations, possibly arginine-containing products, high-dose fluoride products, rinses (containing amine-tin fluoride).
- Hygiene check (one-tuft brush), check for hygienic capability of the orthodontic appliance (e.g. pendulum, GNE).
- Repair/renewal of any defective fissure sealants

treatmentAt the end of treatment

- Intensive prophylaxis or basic prophylaxis (depending on subclinical and clinical findings)
- Possibly professional tooth cleaning measures with CHX-containing cleaning paste/gel.
- Intensive therapy for germ count reduction
- Therapy of smooth-surface demineralisation (fluoridation, infiltration therapy)
- Occlusal surface therapy (CHX varnish/gel), possible renewal of defective sealings
- Application of CHX-containing varnishes in the proximal lingual and buccal spaces
- Recall appointment after eight weeks

12 Therapeutic measures before, during and after orthodontic treatment



13

13 Oral hygiene aids for orthodontic treatment with fixed appliances underneath

fixed appliances. Intensive cleaning of all tooth surfaces with polishing prior to adhesive attachment of the brackets ensures optimisation of the starting conditions in the dental practice.

Below are explanatory notes on some of the therapeutic measures listed in Figure 12.

Domestic measures

Special toothbrushes

Cleaning teeth and brackets requires more time and the tools must be individually adapted to the changed cleaning conditions. It is problematic that the bristle ends of brushes with flat bristles do not reach the tooth surface properly due to brackets and arches. This means that the bracket is cleaned, but not the underlying tooth surface. A thorough oral hygiene instruction with practical

Practice helps to ensure correct use.

Special brushes are required for perfect cleaning (fig. 13). For example, brushes with only two rows of bristle tufts as well as mono-tuft brushes, which can be better placed under the arch for cleaning, have proven to be effective. Hand brushes with different bristle heights are also recommended. Many electric brushes have special attachments for fixed appliances. Spiral brushes, which were developed for the spaces in between, can also be used to clean under the archwire, although the technique is quite complex.

Interstitial care

Due to the arch, normal cleaning of the interdental spaces with dental floss is no longer possible or is so time-consuming that it is rarely accepted. Efficient home cleaning measures from the lingual side would, however, be particularly effective.



14

14 Proximal space brush for cleaning the bow

especially important now, as it promotes the formation of plaque and tartar. If there is enough space, minimal brushes can be used (Fig. 14).

Brushing your teeth after every meal

The fixed appliances encourage food residues to get stuck: fibrous, but also pulpy food often gets stuck after meals. This is not only an aesthetic problem, but also prolongs the time that cariogenic substrate remains in the mouth. Gum inflammation can also occur more easily. Therefore, it is advisable to clean the teeth after every meal. With many fixed appliances, chewing sugar-free chewing gum to stimulate saliva is also possible without any problems.

Fluoride-containing rinsing solutions

Even without fixed appliances, there is a higher need for fluorides in children and adolescents, at least until two years after the end of the tooth change (influencing the



15 Powder jet cleaning of hygienic problem areas as part of preventive care. It should also be performed during normal check-up treatments.

"posteruptive maturation phase"). During orthodontic treatment, the need for systematic application is even greater. A daily rinse with fluoride-containing solutions is a valuable support and is usually carried out willingly, as it does not require much effort. However, the time spent in the mouth must be taken into account, as "just rinsing" is not enough. Rinsing should not be regarded as a substitute for oral hygiene measures. Solutions containing stannous fluoride are particularly suitable because they have a bacteriostatic effect in addition to the fluoridation effect.

The daily use of low-dose fluoride solutions should be avoided during treatment.

The use of a concentrated fluoride gel once a week should be given priority over the treatment period. Nevertheless, depending on the clinical or subclinical findings, this measure is a valuable supplement. During the fixed treatment period, the use of special toothpastes can also be useful as a supplement to the usual recommendation of toothpastes containing amine fluoride.

Weekly staining for self control

Since plaque is almost invisible in everyday life and is even more "camouflaged" by the brackets, it is advisable to carry out regular staining at home. Staining tablets can be purchased in drugstores and pharmacies; the application is simple. By visualising the plaque, the danger can be recognised and averted by better tooth cleaning. The intervals between prophylaxis sessions, in which staining should be a standard measure, are usually too long.

Professional measures

Although cooperation at home when wearing orthodontic appliances is a prerequisite for maintaining healthy teeth and gums, deficits are not uncommon and must be compensated for in the best possible way. Special prophylaxis care in the dental practice ensures intensive control and supplementation of the measures taken at home. The regular annual control of subclinical parameters is an objective diagnostic criterion to diagnose a change in the oral biotope from homeostasis to dysbiosis in time. In this way, preventive measures can be initiated before

there is a clinically visible change. A brief oral hygiene assessment should be made at all orthodontic appointments. The patient and, if applicable, the legal guardians are thus informed about the deficits identified and further steps can be taken. Ideally, the patient should be able to brush their teeth during an archwire change.

