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Concept and practice of plaque-control

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Abstract

The effect of plaque control on gingivitis and periodontitis is well-documented. In short-term investigations, chemical plaque control (oral rinsing twice a day with 0.2% chlorhexidine-gluconate solution) has been effective in the prevention of human gingivitis.

Experimentally produced human gingivitis heals completely within one week when the same method is employed.

Tooth cleaning with oral hygiene aids every other day prevents the initiation of gingivitis. Cleaning every third or fourth day, on the other hand, prevents neither the development nor the persistence of gingivitis.

A combination of oral hygiene instructions and mechanical professional tooth cleaning at proper intervals can almost completely prevent the development of both gingivitis and periodontitis. In crossover studies and studies based on the "split-mouth" technique, frequent mechanical, professional tooth cleaning is superior to oral hygiene instructions assuming the same frequency.

Finally, it must be stressed that the effect of home care and professional tooth cleaning on gingivitis and periodontitis differs radically when ordinary tooth cleaning is concentrated on the "key-risk" as opposed to the "non-risk" surfaces.

Definition of Dental Plaque

Dawes et al. 1963¹ described plaque as the soft, tenacious material found on tooth surfaces which is not readily removed by rinsing with water.

The most clinically observable plaque on the smooth surfaces of the teeth along the gingival margin may be termed dentogingival plaque. Dentogingival plaque which occurs on the approximal surfaces, apical to the contact points, is termed approximal dental plaque. Plaque may be found below the gingival margin in the gingival sulcus or in the periodontal pocket and is termed subgingival plaque.² We normally will find non-attaching bacteria in the most apical position of the periodontal pocket.³

In children and adults up to 40 years of age, interproximal dental plaque is mainly subgingival because the gingival papilla normally fills up the interproximal space. In spite of some loss of periodontal attachment,

the papilla will fill up the interproximal space due to edema.

After tooth cleaning, the supragingival plaque along the gingival border of the teeth reaccumulates slowly during the following two days. The thickness of the plaque increases dramatically after the third day, to a maximum after seven days.^{4,5,6}

Etiology of Periodontal Disease

In 1965, Loe and associates⁷ demonstrated that clinical symptoms of gingivitis developed in students with clinically healthy gingiva within two to three weeks if dental plaque was allowed to freely accumulate. If adequate tooth cleaning was resumed, the gingival inflammation cleared up within a week.

Subclinical symptoms of gingival inflammation in the form of a discharge of exudate from the gingival sulcus appear within four days if plaque is allowed to accumulate freely in the dentogingival region.⁸

Page & Schröder⁹ have demonstrated that an initial gingival lesion develops within approximately four days from a condition of healthy gingiva if plaque is allowed to accumulate freely. Lang and associates¹⁰ demonstrated in 1973 that students who completely freed their teeth of plaque at least every other day, did not develop clinical symptoms of gingival inflammation over a six-week period. On the other hand, those students who cleaned their teeth only every third or fourth day all displayed signs of gingivitis. If gingivitis remains untreated, there is a gradual increase in the edema in the gingiva. The subgingival microflora undergoes a gradual transformation into a preponderance of gram-negative anaerobic rods — straight, curved and mobile.

Saxe et al.,¹¹ Lindhe and associates¹² have demonstrated that gingivitis induced by bacteria, if left untreated, gradually results in periodontitis.

Today the interest in certain bacteria in the subgingival microflora associated with etiology of periodontitis is concentrated on: *Bacteroides asaccharolyticus*, *Fusobacterium nucleatum*, *Actinomyces israelii*, *Eike-*

nella corrodens, *Caphnocytophaga sputigena* and *Actinobacillus actinomycetemcomitans*. The last two types of bacteria are especially associated with juvenile periodontitis.^{13,14}

Prevention of Periodontal Disease

There is overwhelming evidence indicating that complete removal of bacterial plaque from the dentogingival region is the most effective method of preventing gingivitis and periodontitis. Control of periodontal disease by eliminating pathogenic organisms of the microflora is, as yet, impossible, but it is theoretically an attractive approach.

Based on epidemiological studies there is a very strong correlation between the localization of dentogingival plaque and periodontal disease.¹⁵⁻¹⁸ Epidemiological studies clearly show that there are certain key-risk-teeth (molars and premolars) and key-risk-surfaces (the proximal surfaces of the molars and premolars).^{17,22} Furthermore, 13- to 16-year-old Swedish children are the "key-risk age-groups" regarding the progression of dental caries disease in the permanent dentition. In the same age group we find around 20% "key-risk individuals."

Clinical studies carried out by Björn and coworkers have showed that 75% of all interproximal fillings have overhangs in a subgingival position. Also, they found that the loss of periodontal attachment at the same tooth-surface was correlated to the size of the overhang as an effect on increased plaque retention.²³ Hence, successful caries prevention will also result in the prevention of periodontal disease.

The basic principle for preventive dentistry must be that the preventive measures will give the most significant effect if we concentrate them on "key-risk age groups," "key-risk individuals," "key-risk teeth" and "key-risk surfaces." That means preventive programs based on plaque control have to be concentrated on those tooth surfaces where the risk for development or progress of dental disease is most pronounced in a given population.

Definition of Plaque Control

Plaque control normally means preventive measures aimed at removing dental plaque and preventing it from recurring. This can be accomplished either mechanically or chemically: sometimes the two procedures are combined.

Home Care

"Home care" means the sum effect of motivation, knowledge, oral hygiene instruction, oral hygiene aids and motor skill.

Today, toothbrushing and other mechanical cleansing procedures are the most reliable means of controlling plaque at home. In Scandinavian countries almost

100% of the school-children brush their teeth once or twice a day.

A Swedish survey²⁴ showed that no less than 99.5% of all adults with their own teeth use a toothbrush as an oral hygiene aid. However, only 70% of men use a toothbrush daily from the age of 30, whereas 85-90% of women use a toothbrush daily. Nonetheless, industrious use of the toothbrush is not synonymous with tooth cleaning.

