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4

The Importance and Possibilities of Proper Oral Hygiene in Orthodontic Patients

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1. Introduction

The number of orthodontic treatments has been increased nowdays (Silva & Kang, 2001; Thilander et al., 2001; Ciuffolo et al., 2005; Mtaya et al, 2009; Bittencourt & Machado, 2010). The most important motivation for orthodontic treatment is to achieve an improvement in appearance and the fact that in connection with this change some psychological problems could be decreased. These factors are contributed not only to the position but the esthetic appearance of the tooth itself. In some cases orthodontic treatments can attribute to caries preventive intervention, when tooth movements may reduce crowding or other anomalies, thus can contribute to the effectiveness of proper oral hygiene. On the other hand, orthodontic treatments may cause or aggravate plaque accumulation and in this way the development of caries and periodontal diseases which are basically caused by dental plaque. It is suggested that the information about both benefits and risks of orthodontic treatment should be sheared with potential patients.

This chapter explaines the relationships between orthodontic anomalies and orthodontic treatments and dental plaque induced diseases, delineates how to determinate the risk of the orthodontic treatment causing dental caries and periodontal diseases. The third part of this chapter summarizes the possibilities to avoid and reduce these effects using different modern equipments, techniques and adjuvants.

2. Relations between orthodontic anomalies / orthodontic treatment and dental plaque induced diseases

2.1 Associations of the orthodontic anomalies with dental caries

It is wellknown for a long time that in some orthodontic cases patients have greater difficulties in maintaining proper oral hygiene (Katz, 1978; Miller & Hobson, 1961). In spite of this, some authors published no correlation between positional anomalies and the caries prevalence. Helm and Petersen (1989a) examined 176 adolescents aged 13-19 years and re-examined them after 20 years in order to detect any relationship between malocclusion and caries, found no association between malocclusion traits and caries prevalence. Other authors published the relationship between the dental caries and the presence of certain malocclusions concerning oral hygiene (e.g. crowding) (Gábris et al., 2006; Nobile et al., 2007; Mtaya et al, 2009). Stahl & Grabowski (2004) reported no positive correlation between

prevalence of caries and any malocclusion in primary teeth but in their study significant parallelism in prevalence of malocclusion and caries was found for posterior cross-bite and mandibular overjet in children with mixed dentition.

2.2 Associations of the orthodontic anomalies with periodontal parameters concerning oral hygiene

The accumulation of plaque can cause gingival redness, bleeding, edema, changes in gingival morphology, reduced tissue adaptation to the teeth, an increase in the flow of gingival crevicular fluid and other clinical signs of inflammation (Figure 1). Maloccluded teeth can be associated with periodontal diseases because of the physically hampered proper oral hygiene.



Fig. 1. Crowded frontal teeth with large amount of plaque.

In case of this anomaly the oral hygiene is harmful, the plaque elimination needs more time and special method. The picture shows a gingivitis as a consequence of the lack of proper oral hygiene.

According to the oral hygiene the most important basic symptom which can show more serious periodontal problems is gingival bleeding on probing (Geiger, 2001). The presence of a positive correlation between malocclusion (e.g. crowding, when the removal of plaque is difficult) and periodontal health has been described by Helm and Petersen (1989b) and Gábris et al. (2006), but on the contrary other studies found no association between amount of plaque or periodontal parameters and malocclusion (including crowding and spacing) (Geiger et al., 1974; Katz, 1978; Buckley, 1980). Other results had been published by Geiger (2001) found the possible associations between certain malocclusions (eg. anterior overjet and overbite, crossbite etc.) and periodontal problems, but these cases probably are not really in connection with oral hygiene.

2.3 Plaque accumulation concerning removable and fixed orthodontic appliances

The great plaque accumulation on different dental materials has been wellknown for a long time. From these points of view, we also consider removable appliances. In case of removable appliances, the resin base has microporosity. The greater accumulation of plaque

on dental materials than on natural enamel is also wellknown (Skjörland, 1973). This is an increase in microorganisms which can provide an increased risk of carious lesions theoretically. Thus basically the orthodontic treatment with removable appliance causes an additional problem for the oral environment. The surface of the removable appliance will be coated within a short time mainly with streptococci and gram negative and positive rods (Bickel & Geering, 1982). According to the results of Batoni et al. (2001) the use of removable appliances may lead to the creation of new retentive areas and surfaces, which favour the local adherence and growths of streptococcus mutans. However, Schlagenhauf et al. (1989) found that the increase in number of streptococcus mutans was not significant in patients having removable orthodontic appliance comparing to those who weared fixed appliance.

The plaque accumulation is promoted by the physical constituton of different parts of fixed appliance, but there are some other factors having a great importance on plaque accumulation. In the oral cavity all of the tooth surfaces are exposed and rapidly covered by salivary proteins causing different effects (interactions between material, pellicle and bacteria). As a part of fixed appliances, orthodontic bands can cause a gingiva inflammation (Huser et al., 1990). Plaque accumulates particularly beneath bands from which some cement has been washed out adjacent to adhesive retention elements (Gwinnett & Cheen, 1979; Mizrahi, 1982). Plaque is found predominantly cervically to brackets under the arch wires. The scores of different periodontal parameters (Plaque Index, Gingival Bleeding Index) and proportion of spirochetes were found higher for banded molars than for molars with brackets (Boyd & Baumrind, 1992; Freundorfer et al. 1993). The loss of attachment is the highest approximally, particularly in adults, because the margins of band are frequently located subgingivally at approximal sites. In this way band with subgingival margins can promote the higher accumulation of the amount of plaque and contribute to development of gingivitis or periodontitis. In case of periodontitis besides the inflammation of gingiva the loss of connective tissue attachment (wich is irreversible change) also can be seen in the periodontium. In these situations gram negative and anaerobic microrganisms (Porphyromonas gingivalis, Prevotella intermedia, Actinomyces) are disproportionally present along the subgingival band margins (Diamanti-Kpioti et al., 1987) which are frequently associated with further periodontal problems. Beside of this, there is an increased number of spirochetes, mobile rods and fusiform organisms. Gingival hyperplasia may also occure and this complicates the oral hygiene and the dental treatment procedures (Figure 2.)



Fig. 2. Gingival hyperplasia in patient undergoing orthodontic treatment with fixed appliance.

The situation is caused by neglected oral hygiene, which complicate the treatment and oral hygienic procedures.

It has ben published that the elements of fixed orthodontic appliance can change the biologic balance in the oral cavity (Figure 3.).

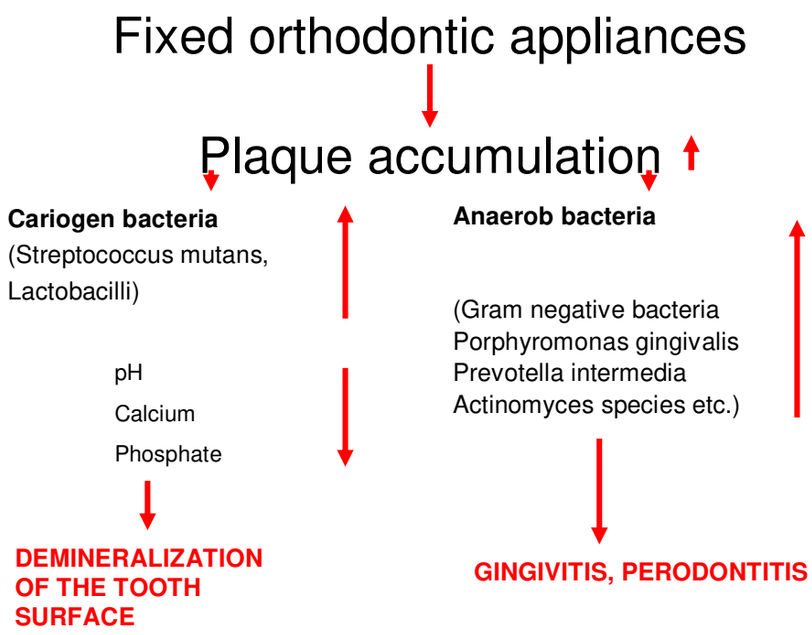


Fig. 3. Risk of treatment with fixed orthodontic appliances.

Plaque in patients with fixed orthodontic appliance has a lower pH than in non-orthodontic patients (Gwinnett & Cheen, 1979). There is a rapid shift in the composition of the bacterial flora, especially there is an increase in the levels of acidogenic bacteria (streptococcus mutans, lactobacilli), which leads to a decrease in pH. As the pH drop reaches the level of critical value (pH 5.5), the demineralization-remineralization balance is pushed toward mineral loss and demineralization/decalcification.

2.3.1 Decalcification of enamel caused by dental plaque accumulation (white spot lesions) during orthodontic treatment with fixed appliances

The first clinical evidence of the demineralization is the white spot lesion (WSL), which potentially can become a cavitated carious lesion extending even into the dentin (Featherstone, 2003; Featherstone et al, 2007). White spot lesions are nonfluoridated opacities having a more defined shape and are well differentiated from sorrounding enamel which are often located in the middle of the tooth (Sangamesh & Amitabh, 2011). The WSL has been defined as „subsurface enamel porosity from carious demineralization" presenting itself as a „milky white opacity" when located on smooth surfaces (Nicholson, 2006). Beside of that fact that WSL is a first step to destruction of the teeth, this enamel demineralization associated with fixed orthodontic appliances means an other significant clinical problem for the orthodontists (Ogaard, 1989; Bishara & Ostby, 20008). Because of the plaque

accumulation on typical places, without proper oral hygiene, during or after the orthodontic treatment demineralization (white spot lesions) can be observed at these above mentioned plaque retention sites and the location of possible carious lesions are changed compared to the situation without orthodontic appliances (Muhler, 1970). The white spot lesions are predominantly appeare on the lower and upper premolars, first molars, maxillary and mandibular lateral inciors and lower canines as a change of tooth structure around the brackets basis or between the brackets/bands and gingival margin in the cervical region and middle third of the teeth, under the orthodontic wires (Ogaard, 2008). The frequency of WSL in orthodontically treated patients were in order lateral incisors, canines, first premolars, 2nd premolars, central incisors (Ogaard, 1989; Chapman et al., 2010). An other previous study showed similar results except those finding that the maxillary central incisors had a greater frequency of WSLs than did the maxillary second premolars (Gorelick et al., 1982). No significant differences were found in WSL incidence and prevalence between the right and left sides of the maxilla and mandible (Gorelick et al., 1982; Ogaard, 1989).