Quarterly recalls

In contrast to the usual half-yearly prophylaxis sessions, an intensification in the form of a quarterly recall is often necessary. In case of a deterioration of the situation, it is possible to react directly before damage occurs.

Oral hygiene control, instruction and practice

An oral hygiene status with assessment of plaque and bleeding situation (API, SBI) should be performed every three months. In almost all cases, problems - at least on individual tooth surfaces - are recognisable. Sometimes there are compact, thick plaque layers that can cause demineralisation and gingival swelling, pseudo-pockets and/or a bleeding tendency in a surprisingly short time. Due to the fixed appliances, these symptoms are often not directly perceptible, so visualisation (staining/intraoral camera/papillary bleeding) is important. Practical exercises with the special tools used follow.

Professional teeth cleaning

Prophylaxis sessions include professional removal of biofilm and mineralised deposits. Tartar on the front teeth is often more prevalent if there are brackets there. The interdental spaces are particularly affected, which is also favoured by the fact that home interdental hygiene is often only carried out in exceptional cases. If pseudo-pockets develop, the risk of calculus formation is also increased. Ideally, the problem areas should be professionally cleaned every time the archwire is changed. In addition



an application of CHXlack (EC 40) around the brackets after cleaning can delay rapid recolonisation (see below) [27,28].

Cleaning with a powder jet device Plaque removal from the bonded tooth surfaces is not always possible with polishing pads and brushes. Instead, powder jet devices should be used, which enable optimal biofilm removal even under "hooks and eyes" (Fig. 15). However, only powders that do not require post-polishing should be used. The use of airflow can also have a positive effect on the gingival situation.

Professional fluoridation by means of gel/varnish

Optimal conditions for fluoridation can be created in the practice by relative drying and adherence to the required exposure time. Depending on the clinical and subclinical findings, highly effective gels and varnishes are available for application, whereby those that are not suitable for application by the patient at home should be given priority as a supplementary measure.

Application of chlorhexidine

If, despite all efforts, demineralisation in the form of white spots (= initial defects) or gingivitic changes are detected during the course of treatment, it is advisable to apply chlorhexidine. Varnishes containing chlorhexidine reduce the number of germs at the application site. The effect may become visible a few days after application as a reduction in the degree of inflammation of the gingiva.

In high-risk cases and worsening subclinical parameters, it is advisable to repeat the application several times in succession during the orthodontic consultations. In such cases, intensive therapy to reduce the bacterial count may also be required after removal of the brackets. In this case, the teeth are cleaned for 14 days with chlorhexidine gel instead of toothpaste. A few weeks after this therapy, it is advisable to check the subclinical parameters (SM, LB, saliva pH, buffer capacity, secretion rate) again. This can be used to check whether the oral environment is still in a dysbiotic state or whether there has been a change to a physiological situation (homeostasis). If the latter is the case, the patient can return to the regular recall with six-monthly appointments.

be discharged. It is advisable to check the subclinical parameters once a year for the next few years. This is especially important because clinical studies have shown that 19-year-olds who had been treated with fixed orthodontic appliances had significantly more and more pronounced initial lesions over five years after the end of treatment than a comparison group that had not received orthodontic treatment [29,13].

Summary

Orthodontic - especially fixed - treatments have a lasting influence on the oral biotope. Without consecutive monitoring of sub-clinical and clinical risk parameters, there is a danger of a constant increase in the risk of caries. The changes in the biotope of the oral cavity can be objectively recorded by appropriate diagnostic measures. The success of dental prevention and home care can be monitored and late damage to the teeth prevented by appropriate follow-up.

 Literature by the author

ABOUT THE

Dr Lutz Laurisch has specialised in caries diagnostics and prophylaxis since the 1980s. He was involved in the development of the SoniflexSeal preparation tip for minimally invasive fissure sealing (KaVo) in 1994 and developed the CRT saliva test procedure (Ivoclar Vivadent) for the detection of caries-relevant germs in 1997. From 1989 to 1998 he was vice-chairman of the Society for Paediatric Dentistry and Primary Prophylaxis in the German Society for Oral and Maxillofacial Medicine (DGZMK) and from 2001 to 2009 he was a member of the board of the DGZMK. In 2002, Dr Laurisch was awarded the Wrigley Prophylaxis Prize for his many years of commitment and services to continuing dental education in preventive dentistry. He has been a lecturer at the Heinrich Heine University in Düsseldorf since 2003. Since 2012, he has been vice-president of the German Society for Preventive Dentistry (DGPZM) and in 2013 he was awarded the golden pin of honour of the DGZMK for his services to the scientific development of concepts in prophylaxis and prevention of oral diseases. Lutz Laurisch is the author of more than 95 publications on prevention, caries risk and practice management as well as various books. He is also a member of the scientific advisory board of various professional journals.

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