In 1971, Hansen & Gjermo²⁴ carried out an investigation with the object of evaluating the plaque removing effect of various toothbrushing methods on individual tooth surfaces. The subjects of the experiment allowed plaque to accumulate freely for three days. Then a dental hygienist, using an ordinary toothbrush, tested the cleaning effect of the roll-brushing method, the Bass method, Charter's method, and the effect of an interspace brush. The cleaning effect expressed in terms of Silness & Loe's plaque-index is very modest for all methods of brushing despite the fact that brushing was carried out by a dental hygienist. Similar findings have recently been discovered in a study by Bergenholz and coworkers.²⁵

There is a strong correlation between brushing frequency and the reduction in plaque/gingivitis on the buccal surfaces. The vast majority of self-taught toothbrushers begin by scrubbing the buccal surfaces, especially at the frontal region, and rarely proceed to the lingual surfaces. Interproximal cleaning is simply non-existent in the self-taught.

Most oral hygiene brochures say that tooth cleaning should begin with the use of a toothbrush and toothpaste on the buccal surfaces, followed by the lingual surfaces of the upper jaw teeth. Then the buccal surfaces of the lower jaw teeth should be brushed, and finally, the brush should be used on the lingual surfaces of the lower jaw teeth. Only then is interdental cleaning considered appropriate. However, there is no odontological necessity for this cleaning order of individual teeth surfaces.

The level of ambition is always greatest at the beginning of a tooth cleaning operation. Moreover, more toothpaste is on the toothbrush in the initial phase and the brush bristles are most rigid. In the buccal region, the alveolar bone is very thin and may even be absent altogether — on the buccal surfaces of the canines for example. In the lingual and palatine regions, however, the alveolar bone is normally very strong.

In light of all these factors, it is evident that the risk of inflicting traumatic lesions during tooth cleaning is very great if one decides to begin the operation with the buccal surfaces of the upper jaw teeth. Moreover, far too many people gradually switch from a correct Bass method to a horizontal scrubbing method as the interval since the time of instruction increases. This again increases the risk of tooth cleaning trauma

on the most prominent sections of the buccal surfaces.

As a result, there is a very positive correlation between brushing frequency, gingival retraction and trauma caused by an abrasive lesion on the buccal surfaces.²⁶

Up to the age of 25, the greatest loss of periodontal attachment is found on the buccal surfaces in the average patient. This is brought about principally by toothbrushing, and is particularly unfortunate in cases where the bifurcations have been exposed on the buccal surfaces of the molars, indirectly causing root separation or extraction.

A fundamental principle for all preventive action is that the positive effect is greatest where the risk of disease development is greatest. Figure 1 shows where the "key-risk surfaces" are located in the dentition. The patient has the greatest chance of being able to see positive results in his oral hygiene efforts if he concentrates initially on "key-risk teeth" and "key-risk surfaces." After this we can make more stringent oral hygiene demands by including buccal surfaces where results are largely indiscernible.

A Swedish survey shows that approximately 46% of adults use toothpicks sporadically. Of these, 12% use toothpicks daily. On the other hand, dental floss is used irregularly by 12% of adults, and 2% of these use dental floss daily. In other words, toothpicks are used six times more frequently than dental floss as an oral hygiene aid by adults!

Despite this, it must be recognized that interdental cleaning is practically non-existent as an established habit in most countries. In the light of normal plaque distribution and dental disease in the dentition and on

individual tooth surfaces, we can therefore state that needs-related tooth cleaning does not take place. The aspirations of the adult patient today focus principally on those tooth surfaces with the least disease formation, and cleaning, therefore, only produces approximately a 20% effect. In other words, there is a largely unexploited source of dental care here which we must tap. Yet out of 8760 hours per year, the individual patient normally spends no more than two hours in the dental clinic.

Needs-Related Tooth Cleaning at Home up to 11 Years of Age

When using needs-related tooth cleaning on children under eight years old, interdental cleaning should concentrate on the distal surfaces of the deciduous second molars and the mesial surfaces of the first permanent molars. A dental floss holder may facilitate matters for the parents doing this for their children.

Unfilled fissures in the molars are next in line for needs-related toothbrushing. A soft, compact toothbrush and normal abrasive toothpaste with fluoride should be used for this purpose. (If parents carry out cleaning of this type on children under the age of eight, an interdental brush can also be used to advantage.) A suitable toothbrush for these age groups has a small head with a handle designed for an adult hand, since the cleaning is preferably done by adults.

Needs-related tooth cleaning of the lingual and buccal surfaces should therefore commence in the lingual position in the lateral segments of the lower jaw. The risk of traumatic tooth cleaning lesions is also lower on the lingual surfaces of the lower jaw than on