Evaluation of white spot lesions can be performed by macroscopic methods (clinical examination, photographic examination, optical nonfluorescent and fluorescent methods), microscopic methods (orthodontic caries models) and research methods (assessing different preventive agents) (Benson, 2008). The detected prevalence depends on the analytic methods. The highest prevalence of demineralization was detected by quantitative light induced fluorescence method which is much more sensitive than the simple direct visualization (Boersma, 2005). Inspector's unique analysis software is available to determinate the demineralization (Amaechi, 2009). Sound tooth tissue will show up glowing brightly without reflections, demineralised areas generally have a diffuse outline and are darker at the center which distinguishes them from stains and discoloration.

According to the study of Gorelick et al. (1982) the incidence of white spot formation in patients treated with fixed orthodontic appliances was nearly 50% compared to 24% in an untreated control group. In the literature great variations have been published (from 2 - to 97% of the patients) for WSL prevalence associated with orthodontic treatment (Zachrisson and Zachrisson, 1971; Gorelick et al., 1982; Mizrahi, 1982; Artun & Brobakken, 1986; Geiger et al., 1988; Ogaard, 1989; Mitchell, 1992). Although orthodontic patients had significantly more WSLs than non-orthodontic patients but in this stage generally were not registered as caries, requiring restorative treatment (Ogaard et al., 2004). However in some cases, the development of these lesions could be such rapid that it requiers rapid debonding and treatment procedures. It can be occured already within 4 weeks (Ogaard et al., 1988). Carious lesions may appear after debonding in association with bonded retainer also. Earlier studies showed increased caries frequency and higher prevalence of caries and also fillings in persons treated with fixed orthodontic appliances, but most of the further investigations did not confirm this statement which could be in connection with the higher motivation of the patients and the widespread possibility of oral hygiene regimens (Ingerwall, 1962; Zachrisson & Zachrisson, 1971; Hollender & Ronnerman, 1978; Southard et al., 1986; Ogaard, 1989). Muhler (1970) published that the orthodontic treatment without proper oral prophylaxis resulted in an increased incidence of caries which was significantly reduced after an appropriate prophylaxis. According to the study of Zachrisson & Zachrisson (1971) in case of cooperative patients with proper oral hygiene dental caries is a relatively minor problem and the number of new cavities is relatively low but it is contributed by different factors. For example, beside of the individual susceptibility, it has to be considered that generally the patients aged 6-10 years

and during an early period of adolescents are in active caries phase, the number of new cavities may increase rapidly during fixed orthodontic treatment in these cases. The publicated incidence and prevalence of WSL can vary by sex. Although Ogaard (1989) found no significant difference between genders, most of the studies published it. According to the study of Zachrisson & Zachrisson (1971), girls had better caries index scores, (and also better periodontal indices) than boys during orthodontic treatment. In spite of these findings, Gorelick et al. (1982) found that females have higher incidence in WSL prevalence, while Boersma (2005) and Al Maaltah et al. (2011) published higher incidence of WSL in male. Chapmen et al. (2010) published a higher incidence of WSLs and also the more severe demineralization in males compared with female patients. It can be in connection with those results of some authors that female patients have been shown to have a greater interest in oral health, they had better oral health and tend to brush and floss their teeth more frequently (Kuusela et al., 1996; Sakki et al., 1998; Ostberg et al., 1999). Chapmen et al. (2010) published that early age at start of fixed appliance treatment, inadequate oral hygiene before the treatment, many treatment appointments with poor oral hygiene were associated with greater incidence and severity of WSLs. Al Maaltah et al. (2011) published that patients with WSLs were significantly younger and more likely to have diseased first molars.

Classification of white spot lesions can be found in a modification of material in publication of Nyvad et al. (1999):

White spot stage 1. Inactive caries (intact surface):

Surface of enamel is white, brown or black. It is glossy with no loss of luster; feels smooth and hard when the tip of the probe is gently moved across the surface. No clinically detectable loss of enamel. Smooth surface lesion typically located away from the gingival margin.

White spot stage 2. Inactive caries (surface discontinuity):

Surface enamel is white, brown or black. It is glossy with no loss of luster; feels smooth and hard when the tip of the probe is gently moved across the surface. Localized surface defects (microcavity) could be found in enamel only. No undermined enamel or softened floor detectable with the explorer.

When on the surface there are cavitated lesion, enamel/dentin cavity easily visible with naked eye, surface cavity feels hard on gentle probing and appears shiney. There is no pulpal involvement.

3. Determination of the risk causing dental caries and periodontal diseases during orthodontic treatment

It is wellknown that because of the great possibility for the increased plaque accumulation orthodontic patients who are treated with fixed appliance, mainly generally belong to a potentially higher risk group. So a list of risk factors should be recorded for orthodontic patients to identify those persons who need special preventive interventions. Orthodontic treatment may be hazardous for those patients who have no motivaton, no proper supervision or preventive programme. To notice the increased plaque accumulation, it is important for both patients and clinicians to prevent tooth decay, gingival or periodontal problems and tooth discoloration that could compromise the esthetic of smile and well being of the patients. The key for this is represented by dental plaque.

3.1 Identification of dental plaque

Dental plaque is „the soft tenaciosus material found on tooth surfaces which is not readily removed by rinsing with water" (Axelsson, 2000) (Figure 4.).



Fig. 4. Unstained dental plaque on the labial dental surfaces, on the cervical regions of the frontal teeth.

In this patient the consequences of the large amount of plaque (decalcification, gingivitis) are also seen.

In some cases the identification of plaque can be hard with the naked eye because it could have a whitish colour, similarly to the teeth. The plaque amount and localization can be determined by different methods. The simpliest way to scrape the tooth surface with a periodontal probe. Special test tablets containing red or blue dye can be used to stain the plaque. One tablet is chewed thoroughly, moving the mixture of saliva and dye over the teeth and gums for approximately 30 seconds. Then the mouth is rinsed with water and teeth are checked to identify the stained unremoved plaque. The disadvantage of these tablets that may cause a temporary pink or blue color of lips, cheeks, mouth or tongue. (Figure 5.). An other method is using plaque fluorescence. A special fluorescent solution is swirled around the mouth. After that the mouth is rinsed gently with water and the teeth and gums can be checked with an ultraviolet light. The plaque will be coloured in a brillant orange-yellow. This method does not leave stains on other tissues in the mouth.



Fig. 5. The situation after plaque staining with tablets.

The method cause a temporary discoloration on the bucca or the tongue. Matured and fresh plaque can be seen in different colors. More blue plaque coloration means inproper oral hygiene

Some types of plaque staining products can differentiate between the cariogenic and noncariogenic plaque with different colors (Figure 5.). Acid producing ability of a plaque sample and its cariogenic potential can be determined. Non-cariogenic samples turn green or yellow, while cariogenic plaque samples turn red or orange after sucrose challenge from the solution. Some products contain a neutralising solution (e.g. Plaque Indicator Kit from the GC) which can be used for education of the patients, eg. regarding the protective actions of the saliva and a disclosing gel for the demonstration of plaque. The composition of plaque changes in time, which allows pathogenic bacteria to be active on the tooth surface. Using a special disclosing gel, a more than 48 hours old (matured) plaque and a fresh plaque can be seen in two different colours (blue, redish-pink).

The Inspektor QLF-D BiLuminator™ is a sophisticated device for assessment and monitoring of oral hygiene in the dental surgery. The QLF-D BiLuminator software supports easy acquisition of image pairs and orders them automatically on a visit-patient basis. Plaque and calculus show up brightly red in the QLF –image made by this equipment (Figure 6.). Only those plaque will be seen that has been present for some time (> 1 day).



Fig. 6. White light and QLF image of teeth with orthodontic brackets (publication of the pictures with permission of Inspektor Research System BV, Netherlands).

The BiLuminator™ can be tremendous help to prevent any damage that may follow the placement of orthodontic brackets. By regularly inspecting teeth it can be ensured that teeth are well cleaned before the brackets are placed and mature plaque will not seen during the orthodontic treatment (Amaechi, 2009).

3.1.1 Measurement of plaque amount

There are a lot indices for the measurement of plaque amount, among them the index of Silness and Löe (1964) which is very easy to use, is one of the most frequently used in clinical practice. The Plaque Accumulation Rate Index (PFRI) performed by Axelsson (1991), based on the amount of disclosed plaque which is freely accumulated in the 24 hours following professional mechanical tooth cleaning (during which period subjects refrain from all oral hygiene practices. For the PFRI a five point scale was constructed (Figure 7.). There are positive correlations between the scores of PFRI and e.g. gingival bleeding, Plaque Index, level of streptococcus mutans, caries prevalence etc. (Axelsson, 2000).

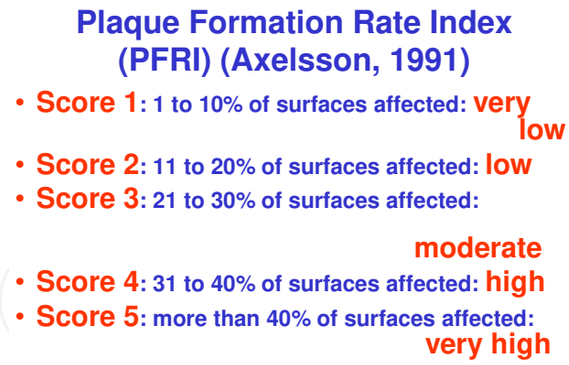


Fig. 7. The scores of Plaque Formation Rate Index by Axelsson (1991).

3.2 Microbiological and clinical parameters for determination of caries risk

As caries is a multicausal disease, it is not optimal to examine just one etiological factor for the general prognosis. Caries risk assessment models involve a combination of factors including diet, fluoride exposure, a susceptible host, microflora which all can interplay with a variety of social, cultural and behavioural factors (Featherstone, 2003; Nicolau et al., 2003).

The combination of clinical and microbiological findings increases the sensitivity of caries prognosis to almost 100% (Kneist et al., 1998; Krasse, 1988). New carious lesions will develop if high bacterial counts have been recorded, thus the evaluation of microbiological data is also recommended before the starting of orthodontic treatment, because the caries risk tends to increase dramatically in patients with high bacterial counts after the placement of brackets, due to the difficulties in performing adequate oral hygiene (Kristofferson et al., 1985).

The risk of caries can be determined by other different testing procedures, these are based on determination of quality and quantity of saliva.

3.2.1 Microbiological parameters

In a regular dental practice the „chairside tests" are very easy to apply for determination of cariogen bacteria and salivary parameters. These tests are available since the begining of 1970s years. Using these products allows semiquantitative evaluation of mutans streptococci in saliva or plaque and lactobacilli in saliva (Larmas, 1975; Jensen & Bratthall, 1989).

Earlier test systems (Dentocult SM, Dentocult LB from Orion Diagnostica, Cariescreen SM from APO Diagnostics, Caries Check SM and Caries Check LB from Hain Diagnostika) needed relatively complicated laboratory working procedures. The newer type of Dentocult tests allows simplier technical work but they work on the same basis.

3.2.1.1 Estimation of mutans streptococci

The basis of the determination of streptococcus mutans is represented by a basic method of Dentocult SM test could be used for estimation of mutans streptococci. Originally it has been developed by Jensen & Bratthall (1989), but this Dentocult SM (Strip Mutans) is a newer development of the spatula method of Köhler & Bratthall (1979). The test is based on those

facts that adhesing of mutans streptococci can be experienced not only to tooth surface but to wooden or plastic spatulas and removable devices also and on the ability of mutans streptococci to grow on hard surfaces and use of a selective broth (high sucrose concentration in combination with bacitracin). The test result shows the risk of caries depending on the level of mutans streptococci CFU (Colony Forming Units/ml) in saliva or in dental plaque, but the result has to be interpreted in relation to the number of the teeth in the mouth (Zickert et al., 1982). An other type of the available simple and accurate chairside test is „Saliva – Check mutans" from the GC, which detects the patients level of streptococcus mutans in 15 minutes only. For this test there is no need for incubator (in contrast with the previously mentioned product) or any other devices. High accuracy is possible as the test strip containes 2 monoclonal antibodies that selectively detect only the streptococcus mutans species, meaning no other bacteria modify the results.

3.2.1.2 Estimation of lactobacilli

The other organisms that can be associated with caries are lactobacilli. Althoug probably they don't play a primary role in the etiology of caries, lactobacilli can be important from the viewpoint of caries activity (Socransky, 1968). Based on different studies the presence of lactobacilli reflects only high consumption of carbohydrates and therefore it is an indirect test for caries (Klock & Krasse, 1979; Crossner, 1981). On the other hand the test provides information about the activity of existing carious lesions (high levels of lactobacilli show an incresed carious activity which can lead to early treatment of the lesions).

For the estimation of lactobacilli can be used a method of dip slide test (Larmas, 1975). The applied selective lactobacillus agar which supports the grows of the acid forming and acid resistant lactobacilli (mainly Lactobacillus casei). The dip slide has to be placed into the transport tube and incubated for four days at 37 °C (99 °F). Estimation of lactobacilli, similarly to mutans streptococci, can be performed by comparing the result to the chart. For the evaluation the number of the colonies means the relevant information. Because of different incubation times for the various test vials and the short shelf life of the mutans streptococci tests, further efforts have been made for optimize the tests in accordance with the practical viewpoints.

3.2.1.3 CRT bacteria test for combined determination of cariogenic bacteria

The prognosis for caries risk is more certain in those case when mutans streptococci and lactobacillus tests are combined (Stecksen-Blicks, 1985). CRT Bacteria (Vivadent, Shaan, Lichtenstein) (Figure 8.) is a test which is available for the evaluation of the level both important oral microorganisms by means of selective agars as previously described.



Fig. 8. CRT Bacteria test.

This test give a possibility for the determining mutans streptococci and lactobacilli at the same time, during the evaluation of caries risk.

Performing the clinical procedures, after two days incubation at 37 ^{o}C (99 ^{o}F) can be detected and evaluated for both mutans streptococci and lactobacilli. Leaving CRT bacteria in the incubator for more than 48 hours for any reason, it will not cause any change in bacterial count. The test sample can be stored in the refrigerator for up to two weeks without any changes.

Evaluation of the CRT bacteria test (with the model chart): higher values than 10^5 CFU/mL of mutans streptococci in saliva indicate a high risk (Krasse, 1988; Anderson et al., 1993). CRT bacteria test can be applied to check the effectiveness of different antimicrobial treatment of the risk patients. The modification of the above presented procedure gives a possibility for the determination of mutans streptococci not only in saliva but in dental plaque also, but applying this saliva based method, the examination of incubated plaque samples provides only a semiquantitative evaluation of the microorganisms (Kneist et al., 1998). This measure is indicated to monitor the the edges around brackets in orthodontic patients.

The tests are contraindicated after treatment with previous antibiotic treatment (within the previous two weeks) or after the use of antibacterial rinsing solution (the waiting time at least 12 hours).

All tests are very easy to use, can be applied to demonstrate the proper oral hygiene and to check the effects of motivation, generally less expensive than conventional microbiological methods (Newbrun et al., 1984) and do not need specially trained personnel. These are important diagnostic tools for dentists who strive to maintain oral health of their patients.

Presently the trends towards using simple, quick tests which can demonstrate the results clearly (without any other special equipments like e.g. incubator) for the patients in a short time. These tests are based on various methods: e.g. monoclonal antibodies are employed in Saliva Check Mutans from GC, Clinpo ™ Cario L-Pop ™ from 3M need local measurement of acid production for assessment. This last test was used in a 12 month follow up cohort study to evaluate the association between having a high score on this test and caries occurance in young patients undergoing orthodontic treatment (Chaussain et al., 2010). More studies are needed for the evaluation because of basic method of these tests not yet fully matured in terms of their sensitivity and handling properties.

3.2.2 Assessment of salivary factors

Salivary factors are in closed connection with caries risk. Determination of salivary enzymes and ions is difficult in the everyday practice, but measurement of salivary flow rate (the volume of saliva during a given period of time) or salivary buffer capacity can be performed relatively easily.

3.2.2.1 Salivary flow rate

It is wellknown for a long time that in patients with xerostomia the caries rate is increased. So the measurement of this factor must be of interest to evaluate the potentially high risk groups of orthodontic patients. The flow rate can be established easily without any special equipments. The saliva has to be collected in calibrated tube (tube for the lactobacillus test can be used to measure the salivary flow rate as well) (Figure 9.). Secretion rate should be

determined for resting saliva and paraffin stimulated saliva. The values for the determination are shown in the Table 1.



Fig. 9. Collecting saliva in a calibrated container.

For determining the risk of caries the dentist should measure the salivary secretation rate.

For the adults stimulated salivary flow rate is less than 0.7 ml/min is considered low, while higher than 1.0 mL/min is considered normal. In case of women the salivary flow rate is generally slightly lower than in men (similarly to the children when compared with the adolescents).

Secretion rate (ml/min)	Very low	Low	Normal
Resting saliva	< 0.1	0.1 - 0.25	0.25-0.35 (mean 0.30)
Stimulated saliva	< 0.7	0.7 - 1	1 – 3 (mean 2)

Table 1. Classification of salivary secretion rate for resting and paraffin-stimulated whole saliva (Axelsson, 2000).

The results could be affected by different drug intake (e.g. antihistamines, neuroleptic or antihypertensive agents).

3.2.2.2 Buffer capacity

Buffering capacity of saliva ensures the pH level and ability for remineralization. The threshold is *under 4* when the process of caries can become faster. For the evaluation can be easily used e.g. Dentobuff strip test also from the Vivadent. A disposable syringe is used to place a single drop paraffin stimulated saliva on a test strip. After about five minutes the color change on the pH indicator strip is compared with the color chart provided. Similar possibility for measuring buffering capacity is Saliva Check Buffer from the GC.

Although it can be important information, the determination of buffer capacity, similarly to the salivary flow rate, has only subordinate role in the reliable identification of patients at high caries risk. The buffer capacity test has greater value in those patients who have exposed root surfaces because exposed dentin is more sensitive to acid than the enamel (Heintze et al, 1999).