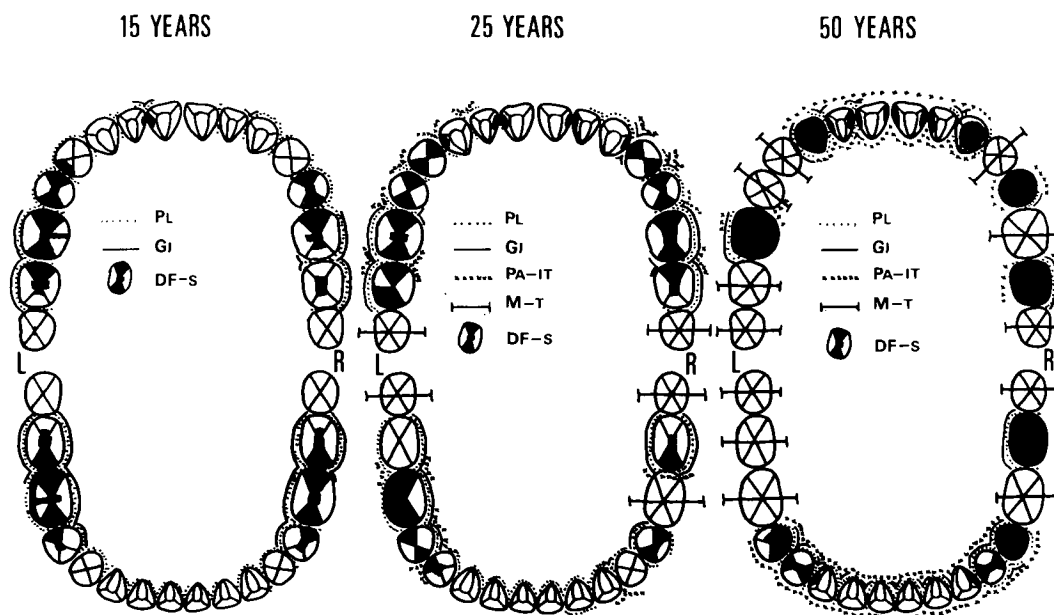


Figure 1. Location of "key-risk surfaces" in the dentition.

the buccal surfaces of the upper and lower jaws due to the presence of thick alveolar bone and lingually inclining teeth.

Needs-Related Tooth Cleaning at Home From 12 to 16 Years of Age

Needs-related tooth cleaning at this age should begin with interproximal cleaning of the lateral segments up to the distal surfaces of the canines. The most suitable oral hygiene aid is dental tape with or without a dental floss holder. When flat, waxed tape is used, the "rubbing method" is most effective. This method is easy to learn and can be combined with toothpaste. If there is a large number of filled interproximal surfaces, toothpicks might also be appropriate. Bitewing X-ray photographs of the lateral segments should be used as a guide in selecting a suitable oral hygiene aid for interproximal areas.

According to an *in vivo* study by Badersten and Egelberg²⁷ designed to evaluate the plaque-removing effect of toothpaste during toothbrushing, the toothpaste resulted in a 50% increased effect. It is clear that toothpaste should also be used interdentially in the molar and premolar regions.

Needs-Related Tooth Cleaning at Home for Adults

Figure 2 shows the average 25-year-old Swedish inhabitant's oral health status. The loss of periodontal support is 1 mm on the average and is localized mainly on the buccal surfaces. It may be assumed that filling and cavity margins in the interproximal areas are located subgingivally and that subgingival plaque is found on the remainder of the filled interproximal surfaces.

Waerhaug has shown *in vivo*, and on autopsy corpses, that you can maintain the subgingival regions free of plaque to a depth of 2 to 3 mm because of the resilience of the gingival papilla by using a triangular toothpick inserted interproximally, Figure 3. This allows cleaning to take place apically to the margins of fillings located subgingivally — surfaces where recurrent caries can develop. Open interproximal spaces are very common among the normal adult clientele. Toothpicks, or the equivalent, are the most appropriately designed oral hygiene aid for open interproximal spaces. (In the process of filling a tooth interproximally, a toothpick or the equivalent can be used as a wedge to guarantee a correctly shaped interproximal space, since toothpicks, or V-shaped parts of mechanical prophylactic aids, are normally used for interdental oral hygiene.) The bitewing radiograph can act as a guide in selecting a suitable oral hygiene aid for interdental cleaning.

Figure 2 shows that the exact moment when the gingival papilla is depressed is definitely the best time to utilize the cleaning power of toothpaste as a fluo-

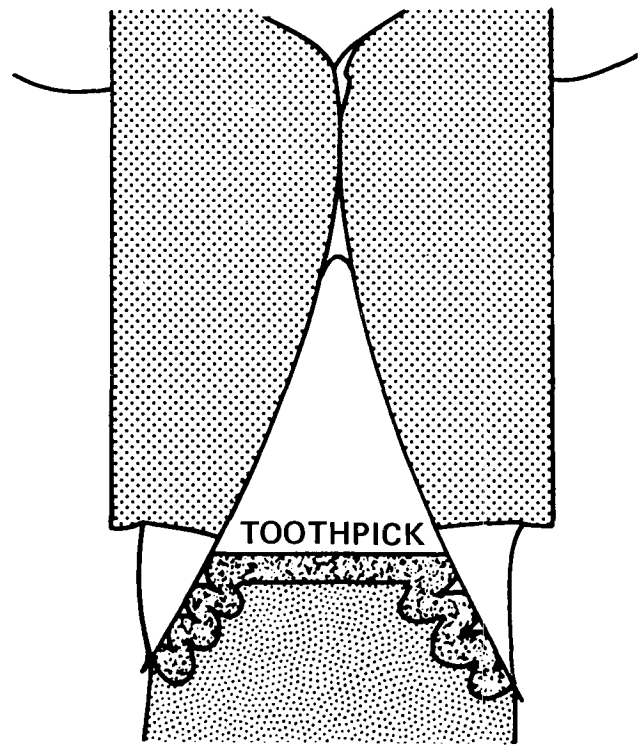


Figure 2. 2 to 3 mm subgingival cleaning with toothpick. (J Waerhaug).

ride-bearer during needs-related tooth cleaning.

The occurrence of interproximal plaque distal to the canines is most frequently underdiagnosed up to the age of 40, despite the use of a disclosing agent. This is because the gingival papillae completely fill up the interproximal spaces in the premolar and molar regions and obstruct disclosing solution vision. The few exceptions are those patients under the age of 40 who have exposed interproximal surfaces because of advanced periodontitis.

Because the interproximal spaces in the premolar and molar area normally have a wider triangular opening from the lingual side it is very important to use triangular pointed toothpicks from a lingual direction to get the best plaque removal. This procedure can be carried out more comfortably and properly if the toothpick is fixed in a handle. Needs-related tooth cleaning in adults ought to start interproximally from a lingual position in the molar area of the lower jaw.