3.3 Determination and assessment of the risk of periodontal diseases

Development and progression of periodontitis basically depends on the interaction of periodontopathogenic bacteria and the host's immune defense system. Science has long sought a diagnostic procedure to predict the risk of periodontitis with determination of the attack and defense mechanisms. For the daily practice, clinical parameters are sufficient to identify patients with potential disease activity. Periodontal diseases are in tight connection with systemic diseases (eg. cardiovascular diseases, diabetes etc.), and there is an evidence that periodontitis associated bacteria or their tissue derived inflammatory mediators are transmitted eg. during pregnancy from mother to child (Genco, 1996; Herzberg & Meyer, 1996; Slavkin, 1997). There are some chairside test which can measure different parameteres associated with periodontitis development. However, it is not clear how these tests could be clinically significant. According to several recently published reviews, none of the available tests is capable identify with at least 80% accuracy those individuals who are at risk for periodontitis (Lang & Bragger, 1991; Jeffcoat et al., 1997). Therefore, clinical evaluation seems to be more useful to carry out periodontal diagnosis and assessment the risk. The dentist has to determine the following points (Heintze et al, 1999):

1. Does gingival bleeding appear on probing?
2. Do periodontal pockets exist and how deep are they?
3. Are alterations of periodontal bone apparent on radiographs (for this periapical, bitewing and panoramic pictures are needed)

3.3.1 Clinical measurements

Greater plaque accumulation, tendency for bleeding and increased pocket depth have been observed more frequently in orthodontic patients. Therefore, to examine these factors are necessary to determine and monitor a risk of periodontal disease concerning orthodontic treatment.

3.3.1.1 Gingival Bleeding Index

Gingival Bleeding Index published by Ainamo & Bay (1975) is very simply to use in orthodontic patients. The sulcus is probed carefully on the buccal and lingual surfaces with periodontal probe. It is useful to develop a specific system e.g. to proceed by quadrants. Probing begins on the buccal surface, proceeding from the distal to mesial surfaces, then on the lingual surface from the distal to mesial. Thus each tooth has four points of measurement: buccal, lingual, mesioproximal and distoproximal.

In patient with fixed appliance performing the probing can be more difficult due to bands and other attachments limiting access to the gingival margin (Figure 10.). Still, it is necessary to probe the gingival margin along its entire lengh to get valuable data and to perform adequate preventive interventions.



Fig. 10. Performing clinical measurements for the evaluation of periodontal conditions with a periodontal probe in orthodontic patients.

Although periodontal parameters are very important for the determination of the risk or the exist of periodontal diseases due to orthodontic treatment, sometimes it is difficult to perform because of different parts of the appliance.

3.3.1.2 Loss of attachment

The gingival sulcus is probed gently with a special periodontal probe. The depth of the gingival sulcus is considered maximally 0.5 mm deep in case of sound gingiva. In some orthodontic cases (mainly in adult patients) the measuring loss of attachment and its documentation are important, but measurement of attachment loss does not correlate with inflammatory activity of a pocket (Lang & Bragger, 1991).

3.3.2 RT-PCR (Reverse Transcription –Polymerase Chain Reaction)

One of the newest method is the RT-PCR. This is the most sensitive technique for mRNA detection and quantification currently available. It is a fully automated process and exact quantification of anaerob periodontopathogenic bacteria from a small sample of dental plaque. The advantages of this method are high specificity, high sensitivity and objectivity (Dharmaraj, 2011).

In addition to clinical and radiographic parameters and additional data provide information about the groups at higher risk for periodontitis (Fox, 1992). Patients are in higher risk in the following cases:

1. Heavy mokers
2. Diabetics
3. Patients with osteoporosis
4. Persons with inproper oral hygiene
5. Patients with previous periodontal disease
6. Elderly patients

The clinicians must identify susceptible patients and develop strategies to prevent loss of attachment and/or gingival recession. Each patient must be assessed individually for periodontal factors which mean for the patients high risk of developing periodontal disease during orthodontic treatment (Vanarsdall, 2000).

4. Possibilities to avoid or reduce the risk of caries and periodontal diseases concerning orthodontic treatment

Concerning the orthodontic treatment removable appliances do not cause significant plaque accumulation, while patients with fixed orthodontic appliances have a higher risk for increased plaque formation and with its harmful consequences for demineralization of the teeth and periodontal problems. Most of the lesions occure during fixed orthodontic treatment and appear mainly to be surface demineralization rather than a subsurface lesion. De-and remineralization processes are performed continuously. Sometimes the amount of remineralization can not totally overcome the amount of demineralization (Wilmot, 2008).

Longitudinal studies have shown the beneficial effects of recommendation to perform preventive measures during orthodontic treatment mainly in case of fixed appliances. Applying the possibilities, in these patients there was no clinically significant damage on either hard tissues of the teeth or periodontium (Boyd et al., 1989; Zachrisson & Zachrisson, 1971). Beside of the orthodontists, the general dentists and oral hygienists have a significant role in maintaining proper and effective oral hygiene of the patients undergoing orthodontic treatment with fixed appliances.

4.1 Patients with removable appliances

Although removable orthodontic appliances do not increases alone the absolute level of pathogenic microorganisms, but frequently provide more retention places for bacterial deposits (Figure 11.). In these cases the aim of oral hygienic procedures is the elimination of plaque from the appliance to prevent reinfection of the cleaned teeth. It is very difficult to keep the removable appliance totally free of plaque. Different cleaning methods are recommended mainly for home care. The orthodontist can suggest to clean with toothbrush and toothpaste (or soap) under running water or to clean the appliance in water bath containig a cleanser tablet. Both of them show some disadvantages: the combination of toothbrush-toothpaste cleaning is effective only on the easily accessable surfaces (Diedrich,

1989), while the use of self acting cleansing tablet allows just 2-3% of total deposits remaining on the appliances (Rabe et al., 1986). The antibacterial effectiveness of these tablet cleansers is doubtful and they can lead to obvious corrosion of the metal solder connections (Rabe et al.,1986). One more possibility for cleaning the removable appliances can be an ultrasonic bath, which is an expensive method and is not affordable for all patients wearing removable orthodontic appliances.



Fig. 11. Removable appliance with many retention sites and bacterial deposits.

In case of removable appliance it is necessary to clean the appliance to prevent reinfection of the cleaned teeth.

In the literature different materials are mentioned for reducing the level of pathogenic bacteria in the mouth. E.g. application of SRD (Slow Release Dosage) of chlorhexidine on the tooth surface showed a plaque reducing effect (Friedman et al., 1985), but other material with the same ingredient (e.g. Cervitec varnish) can be used effectively. Cervitec can successfully reduce cariogenic bacteria like mutans streptococci on different tooth surfaces, and promote the plaque reducing effect in the mouth (Huizinga et al., 1990; Petersson et al., 1991; Twetman & Petersson, 1997; Madléna et al., 2000). Slow release fluoride devices also can be used in case of high risk patients with removable appliances, although these products are preferred for patients treated with fixed appliances. Using slow fluoride release containing polymethyl metacrylate (Orthocryl Plus) ensures continuous low concentration of fluoride in saliva for more months which provides an optimal circumstance for the remineralization of initial carious lesions (Miethke & Newesely, 1988; Alacam et al., 1996). In case of patients using removable appliance to perform all dental and gingival treatment should be offered before the begining of the treatment.

4.2 Patients with fixed appliances

For the proper effects preventive actions and interventions should begin as early as possible, long before the active orthodontic therapy both in removable and fixed applience cases, but especially important for patients with fixed appliances.

There are three main categories should be considered concerning the preventive program for orthodontic patients: preventive actions and interventions *before, during and after* the active orthodontic treatment (Table 2.).

<table>
<tr><th>Before</th><th>During</th><th>After</th></tr>
<tr><td colspan="3">Motivation of the patients and oral hygienic training</td></tr>
<tr><td colspan="3">Control of oral hygiene</td></tr>
<tr><td colspan="3">Dietary counselling</td></tr>
<tr><td colspan="3">Professional tooth cleaning (repeatedly if it seems to be necessary)</td></tr>
<tr><td></td><td>Special oral hygienic instructions concerning the fixed orthodontic appliance</td><td></td></tr>
<tr><td rowspan="3"></td><td colspan="2">Use of fluorides</td></tr>
<tr><td>Chemical plaque control</td><td>Chemical plaque control in case of fixed retainer</td></tr>
<tr><td></td><td>Remineralization</td></tr>
</table>

Table 2. Preventive viewpoints before, during and after the active orthodontic treatment with fixed orthodontic appliance (Lundström et al., 1980; Hotz, 1982).

In all patients but especially in case of fixed appliance it is very important that all general dental and periodontal treatment should be completed *before* orthodontic treatment. It is compulsory to consult with the general dentist or any specialist to gain a statement that the patient is ready for orthodontic treatment. To prepare a written inform consent including the necessity of improved oral hygiene is also necessary before begining of the treatment. The oral condition has also to be recorded on the patient's chart and demonstrated with clinical photos.

Concerning the treatment, bonding of molars is better and ensures better possibilities to remove the plaque than banding, especially in adults. For the same reason it is suggested to use single arch wires, if the case allows and to remove excess composite around brackets (mainly from the gingival third). Theoretically use of fluoride containing orthodontic adhesives are preferable during orthodontic treatment and in case of fixed retainer. In vitro studies glass ionomer cements have demonstrated a more sustained fluoride release and evidence that these cements may reduce decalcification (Vorhies et al., 1998; Chung et al., 1999; Millett et al., 1999). At the same time, according to a systematic review, glass ionomer cement could be more effective than composite resin in preventing white spot formation, but still the scientific evidence is weak. The authors conclude that fluoride releasing

bonding material for bonding brackets showed almost no demineralization-inhibiting effect (Derks et al., 2004).

Because of the limitation of successful bonding with glass ionomer adhesives, further investigations are needed for the recommendations on the usage of fluoride containing adhesives during fixed orthodontic treatment (Rogers et al., 2010). Uysal et al. (2011) conclude that using antibacterial monomer containing adhesive for bonding orthodontic brackets successfully inhibited caries incidence in vivo, the cariostatic effect was localized around the brackets and proved to be significant after 30 days.

Lingual appliances can cause extra difficulties in performing proper oral hygiene. The longer the treatment time with fixed appliance, the more time needed to maintain oral health in such a non-ideal circumstance. It is preferable to minimize the length of treatment with either conventionally or lingually placed fixed orthodontic appliance (e.g. by early corrections of skeletal and alignment problems in the mixed dentition with removable appliances). In addition a light cure sealant containing fluoride should also be advisable to be applied on the entire free surface, which can also be reapplied during the treatment (Frazier et al., 1996). Fluoride containing elastomeric chains also may reduce the degree of decalcification (Banks et al., 2000).

4.2.1 Motivation of the patients and oral hygienic training; control of oral hyiene

Before the orthodontic treatment it is very important to inform the patients about the importance of the improved oral hygiene concerning orthodontic treatment with fixed appliance and to explain the causes of caries and periodontal disease. The dentist can use any gingival indices and disclosure of the plaque for the patient to be motivated. The patients need proper information about the preventive possibilities concerning fixed orthodontic appliance after its application. It could be very useful to check the oral hygiene throught the complete orthodontic therapy. Beside of the use of fluoride containing toothpaste and brushing with conventional brushes also during the treatment at least twice a day, additional methods could be suggested helping to improve oral hygiene. Recording and documentation of the improvement in oral hygiene in the patient's chart is also necessary. Although motivation and oral hygiene training represent the most important points before the orthodontic treatment, it can be repeated as frequently as it is needed not only before but during the active orthodontic treatment as well. *After finishing the orthodontic treatment* the orthodontist also has to advice the patients to maintain proper oral hygienic habits.

4.2.2 Oral hygienic training methods

It is a possibility and a responsibility of the orthodontists to involve their patients in a systemic program for the prevention of caries and periodontal diseases focusing on mechanical removal of plaque and elimination of pathogen microorganisms. Because of tooth cleaning is much more difficult in patients undergoing orthodontic therapy with fixed appliance, patients and orthodontists/dentists or specially trained personnel require much efforts and time to show the possibilities of proper oral hygiene. Ask the patients to demonstrate the efficiency of brushing at each regular visit until they have mastered the technique.

The patients can use both hand or electric tooth brushes with short head, soft and rounded bristle end, but they can apply special orthodontic brushes (eg. when middle row of bristles is shorter than the outer row) and have to ask other special equipments also (eg. floss, interdental brushes, etc.) (Figure 12.). The patients may be instructed in the modified Bass technique. It is also important to let the toothbrush air-dried for 24 hours between uses. Tooth cleaning requires at least 10 minutes for patients. Approximal surfaces could be cleaned properly with dental floss. Interdental brushes and Superfloss must be used for the proper oral hygiene not only on the approximal surfaces but the tooth surfaces around the bracket and band margins as well (Heintze et al., 1999; Boyd, 2001).



Fig. 12. Special brushes for orthodontic patients.

During the orthodontic treatment with fixed appliance it is necessary to suggest special equipments for the proper oral hygiene and to check the effectiveness of them.

4.2.3 Control of oral hygiene

During the active treatment patients should evaluate their teeth (and appliances) and determine these are whether clean or not. Regular recall examinations are necessary but the intervals between the recall examinations depend on the initial conditions. At the recall examinations during both the active treatment phase and the retention period regularly should perform the determination of caries risk (mutans streptococci and lactobacilli counts) and the evaluation of the condition of gingiva.

During the retention phase, removable retainers mean lower risk because these appliances allow an easier tooth cleaning procedure. The attached fixed retainers represent plaque retentive sites in the mouth, although these appliances are believed not to lead to initial carious lesions or periodontal problems if properly fabricated (Artun, 1984; Gorelick et al., 1982). Further advantage of removable devices is that they could be used as carriers of medicaments to provide more intensive prophylaxis.

4.2.4 Dietary counselling

Sugar is not a single causative factor of dental caries but it can appear as an important external modifying risk factor in this process. Due to this reason the dental personnel have to ask the patients about their nutritional habits, optimally using a questionnaire. It is very important to know the average frequency of intake of any types of the cariogenic foods (Axelsson, 1999).

The dietary control is in close connection with microbiologic evaluations. As high salivary levels of lactobacilli indicate a high sugar intake and a low pH in the oral cavity, the lactobacillus test is useful for the objective supplement to the dietary questionnaire (Axelsson, 1999). Sugar intake can be assessed eg. from a 24 hour recall questionnaire. For caries prevention and control the following dietary recommendations should be performed for the patients according to Axelsson (1999):

1. The first meal of the day (breakfast), should be a balanced composition of dairy products, grains and fruit eg. yogurt and muesli, fresh fruit and vegetables. It is not the same as the commercial continental breakfast containing mainly fat, sugar and water which causes rapid swings in blood sugar levels stimulating a high frequency of sugar intake all day.
2. The total number of meals, including all, should be limited to about four.
3. Sticky, sugar containing products should be eliminated. Sugarless sweets containing sugar substitutes (xylitol, sorbitol, aspartam etc.) should be used.
4. In each meal, fiber rich products that stimulate chewing and salivary flow should be included.
5. Selected individuals with extremely high risk of development of caries should clean all surfaces just before each meal, to limit the drop in pH during and immediately after the meal.

4.2.5 Professional tooth cleaning

Professional tooth cleaning represents a basic method and means professional removal of all deposits from the teeth by dentist, dental hygienist or specially trained nurses. For the proximal surfaces dental floss must be used (and fissures must be sealed if indicated). Calculus (mineralized plaque) can be removed with manual or ultrasonic scalers, after it the teeth should be polished. A complete professional tooth cleaning should be performed before the active orthodontic treatment and at the appointments of control examinations.

4.2.6 Use of fluorides

A correlation between reduced caries prevalence and natural fluoride content of drinking water was published firstly by Dean (1938). Saliva usually contains a low amount of fluoride (Twetman et al., 1999). The importance of fluoridation is basic to maintain the health of teeth, particularly in the prevention of caries and remineralization of incipient carious lesions. A report published by the WHO (1994) and a review article by Rolla et al. (1991) state that the use of fluoridated tooth paste had led to a significant decrease in the incidence of caries in the industrialized countries. The ability of fluoride to retard or prevent the development of dental caries appears to involve several mechanisms including a reduction in the acid solubility of enamel, promotion of enamel remineralization, inhibition of glucose uptake and utilization by acidogenic bacteria. Demineralization refers to the loss of minerals (mainly calcium and phosphate ions) from the tooth structure due to the acidic and cariogenic challenge. Fluoride can help to prevent the mineral loss. When the pH drops below approximately 5.5, calcium ions are dissolved from the enamel and bond with fluoride ions forming a calcium fluoride (CaF_2) layer (Rolla & Saxegaard, 1990). CaF_2 is

insoluble in the saliva and remains on the teeth for months (Dijkman et al., 1983). The CaF_2 layer functions as a pH controlled fluoride reservoir and is the most important supplier of free fluoride ions during the cariogen challenge (Fischer et al., 1995). Fluoride uptake and release of the enamel are strongly dependent on the duration of contact with the fluoridated agent (Ten Cate & Arends, 1980; Chen et al., 1985). With an appropriate fluoride formulation, incipient lesions could be reduced in size or even be repaired (Tranaeus et al., 2001).

Research suggests that topical fluorides might also decrease decalcification during orthodontic treatment (Geiger et al., 1988; Shannon & West, 1979; Benson et al., 2004; Derks et al., 2004; Chadwick et al., 2005; Sudjalim et al, 2006). Daily use of fluoride toothpaste, in combination with specific oral hygienic instructions, is recommended as the basis of caries and periodontal prophylaxis programme. Although fluoride concentration in different products may vary, below 0.1% in a dentifrice is not recommended for orthodontic patients (Ogaard et al., 2004). There are a number of locally applicable agents to improve maintain proper oral hygiene. The most important aim with the fluoridated dental care products first of all to strengthen of enamel against to caries, enhance the remineralization, protection against demineralization and improve or ensure gingival health. Beside of the toothpaste, fluoridated agents are included in different forms of gels, mouthrinses, varnishes and other products.

Topical fluoride may be applied by professional personnel in dental office or by patients at home. Using other local fluoridaton's method, a balance should be maintain between the prevention of dental caries and minimising the risk of dental mottling (Oulis et al., 2009). Generally, dentifrice alone is ineffective in preventing development of lesions (O'Reilly & Featherstone, 1987).

4.2.6.1 Fluoride rinses

Relevant studies have shown that daily use of fluoride rinse during the orthodontic treatment can reduce the incidence of initial carious lesions. At the same time, relatively few of orthodontic patients rinsed daily with fluoride containing mouthrinses (Geiger et al., 1988).