In individuals with advanced periodontal disease we find a relatively large number of wide interdental spaces and partially exposed root surfaces. The interdental brushes usually have the greatest cleaning effect in wide interproximal spaces. The effect would probably be enhanced if the brush were triangular in cross section instead of round (Figure 3). If there are exposed root surfaces in the interproximal area, caution should be used with abrasive toothpaste.

How to Establish Oral Hygiene Habits Focused on the Localization of Dental Plaque and Dental Disease?

The fundamental precondition of establishing needs-related tooth cleaning habits is a patient who is sufficiently motivated, informed, and instructed.

Since established habits are reliable, the new habits we want to establish should be linked very firmly to habits already established. The new habit should always be done immediately prior to the established habit. These principles are known as the linking method and have been described by Weinstein and Getz.²⁸

The linking method may be used in practice as follows: If the patient has irregular oral hygiene habits, you should take advantage of habits already established to link with those times we wish the oral hygiene procedures to be performed. For example, according to the linking method, the oral hygiene procedure should be performed immediately prior to the daily morning shower and evening news.

Although more than 80% of all adults brush their teeth daily, there are practically no daily interdental tooth cleaning habits. As we have seen, use of the toothpick is about six times more common among adults than dental floss or interdental brushes.

According to the linking method, needs-related tooth cleaning on adults begins with interdental cleansing from the lingual side in the molar/premolar region of the lower jaw with a toothpick in a handle and mildly abrasive fluoride toothpaste. Following this, the interproximal surfaces of the molar and premolar regions of the upper jaw should be cleaned. A toothbrush should first be used lingually on the lateral segments of the lower jaw where most people do not efficiently use the toothbrush. Therefore, it is important

to begin toothbrushing there when the most toothpaste is on the brush and the bristles are most rigid. After this the buccal and occlusal surfaces of the lower jaw should be cleaned. In the upper jaw, cleaning with the toothbrush can begin on the palatal side, then the buccal and occlusal surfaces of the molars should be cleaned. Needs-related tooth cleaning, following the linking method toothbrushing, should be carried out in the reverse order from that which we have traditionally recommended for our patients. If interdental cleaning with toothpick and toothpaste according to the method described here has become an established habit, this should have such a highly preventive effect that it may never be necessary to use the interdental brush.

Similarly, professional needs-related tooth cleaning should begin interdentally from the lingual side on the lateral segments of the lower jaw with mechanically powered toothpick and fluoride polishing paste.

Agerbaek and associates²⁹ did not receive any positive effect on plaque and gingivitis scores in a one-year study including biweekly repeated 20-minute lectures in preventive dentistry for small groups (eight to ten school children). The program also included oral hygiene training.

Moreover, there are studies which demonstrate that efforts of this nature do not produce a long-term effect beyond one month.^{30,31} If, however, oral hygiene motivation, information and instruction are combined with professional tooth cleaning, the effect of the operation, expressed in terms of plaque and gingivitis values, is present after three months.³²

From the study described earlier by Lang and associates¹⁰ we know that clinical signs of gingivitis will not occur during a six-week experimental period if proper

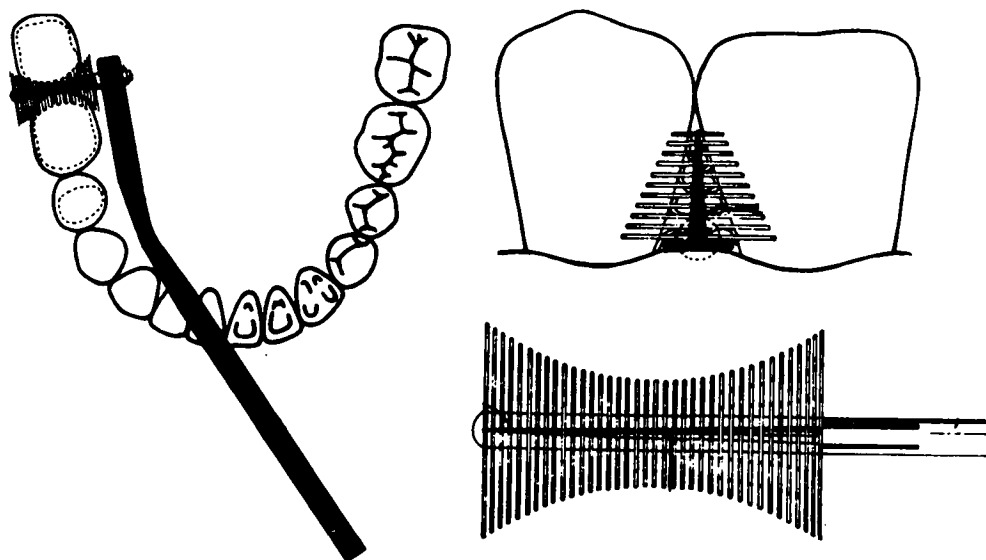


Figure 3. "Tailor-made" interdental brush as it should look.

mechanical tooth cleaning, including use of interproximal aids (dental floss and toothpicks) as well as the toothbrush, is done once every other day.

Figure 4 shows the pattern of plaque distribution according to Silness & Løe's plaque index at different tooth surfaces in upper and lower jaws if tooth cleaning procedures are carried out twice a day every day, every third day, or every fourth day.

Score 2 means visible plaque (black). We can see that almost 100% of the proximal surfaces have visible plaque immediately before the tooth cleaning every second day without inducing clinical signs of gingivitis. If the teeth were cleaned only every third or fourth day, gingivitis gradually developed interproximally in the molar area.

Bosman & Powell,³³ in another study, induced experimental gingivitis in a group of students. In those students who freed their teeth from plaque only every third or fifth day, the symptoms of gingival inflammation persisted. But in the two groups that cleaned their teeth properly once a day or every second day, the gingivae healed within seven to ten days.