It has been published that caries reduction with different mouthrinses was estimated 25-30 % (Geiger et al., 1988; Newbrun, 1992). Rinses generally contain 0.025 to 0.05 % sodium fluoride, 0.025 % amine fluoride, 0.01 % zinc fluoride or 0.025 % APF (Acidulated Phosphate Fluoride), but more highly concentrated solutions are recommended for patients with increased risk (Zachrisson, 1975). Patients in high caries risk such as orthodontic patients should use a daily rinse of eg. 0.05% sodium fluoride at home (Petersson, 1993). Fluoride containing mouthrinse can be used at a time that is different to any tooth brushing for an additive effect to fluoride toothpaste (Oulis et al., 2009) or after the toothbrushing to complete the fluoride intake.

4.2.6.2 Fluoride gels

Fluoride containing gels can be used on patients yearly or half-yearly in dental office or can be used regularly by the patient, at home. The application of fluoride gels can reduce the occurance of caries by 21-30 % (Marinho et al., 2002; Marthaler, 1988).

4.2.6.3 Fluor protector gel

The Fluor Protector Gel (Vivadent, Shaan, Liechtenstein) contains calcium (Ca), phosphate and 1450 ppm fluoride (F) forming a CaF_2 layer and a direct incorporation of Ca, fluoride and phosphate ions into the tooth enamel. CaF_2 preferably deposits on demineralized surfaces and this layer is additionally stabilised by phosphate ions (Rolla and Saxegaard, 1990), which are also contained in Fluor Protector Gel. If the pH falls into the acidic range, the calcium fluoride layer releases Ca and phosphate ions which are released into the saliva and form a depot. It will work against demineralization or can contribute to the formation of fluoro-apatite or fluoro-hydroxyl-apatite. This replacement of hydroxy ion by a fluoride ion in the hydroxy apatite ensures the tooth enamel with higher resistance to pH drops (Fischer et al., 1995).

The Fluor Protector Gel can either used by the dentist in the dental surgery or by the patients at home, in different ways. It can be used in place of toothpaste to brush the teeth, or in the evening, after cleaning the teeth with toothpaste, when Fluor Protector Gel can be additionally applied with the toothbrush. It is suggested for cleaning interdental spaces of natural dentition or fixed dental restorations etc.. It also can be used with a tray filled with gel inserting it once or twice daily, and leaving it in place for 10 minutes every occasion.

It is especially recommended in high risk patients undergoing orthodontic treatment with fixed appliances.

4.2.6.4 Stannous fluoride gel

Since the late 1970s, 0.4% stannous fluoride (SnF_2) gels have been widely used as therapeutic agents for number of common oral diseases and conditions, and promoted as the preferred preventive and treatment products (Hastreiter, 1989; Paraskevas & van der Weiden, 2006). It contains more than 90% available stannous ion (Sn^{2+}) which is useful againts either plaque accumulation or gingivitis.

4.2.6.5 Halitosis tooth and tongue gel, Amine fluoride gel (see below)

4.2.6.6 Amine fluoride/ amine and stannous fluoride containing products

The use of amine fluorides in dentistry was recommended firstly by Mühlemann et al. (1957). The beneficial effects of them are well known as protective agents against mainly caries and dental plaque accumulation (Schmid, 1983; Öhrn & Sanz, 2009). These products were used in the form of dentifrices, gels and fluids in various caries preventive programs and suggested as alternatives or adjunctives for systemic fluoridation. Clinical studies with amine fluorides can be divided into trials with dentifrice only, with gel only or combined use of these products similarly to the use of mouthrinse and/or toothpaste. Fluoride containing gels are recommended annually or semiannually in the dental office. By the patients' home use, it is suggested to brush once a week, after a regular toothbrusing. Gels contain high concentration of different types of fluorides. Gels containing amine fluoride (in 12 500 ppm concentration) (Elmex gel, Gaba Int. Ltd., Switzerland) are used mostly in Europe. The active ingredients of the clinically tested relatively new product (Halitosis tooth and tongue gel) (Gaba Int. Ltd., Switzerland) (Figure 13.) are amine fluoride/ stannous fluoride and zinc lactate). This gel protects against caries, cleans the teeth and tongue (by

helping a special tongue cleaner) and even neutralizes odour-active compounds in the oral cavity. It is offered for adults and childrens above the age of 12 years. It is also very useful for orthodontic patients with fixed orthodontic appliances because of these appliances can cause oral malodour (Babacan et al., 2011). This product is available in the form as mouthrinse with 250 ppm fluoride content.



Fig. 13. Halitosis tooth and tongue gel and a tongue scraper.

This product is very useful for the patients undergoing orthodontic treatment.

Clinical trials with amine fluoride toothpaste, performed between 1968 and 1995 with a duration of 2.5-7 years, has reported reduction in mean DMFT/DMFS of between 7.1 and 35 % (Marthaler, 1968; 1974; Patz & Naujoks, 1970; Ringelberg et al., 1979; Cahen et al., 1982; Leous et al.,1995). Studies with amine fluoride gel between 1970 and 1989 with a duration of 1.5-7 years reported caries reductions of 31 - 53 % (Marthaler et al., 1970; Shern et al., 1976; Franke et al., 1977; Obersztyn & Kolwinski, 1984; Szőke & Kozma, 1989). In a 7-year clinical study using a combination of amine fluoride products a 43% reduction in DMFS mean values was found (Künzel et al., 1977). Madléna et al. (2002) published significant reduction in DMFS value (38 % including white spot lesions) and 34 % (not including white spot lesions) and a significant reduction in Plaque Index values with the combined use of amine fluoride containing toothpaste and gel in a high risk groups of adolescents. Márton et al. (2008) published beneficial effects of amine fluoride products.

The effects of Sn_2F or AmF/Sn_2F containing products on plaque accumulation were examined by many investigators (Øgaard et al., 1980; Bánóczy et al., 1989; Zimmermann et al., 1993; Mengel et al., 1996; Madléna et al., 2004; Gerardu et al., 2007). Madléna et al. (2009) proved the beneficial effects of amine fluoride /stannous fluoride containing products on periodontal parameters in patients treated with fixed orthodontic appliances. However, during a short term (four week-) examination period, there was no found significant difference between the groups using amine fluoride containing toothpaste only and the other group with combined use of toothpaste and mouthrinse containing the same ingredient. Although, at the same time numbers of streptococcus mutans and lactobacilli were reduced and level of periopathogen microorganisms also showed a very impressive decrease after even a four weeks use (Madléna et al., 2009; Nagy et al, 2010).

4.2.6.7 Fluoride varnishes

The development of fluoride varnishes started after the study of Mellberg et al. (1966). These authors found that considerable amounts of fluoride were released from enamel within the

first 24 hours following the topical application of acidulated fluoride phosphate preparations. APF (Acidulated Phosphate Fluoride) increases the uptake of fluoride into the enamel because of its low pH. It is used mostly in the US. Schmid (1964) presented a topical fluoride method using a varnish with a high fluoride concentration. It was the Duraphat (Colgate Oral Pharmaceutical Inc., Canton, USA) which had the ability to adhere to tooth surfaces in the presence of saliva. Duraphat varnish consists of a natural resin (colophonium base with 5 % sodium fluoride (2.23 % F^-) dissolved in ethanol. It hardens the enamel in contact with saliva producing a temporary cover over the enamel. The patient is instructed to refrain from brushing for four hours after application (Retief et al, 1985; Staley 2008). The varnish also leaves calcium fluoride on the surface of the enamel in a CaF_2-like material that is less soluble and most likely leaches away from the surface through the pellicle (Dijkman & Arends, 1988). The other similar varnish system (Fluor protector) (Vivadent, Shaan, Liechtenstein) was introduced by Arends and Schuthof in 1975. Fluor protector contains 0.1 % F^- as difluorosilane dissolved in ethyl acetate and isoalylpropionate solution which has acidic properties. It is advisable that the patients avoid rinsing after application. Eating or brushing the teeth should also be avoided at least 45 minutes after the treatment. The differences can be found between the two varnishes are important in solvent, fluoride concentration, consistency, hardening time, colour, scent and taste. The varnishes coat the tooth surfaces as a thin layer that hardens a few minutes after application. The cost benefit ratio of fluoride varnishes is better then that of gels, and these products ensure the elimination the problem of compliance, as they are applied professionally (two to four times per year).

Beside of the above mentioned two types of fluoride varnish there are some other products. Duraflor (DenTrek, registered trademark of OMNI™ Preventive Care) is a 5 % NaF varnish containing xylitol and a bubble gum flavouring. Cavity shield contains 5% NaF in a neutral resin. The fluoride content is reported more uniform than that of Duraphat (Shen & Autio-Gold, 2002). The unit dose can be mixed easily and applied to teeth (Chu & Lo, 2006). Bifluorid 12 (Oceanwealth Horizon , (Voco), Düsseldorf, Germany) contains both NaF (2.7% F) and CaF_2 (2.9 % F). This combination of fluoride allows more fluoride deposit on the surface of demineralized enamel than NaF varnish alone (Attin et al., 1995).

Clinical studies showed beneficial effects of fluoride varnishes on caries reduction in both permanent and deciduous dentitions (Marinho, 2004). In the permanent dentition it was ranged from 20-70% compared to untreated controls (Petersson, 1975; de Bruyn & Arends, 1987), although it is very important to consider that clinical results are strongly influenced by different factors (e.g. caries prevalence, frequency of application of the varnish, caries risk etc.). Fluoride varnishes should be considered for use as a preventive adjunctive method to reduce demineralization adjacent to orthodontic brackets, especially in patients exhibiting pure compliance in oral hygiene and home fluoride use (Todd et al., 1999).