We can conclude that proper mechanical tooth cleaning including the key-risk surfaces every second day is superior to daily toothbrushing concentrated mainly on the "non-risk surfaces."

Chemical Plaque Control

Among the chemicals tested so far for their plaque and gingivitis inhibiting potential, chlorhexidine digluconate has shown greatest promise for short-term use.

In 1970 Løe and co-workers³⁴ demonstrated that in the absence of any form of mechanical hygiene, two daily mouth-rinses with 0.2% chlorhexidine gluconate completely inhibited the development of plaque and gingivitis during a three-week experimental period. In a two-year study, students who rinsed daily reduced their P1I from 0.75 to 0.3 and GI from 0.75 to 0.4.³⁵ In experimentally-induced gingivitis, Bosman & Powell³³ showed that the gingiva healed within five to seven days when daily 0.2% chlorhexidine mouth rinses were introduced. One of the most intriguing characteristics of chlorhexidine is its selective absorption to the tooth surface.³⁶ Also, it seems to have a specific antimicrobial effect on *Strep mutans*.^{37,38}

Staining of teeth and restorations is a major side effect which excludes chlorhexidine for long-term and public health use.^{39,40} For long-term use, fluoride appears to hold the most promise for preventing gingivitis.

In vitro studies by Glantz⁴¹ have shown that stannous fluoride solution reduces the surface energy and the wettability of the enamel surface. Consequently, the wet weight of attached plaque was reduced. Organic fluorides such as amine fluoride appear to have a greater plaque reducing activity than inorganic fluoride.⁴² In areas with fluoridated water, the wet weight dental plaque per individual is significantly lower than in non-fluoridated water areas.⁴³ Topically applied fluorides reduce the amount of plaque⁴⁴ and the proportions of *Strep mutans*.^{45,46} For reviews of chemotherapy of dental plaque, see Emilsson,³⁷ Loesche,⁴⁷ and Løe.⁴⁸

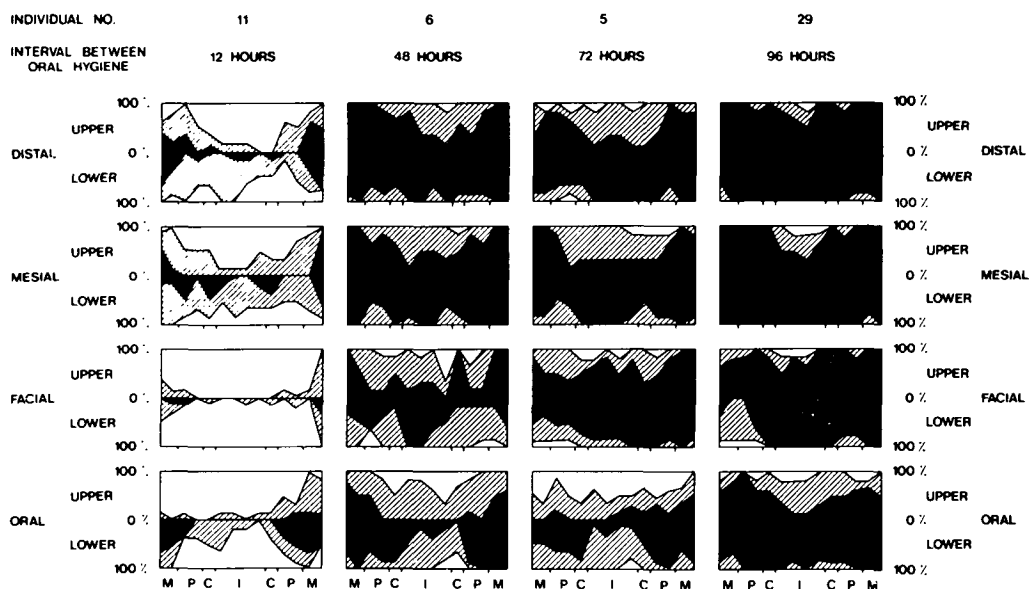


Figure 4. Pattern of plaque distribution according to Silness & Løe's plaque index at different tooth surfaces in upper and lower jaws when tooth cleaning is done at 12, 48, 72, and 96 hours intervals.

Professional Mechanical Tooth Cleaning

Professional mechanical tooth cleaning is the selective removal of supragingival, but also subgingival plaque, from all tooth surfaces with mechanically driven instruments and fluoride polishing paste by specially trained personnel — prophy dental nurse, dental hygienist or dentist. It also includes the removal of calculus and subgingival plaque. (These later methods are only performed by dentists and dental hygienists, and are usually referred to as scaling procedure.) Professional mechanical tooth cleaning not including scaling procedure will be abbreviated as PMTC.

Beginning with 15-year-old patients, interproximal PMTC in molar- and premolar-areas is carried out using mechanically-driven, pointed, triangular tips with a speed of 10,000 strokes per minute⁴⁹ and an abrasive fluoride-containing prophy-paste. As before, needs-related PMTC normally ought to start interproximally from a lingual position in the molar area of the lower jaw.

In children, dental tape adapted to a holder is the instrument of choice for interproximal PMTC. The buccal and lingual surfaces are normally cleaned using a rotating rubber cup and the same type of prophy-paste.

Some effects of PMTC: after one single PMTC performed by a dental hygienist, the amount of gingival exudate diminishes continuously in the first 24-28 hours. The amount of exudate did not return to the pre-experimental level until one week later.⁵⁰

The new formation of perceptible complex plaque in the dentogingival region may be retarded in a normal patient until 24-30 hours after PMTC, compared with about 12 hours after dealing with oral hygiene aids.⁵¹ In some cases this may have a decisive significance in possible remineralization of incipient caries and shallow caries at the microscopic level.

PMTC may completely free all tooth surfaces of partially hardened and soft accumulations. Accumulations with caries-associated *Strep mutans* grow in a very predictable pattern on approximal surfaces, in fissures, and generally in association with the initial caries attack on enamel.^{52,53} Since old plaque with an aggregate of *Strep mutans* is removable completely from all enamel surfaces by PMTC, other non-cariogenic micro-organisms may establish themselves. *Strep sanguis*, for example, normally re-colonize the tooth surface earlier than *Strep mutans*.^{2,6,47} Frequently repeated PMTC heals the gingiva quickly. This results, indirectly, in a reduced plaque formation rate. Saxton⁶ has shown that the reaccumulation rate of gingival plaque is directly correlated to the degree of gingival inflammation and the quantity of gingival exudate. Therefore the patient's own tooth cleaning with oral hygiene aids is enhanced by the removal of

the old, partially-mineralized plaque and the reduction of the rate of re-formation of new plaque.

PMTC may also be expected to have a strong patient-motivating effect: The patient experiences PMTC as a positive treatment form and with varying success attempts to preserve the clean feeling with his own oral hygiene aids.

A one-year investigation with adult periodontitis patients using PMTC once a month in a random right or left side (split-mouth method) showed a near-corresponding reduction of plaque and gingivitis even on the untreated side.⁵⁴ This strengthens the opinion that the motivating effect of PMTC should not be underestimated.

The preventive effect of plaque-control program on gingivitis and periodontitis is generally accepted. But there is a question as to whether or not the development of caries can be avoided or reduced by improved oral hygiene.^{55,56}

These considerations were one of the reasons we initiated a series of longitudinal plaque control programs including PMTC in school children to test the effect of mechanical plaque control on gingivitis and dental caries.^{17,57-63}

In 1971 a longitudinal clinical trial was initiated to test the hypothesis that gingivitis and dental caries do not develop in school children maintained on an oral hygiene program that included meticulous professional tooth cleaning and oral hygiene instructions once every two weeks. Two hundred sixteen children were selected for the study. They were all pupils of the same elementary school in the city of Karlstad. They had the same socioeconomic background and were seven to eight, 10 to 11 and 13 to 14 years old at the onset of the study. They were assigned to experimental and control groups by arbitrarily assigning one of two classes to the experimental regimen and the other to the control group.

Following the baseline period, members of the control groups continued a preventive program which included supervised tooth brushing with a 0.2% sodium fluoride solution once a month.

The experimental groups of children were subjected to a very intense prophylactic regime. Dental plaque was stained with 4% erythrocin-disclosing pellets and the Bass method of toothbrushing was demonstrated for each child. The children were also instructed in interdental cleaning with dental tape. The oral hygiene instructions were repeated as necessary at each oral hygiene session.

The vestibular and lingual surfaces of all teeth were cleaned with the aid of a rotating rubber cup. Interdental cleaning was carried out with reciprocating interproximal tips and dental tape. An abrasive paste

containing 5% sodium monofluorophosphate was used for all PMTC.

After two years, the intervals between consecutive prophylactic sessions were extended to either four or eight weeks for the third experimental year. During the fourth and final year, the children received only four to six PMTC. Figure 5 shows the mean PII and GI in the control groups and the experimental groups at baseline, and the four yearly re-examinations.

Low PII in the test groups after one year was maintained during the following experimental period and associated with low GI. In the control groups there were no significant alterations.

The controls also developed 941 new carious lesions during the entire four-year period compared to the tests, who developed a total of only 61 new carious lesions.

In 1973 a study⁶¹ using the crossover design was initiated at the same school to evaluate the relative effect on gingivitis and dental caries of: 1) PMTC; 2) Chemical plaque control (Hibitan-Gel); 3) Oral hygiene information and instruction; and 4) Topical application of fluoride.

One hundred sixty four 13- to 14-year-old children participated in the two-year trial. Following a baseline examination, the children were randomly divided into four groups. All participants were recalled to a prophylactic dental clinic once every two weeks for preventive treatment.

During the first year Group 1 received a preventive program that included 0.5% Hibitan-Gel application every two weeks, and a 2% monofluorophosphate solution mouthwash and dentifrice with fluoride for home use (H + F). Group 2 received a preventive program that included 0.5% Hibitan-Gel application, distilled water for mouthwash and placebo dentifrice for home use (H). Group 3 received a preventive program similar to that described in the four-year study; PMTC, rinsing with 2% monofluorophosphate solution and fluoride-containing dentifrice for home use (P + F). Group 4 received a preventive program including PMTC, rinsing with distilled water and placebo dentifrice for home use (P).

During the second year, group 1 received a preventive program similar to the regimen followed by group 3 during the first year of trial. During the second year, group 2 received a preventive program similar to the regimen followed by group 4 during the first year of trial. Group 3 received a preventive program that included oral hygiene instructions, and 2% monofluorophosphate mouth wash and dentifrice with fluoride for home use during the second year of trial (OH + F). Group 4 received a preventive program during the second year similar to group 3, but fluoride was excluded. It should be noted that groups 2 and 4 did not receive fluoride application at any time during the two-year period (OH).

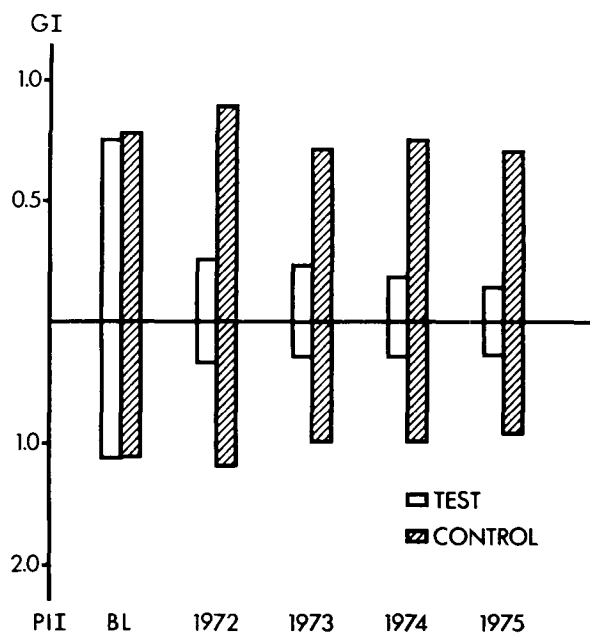


Figure 5. Mean PII and GI in the control groups and the experimental groups at baseline and the four yearly re-examinations.