Advantages of fluoride varnishes are multiple: prolonged contact time acting as a slow release reservoir; these could be applied simply, quickly, easily; there is no need for widespread professional prophylaxis before the application of varnish because this procedure does not mean any additional effect, varnishes are safe, for even very young children. (Chu & Lo, 2006). Both parents and dentists prefer fluoride varnishes to fluoride

gels (Warren et al., 2000). One disadvantage of Duraphat is its poor esthetic effect (a yellow film of varnish remains on the teeth for several hours after application) (Warren et al., 2000).

In a conclusion: there is moderate information is available on remineralization effectiveness of fluoride varnishes, but based on some investigations these could be offered for potential remineralization of the enamel (Castellano & Donly, 2004; Ogaard et al., 1984, 1996).

4.2.6.8 Slow release fluoride devices

Considering that intraoral levels of fluoride play a key role in the dynamics of dental caries, it has been suggested that the use of controlled and sustained delivery systems can be considered as a means of controlling dental caries incidence in high risk individuals (Mirth, 1980).

In a review of Pessan et al. (2008) there are three types of devices: Copolymer membrane device, Glass device, Hydroxyapatite Eudragit RS100 diffusion controlled F system. The third one is the newest type of slow release device, which consists of a mixture of hydroxyapatite, NaF and Eudragit RS100; it contains 18 mg NaF and intended to release 0.15 mg F/day. It was demonstrated that the use of this device is able to significantly increase salivary and urinary F concentration for at least 1 month (Altinova et al., 2005). These devices are effective in raising intraoral F concentrations at levels able to reduce enamel solubility, resulting in caries protective effect. The use of slow relesase devices have been shown to have a very favourable benefit regarding cost-effecitiveness ratios (Toumba, 1996). Slow release devices can show a high anticaries effect for patients in high caries risk (Featherstone, 2006). Beside of this, such a device would overcome compliance problems also. It may not eliminate all carious lesions, but would lead to dramatic reduction and in combination with antibacterial treatments could indeed eliminate caries in high risk individuals (Pessan et al., 2008).

4.2.7 Oral health care products for chemical plaque control

4.2.7.1 Chlorhexidine (CHX) containing products

Among chemical plaque control agents chlorhexidine digluconate has proven to be the most effective and safe. It seems to be the most important antimicrobial ingredient in dental products, which is available in forms of rinse, gel and varnish. Inspite of the side effects, experienced first of all with the mouthrinse, using of these products is considered as the best possibility to treat gingivitis.

4.2.7.1.1 Chlorhexidine mouthrinses

These types of clorhexidine containing products [(e.g. Corsodyl mouthrinses (GlaxoSmithKline, Brentford, UK)] are the most frequently used form in dentistry for patients with gingivitis and periodontitis and before or after surgical procedures. Professionally chlorhexidine solution could be used for irrigation the inflammed pockets. Anderson et al. (1997) published that use of CHX mouthrinse in addition to regular oral hygiene was effective in reducing plaque and gingivitis in adolescents undergoing

orthodontic treatment. Ready to use 0.1 or 0.2 % mouthrinses are available. Löe et al. (1972) published that twice daily rinsing with an 0.2% CHX solution reduced the total bacterial count in saliva by 85-90%. In practice, it is offered for twice-daily use for a limited, 6 week term because of the side effects of this agent. These are the discoloration of the teeth, fillings and tongue, taste disturbances (hot and bitter) in the mouth. It can leave an unpleasant aftertaste and repeated use lead to an impaired sense of taste and desquamations.

Based on the available reviews, chlorhexidine rinses have not been highly effective in preventing caries or at least the clinical data are not convincing (Autio-Gold, 2008). Due to the current lack of long term clinical evidence for caries prevention and reported side effect, CHX rinses should not really be recommended for caries prevention. However, the use of gels, and varnishes should also be studied further on to have evidence-based recommendations for their clinical role in caries prevention (Autio-Gold, 2008).

4.2.7.1.2 Chlorhexidine gels

Treatment with gel seems to be more effective than treatment with mouthrinse because the gel adheres to the tooth surface for longer period. Emilson (1981) published that CHX containing gel inhibited the plaque formation on tooth surfaces, effected on Gram positive and Gram negative bacteria such as mutans streptococci. CHX containing gel (e.g. Corsodyl with 1% CHX) (GlaxoSmithKline, Brentford, UK) similarly to other gels can be applied with toothbrush or in a custom made tray. The use of tray is better because the gel can attach the tooth surface without dilution and it is not distributed on the mucosa. The CHX gel ensures significant reduction in mutans streptococci, at the same time the patient has no unpleasent sense of taste. The time tested ingredient CHX reduces the growth of harmful bacteria and yeast. So there are less plaque formed on the teeth or appliances and the inflammation of gum tissues subsides.

Because of the beneficial effects, CHX containing gel suggested to use with a special soft tray. This therapy delivered by a tray which is offered for only older children, adolescents or adults who are able to apply the gel and tray safety, otherwise the gel should be used with toothbrush or with cotton roll.

Clinical studies defined the caries inhibiting effect of CHX (Zickert et al., 1982). It was also published that the effect of CHX gel is increased with combined use of fluoride gel (Ostela & Tenovuo, 1990; Meurman, 1988). In addition to the antibacterial CHX (0.11%), Cervitec gel (Vivadent, Schaan, Liechtenstein) containing fluoride (900 ppm) which promotes remineralization and protects the teeth from caries. At the same time it is an effective antimicrobial product. Cervitec gel can be used with interdental brushes, with toothbrush, tray or it can be applied directly on the gum.

4.2.7.1.3 Chlorhexidine varnishes

During the past decade, varnishes for local delivery of antimicrobial agents have been developed and investigated in vitro and in vivo. The inhibitory effect of CHX on mutans streptococci or new carious lesions was confirmed with fixed orthodontic appliances (Lundström and Krasse, 1987; Madléna et al., 2000; Derks et al., 2004) (Figure 14.).

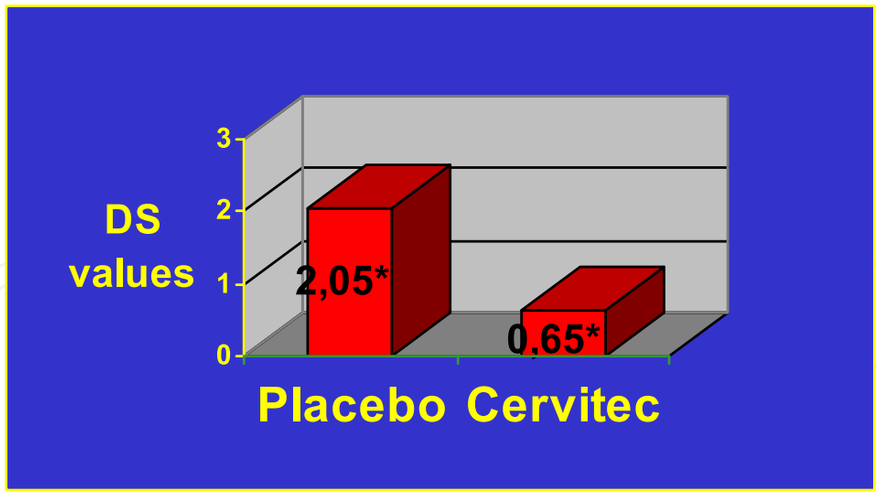


Fig. 14. The effect of chlorhexidine containing varnish (Cervitec) on newly developed carious lesions during orthodontic treatment (*p<0.05)
The number of the new carious lesions was significantly lower in the quadrants treated with Cervitec than in the quadrants treated with placebo (*p<0.05).(Madléna et al., 2000).

It has been concluded by a review that the most persistent reduction of mutans streptococci have been achived by chlorhexidine varnishes followed by gels and lastly mouthrinses (Autio-Gold, 2008). Cervitec plus is a newer, now available member of the „Cervitec family" (Vivadent, Shaan, Liechtenstein) containing chlorhexidine and thymol). Comparing three varnish systems (Chlorzoin, containing CHX 10% (Knowell Therapeutic Technologies, owned company Toronto, Canada), EC 40, containing CHX 40% (Biodent BV, Nijmegen, The Netherlands), Cervitec Plus, containing CHX 1%), a single application of a highly concentrated varnish (EC 40), is sufficient even with reduced contact time, whereas repeated applications and longer retention time required for varnishes with lower chlorhexidine concentration (Chlorzoin and Cervitec). All of the three varnish systems had a similar effect on mutans streptococci in the oral flora. However, none of these varnishes could maintain a significant suppression of mutans streptococci for a period of up to 6 months (repeated application is required for the effectiveness). Concerning the chlorhexidine containing varnishes there may be noticed some advers effects, similarly to other chlorhexidine containing products: staining of teeth and tongue, or taste disturbancies associated with accidental contact of CHX varnish with oral mucosa (Matthijs & Adriaens, 2002).

The most sensitive bacteria to chlorhexidine-thymol varnish (Cervitec plus) are Porphyromonas gingivalis and Aggregatibacter Actynomycetemcomitans. Therefore, chlorhexidine varnishes may be promising for the prevention of periodontal disease or as an adjunct to periodontal therapy (Petersson et al. 1992; Matthijs & Adriaens, 2002). Twetman and Petersson (1997) reported that a combined treatment with a chlorhexidine – thymol and a fluoride varnish resulted in a longer inhibiting effect on interdental plaque samples, than chlorhexidine-thymol varnish alone. The use of dental varnishes with antimicrobial properties might have potential benefits for patients with chronic gingival inflammation (Matthijs & Adriaens, 2002).