During the first year of the trial no alterations occurred in either the PII or GI in groups 1 and 2. That means that Hibitan-Gel used only once every two weeks had no effect. The preventive program that included PMTC (groups 3 and 4) resulted in a considerably reduced PII and GI. On the average, the PII decreased from 69 to 28%, while the GI decreased from 23 to 6%.

During the second experimental year groups 1 and 2 received a preventive program that included PMTC. The PII decreased from 64 to 23%, the GI from 22 to 4%. The reductions in groups 3 and 4 closely paralleled the previous reductions observed in groups 1 and 2. The significant alteration was due to the addition of a preventive program which included oral hygiene instruction once every two weeks during the second year of the trial, similar to groups 3 and 4. The GI and PII observed in groups 3 and 4 at the end of the first year continued without significant change.

During the first year 5.8 new carious lesions developed per child in group 1. Group 2 developed 5.3. Only 0.3 and 0.4 carious lesions developed in groups 3 and 4 respectively. During the second year of the trial children of groups 1 and 2 developed 0.4 new carious lesions on the average. Reversals of incipient carious lesions were observed. An average of 1.3 and 1.8 new carious lesions developed in groups 3 and 4 during the second year. At the first follow-up examination there was no significant difference in caries development between groups 1 and 2, but the difference between groups 3 and 4 was highly significant. At the follow-up examination after the second year, we found that

groups 3 and 4 developed a significantly larger number of new carious lesions than 1 and 2.

These studies have confirmed that by frequent PMTC and oral hygiene instruction it is possible to substantially reduce caries development and almost entirely eliminate gingivitis. It must also be concluded that in a preventive program based on meticulous plaque control, topical application of sodium monofluoride phosphate has only a marginal effect on caries increment.

In order to evaluate the separate preventive effect of PMTC on gingivitis and dental caries from oral hygiene instructions, a "split-mouth" study was initiated in 1976.⁶³ One hundred four 13- to 14-year old-children were randomly selected into two groups. Group 1 received oral hygiene instructions and random PMTC on the right or left side once every two weeks during a 16 month experimental period (OHP +). Untreated side is (OHP-). Group 2 received only PMTC randomly on the right or the left side (P +) or (P-) during the same period. Figure 6 shows the alterations of the PII and GI scores from baseline examination as a result of the different procedures.

In group 1 PMTC and oral hygiene instructions (OHP+) reduced the PII from 78 to 22% and GI from 49 to 14%. Only PMTC (P+) in group 2 gave a similar reduction of PII and GI. The single effect of PMTC on PII and GI was superior to oral hygiene instructions in this study. But it must be observed that significant reductions of PII and GI were found on the untreated side too.

These reductions can be explained partly by the

fact that children tried to clean the untreated side themselves at the same level as the treated side. Also, the total amount of the oral microflora is supposed to be reduced as an effect of the frequent PMTC.

Figure 7 shows the total number of new interproximal DF-s during the experimental period. Again the preventive effect of PMTC is superior to oral hygiene instructions.

After our original "Kalstad-study" in school children, other studies have been carried out in order to evaluate the effect of PMTC on gingivitis and dental caries. Table 1 is a summary of these studies.⁶⁴⁻⁷⁸

Plaque-Control Program in Adults

In 1972 we performed an investigation to assess the efficiency of a maintenance care program in patients treated for advanced periodontal disease, including surgery.⁷³ The periodontal status of a group of patients who were referred back to general practitioners for maintenance care at the end of treatment was also examined. The population consist of 90 patients who were referred for specialist treatment of advanced periodontal disease by general practitioners. The patients were first examined: they were each given case presentation, instructed how to practice proper tooth cleaning methods, their teeth were scaled and eventually the periodontal pockets were treated using the modified Widman technique.

During the first two months following surgery, the patients were recalled once every two weeks for PMTC. Two months after the end of surgical treatment, the patients were re-examined to provide base-