4.2.7.2 Other products

4.2.7.2.1 Essential oils containing products - Listerine (Johnson & Johnson, Maidenhead, UK)

Active ingredients of this oral rinse are essential oils (eucalyptol, thymol, menthol) for bactericid effect, contains methyl salicylate (against analgesia and inflammation) and alcohol (in which the active ingredients are diluted). It should be used as a rinse twice daily for 1 minute. As it does not contain any fluoride or its fluoride concentration is very low (in the newer products), has no effect on caries, but it has an antigingivitis effect According to a systematic review published by Van Leeuwen et al. (2011), in long term use, the standardized formulation of essential-oil mouthwas appeared to be a reliable alternative to chlorhexidine mouthwash with respect to parameters of gingival inflammation. Listerine toothpaste is not established as effective product against gingivitis (Boyd, 2001).

4.2.7.2.2 Triclosan-containing products - (Colgate total) (Colgate Palmolive Co. USA)

It is also an antigingivitis agent including good taste and supragingival calculus control (Volpe et al., 1996). Triclosan is available only in toothpaste (Colgate total) (Colgate Palmolive Co. USA), has an antibacterial effect and is often combined with zinc to increase the antiplaque effect. Thus, it may give potential benefits for orthodontic patients as a supplement to fluoride dentifrice during orthodontic treatment.

4.2.7.2.3 Hyaluronic acid containing products (Gengigel) (Ricefarma, Milano, Italy)

Hyaluronic acid is naturally occures as physiological constituent of connective tissue (especially in gingival mucosa). It ensures antioedematous and tissue repair functions, helps to perform an antiinflammatoric effect, so can be helpful during the orthodontic treatment with fixed appliances. The lack of hyaluronic acid is responsible for the continuation of the inflammatory condition. In these cases application of hyaluronic acid provides periodontal tissue with accelerated repair functions by preventing the deficiency of natural gingival hyaluronic acid and enhancing its effects.

The hyaluronic acid containing Gengigel can be available in forms gel, rinse and spray. Pistorius et al. (2002) published positive effects of Gengigel spray: this product ensured significant improvements in gingival parameters in case of gingivitis, after 7 days application. All Gengigel products are suggested to use in case of gingivitis, gingival bleeding, gingival pockets (also gingival recession, abrasion and other tissue trauma etc.), after the correct oral hygiene three to five times a day (after main meals) for 3-4 weeks, continuing until the symptomes have disappeared. Side effect has not been experienced with these products.

4.2.7.2.4 Antibiotics

Use of oral or systemic antibiotic therapy is indicated to eliminate specific pathogenic organisms. However, antibiotic therapy can never replace the mechanical removal of subgingival deposits and it should be only a supplemental, supportive therapy, similarly to the treatment of serious periodontal diseases, but this indication belongs to an experienced periodontist and should not be administrated routinly by an orthodontist.

4.3 Remineralization – Treatment of white spot lesions after removal of fixed appliance

4.3.1 Fluorides

Fluoride increses the initial rate of remineralization of early enamel lesions and slow down the progress of carious process by reacting with the minerals present in the surface of the lesion. Enamel can be remineralized with meticulous toothbrushing twice per day, with fluoridated dentifrice. Additional fluoride application can further enhance the remineralization process. This would include eg. fluoridated dentifrice with higher dose, fluoride rinses, topical fluoride gels, fluoride varnishes and professionally applied topical fluoride such as 2% sodium fluoride, 8% stannous fluoride and 1.23% acidulated phosphate fluoride (Donly & Sasa, 2008). At the same time it was published that when high doses of fluoride are used locally (mainly during the first few weeks after completed the orthodontic treatment), the arrested lesion stays the same size and frequently becomes unsightly and stained with organic debris which is esthetically not optimal on the labial surfaces (Ogaard et al., 2004; Willmot, 2008). To avoid arresting the lesion and obtunding the surface layer several authors recommended low dose fluoride applications to enhance subsurface remineralization It was published that 50 ppm fluoride mouthrinse had a higher efficiency for remineralization than control solution for regular mouthrinse containing 250 ppm (Linton, 1996; Lagerwij et al., 1997). In spite of these observations, Wilmot (2004) did not confirm the therapeutic effect of low fluoride (50 ppm) products and concluded that postorthodontic white spot lesions (WSL) reduced in size during the 6 months by approximately half of the original size, but there was no clinical advantage of using the low fluoride formulation of mouthrinse/toothpaste in this process comparing to those of using fluoride free products as a control. The mean size of the lesions reduced with time in both groups. A therapeutic effect (less than 30%) was non significant. Beside of the labial surfaces application of concentrated fluoride was suggested to prevent the progresson of the lesions. It has been also suggested that acid etching of fluoride treated lesions could facilitate remineralization of the lesions by oral fluids (Hicks et al., 1984).

4.3.2 Use of Casein Phosphopeptide-Amorphus Calcium Phosphate (CPP-ACP)

Enamel can also be remineralized with Casein Phosphopeptide-Amorphus Calcium Phosphate preparations. CPP-ACP is capable to be absorbed through the enamel surface and could affect the carious process (Reynolds, 1987) CPP-ACP system (the trade name is Recaldent™) which allows freely available calcium and phosphate ions to attach to enamel and reform into calcium phosphate crystals. The free calcium and phosphate ions released from the CPP-ACP and deposit into the enamel rods. The available types of these products: water based mousse, topical creme (these are the most frequently used forms) mouthrinses, sugarfree lozenges and chewing gum (which is not suggested for orthodontic patients).

As CPP-ACP is derived from milk casein, should not be used in patient with protein and or hydroxybenzoates allergy. Studies of the effects of CPP-ACP show a dose related increase in enamel remineralization (Sudjalim et al., 2006). These products have beneficial effects in reducing area of demineralized lesions after 4 weeks (Bröchner et al., 2011).

Using the mousse (GC Tooth Mousse) to treat post-orthodontic lesions, a thermoplastic retainer needs in which a pea sized amount of CPP-ACP mousse has been spread evenly.

After proper oral hygiene the patient places the mousse at night and wears the retainer throughout sleep. Flavouring helps to stimulate saliva flow rate which helps to rinse bacteria and food residues from the teeth and enhances the effectiveness of CPP ACP in the mouth.

The GC MI Paste Plus is a water based topical creme containing Recaldent ™ CPP-ACP and fluoride (900 ppm). It can be used on teeth at home when the patient apply the products with a tray (Figure 15.), similarly to the mousse or without a tray simply with clean finger or cotton tipped applicator and let it work for 3-5 minutes.



Fig. 15. Use of MI Paste Plus with a tray.

This material containing CPP ACP and fluoride can help in remineralization process e.g. after finishing the orthodontic treatment with fixed appliance

4.3.3 Microabrasion

Enamel microabrasion abrades the enamel surface, leaving a highly polished surface with Ca phosphate packed into the interprismatic enamel surface space. This highly polished enamel surface can then be bleached.

This method has been widely used for the removal of superficial non-carious enamel defects for which it can be use for example performing 18% hydrochloric acid and pumice technique (Welbury & Shaw, 1990; Rodd & Davidson, 1997). This method seems to be an effective treatment approach for cosmetic improvement of long-standing postorthodontic demineralized enamel lesions (Welbury & Carter, 1993; Croll & Bullock, 1994). Studies demonstrate that although microabrasion removes small amounts of the enamel surface, the new polished surface is less susceptible to bacterial colonization and demineralization than natural non abraded enamel (Segura et al., 1997 a,b).

Following the microabrasion technique, a 4 minute 2% sodium fluoride treatment is recommended. If the microbrasion technique could not ensure optimal esthetics and some whitened enamel is still remain, vital tooth bleaching can be considered (Donly & Sasa, 2008).

5. Conclusion

The number of orthodontic treatments among them the frequency of treatments with fixed appliances is increasing nowadays. In some cases orthodontic treatments mean caries preventive interventions when tooth movements may reliese crowding or other anomalies thus can contribute the effectiveness of proper oral hygiene. On the other hand these treatments may have causative effect on plaque induced oral diseases. For these patients effective preventive oral health care is needed and orthodontists have to be responsible for helping to keep proper oral hygiene in their patients.

The risk of caries can be determined by different tests (e.g. SM, LB chairside tests) or assessment of some salivary factors. Measurement of plaque has been found also very useful to determinate the risk of caries. The severity of periodontal diseases and the risk for these diseases can be determined by clinical measurements. Bleeding on probing remained the most certain clinical sign of periodontal inflammations. Chairside tests are available to measure different parameters associated with periodontitis, but presently there is no such a particular parameter or method predicting the possibility of periodontitis.

For prevention of caries and periodontal diseases clinicians should instruct the patients effectively to be able to perform proper oral hygiene. Regular removal of plaque and calculus at critical places can help a lot. Regular recalls, well constructed programs of regular professional oral hygiene can give great help for at-risk patients.

Beside of dietary counselling, to reduce cariogenic bacteria, use of professional and home care measures and techniques (cleaning instruments, fluoridated paste, restorative methods, application of fluoride and chlorhexidine containig materials, plaque disclosing products, special toothbrushes and other equipments etc.) could provide help.

Because of the increasing number of patients in need of orthodontic appliances, this chapter is important and useful not only for orthodontists, but general dentists or periodontists and dental students as well.

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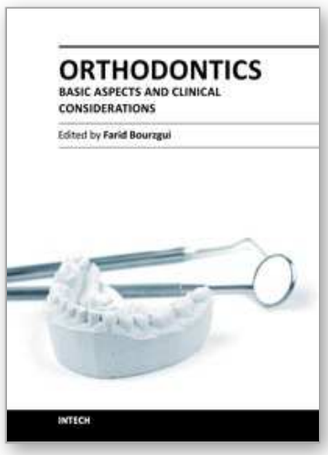
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