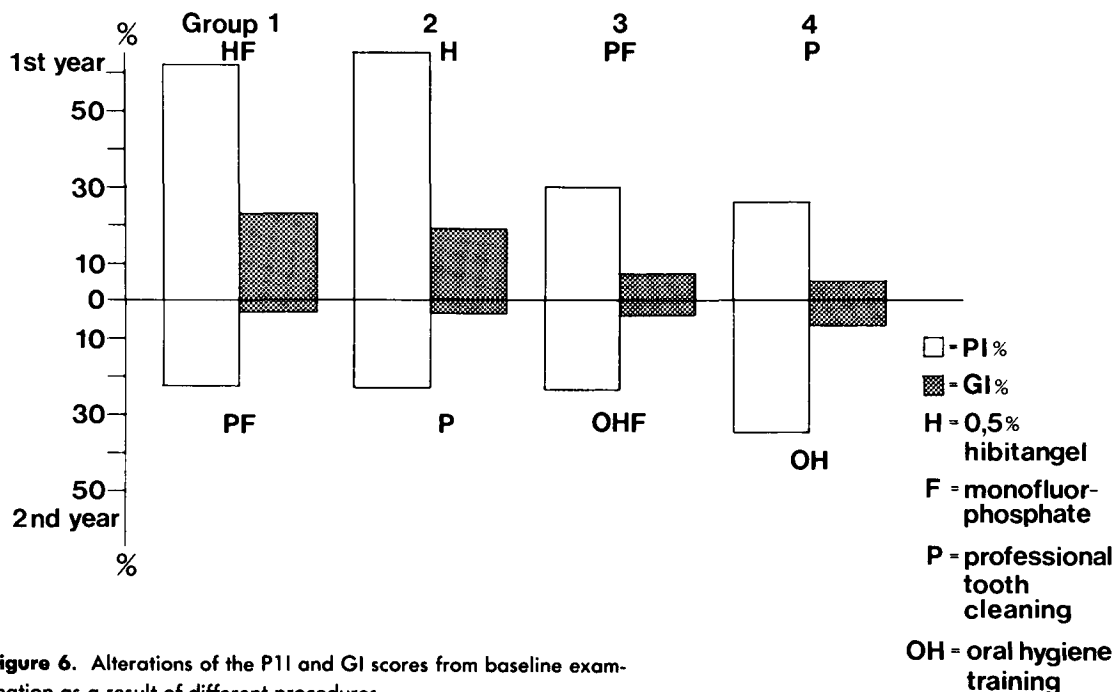


Figure 6. Alterations of the PII and GI scores from baseline examination as a result of different procedures.

line data. Then, every third patient was sent back to the referring dentist for maintenance care. Two out of every three patients were maintained at our clinic in a carefully designed and controlled maintenance care program. This program involved recalls once every two to three months and included instruction and practice in oral hygiene, meticulous scaling, and PMTC. The patients were re-examined three and six years after the baseline examination.

The results demonstrated that in patients suffering from destructive periodontitis, a treatment program involving oral hygiene instruction, scaling, root planing, PMTC and modified Widman flap procedures established clinically healthy gingiva and shallow pockets.

Patients who were placed on a carefully designed recall program over a six-year period were able to maintain excellent oral hygiene standards and unaltered attachment levels. In contrast, patients not maintained in a supervised, active treatment program showed obvious signs of recurrent periodontitis at the follow-up examinations.

Therefore, in 1971-1972 an investigation was initiated in the city of Karlstad to determine if the occurrence of caries and the progression of periodontitis could be prevented in adults and maintained at a high level of oral hygiene by regularly repeated oral hygiene instructions, scaling and PMTC.^{79,80} An attempt was also made to study the progression of dental diseases in individuals who received no special oral hygiene instruction but regularly received dental care of a traditional type.

GINGIVITIS AND PLAQUE

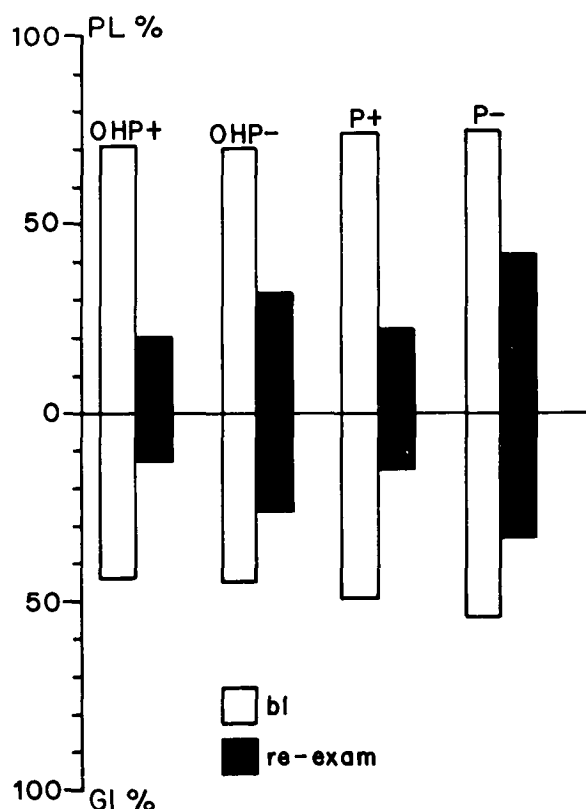


Figure 7. Total number of new interproximal DF-s during the experimental period.

Table 1. The effects of clinical trials based on professional mechanical tooth cleaning (PMTC) on gingivitis and dental caries (The "Karlstad-studies" are not included).

Frequency of cleaning	Annual caries increment		Caries reduction	Reduced P1I		Reduced gingivitis		Age group	Length of trial	Author(s) year	Ref number
	Test	Control		Test	Control	Test	Control				
Fortnightly	0.18	1.75	90%	75%	No diff	No ex	No ex	13-16	2 yrs	Karlsson & Larsson/76	64
Fortnightly	*0.94	3.40	73%	No ex	No ex	No ex	No ex	9-12	2 yrs	Klock & Krasse/78	65
Fortnightly	*2.80	7.30	61%	Sign. red.	—	60%	—	13-17	2 yrs	Björn et al./	66
Monthly	3.40	4.50	24%	No ex	No ex	38%	—	10-12	1 yr	Badersten et al./75	67
Monthly	*1.21	3.40	64%	No ex	No ex	No ex	No ex	9-12	2 yrs	Klock & Krasse/78	65
Monthly	0.81	1.78	54%	75%	—	75%	—	7	4 yrs	Bellini et al./	68,69
Every 3rd month	1.20	2.97	60%	No ex	No ex	—	—	17-19	3 yrs	Malmberg/76	70
Every 6th month	—	—	0	—	—	—	—	10-12	2 yrs	Ripa et al./76	71
Weekly	No ex	No ex	No ex	No ex	No ex	75%	—	20	4 wks	Talbott et al./77	72
<i>Balancing the effect of fluoride</i>											
Fortnightly	0.14	0.40	64%	75%	10%	70%	—	7-14	2 yrs	Kjaerheim et al./79	73
Fortnightly	0.43	1.42	70%	60%	8%	70%	10%	7	1 yr	Poulsen et al./76	74
Every 3rd week	1.40	2.09	33%	40%	15%	45%	20%	8	1 yr	Agerbaek et al./77	75
Every 3rd week	2.10	4.17	51%	73%	—	59%	—	7-16	3 yrs	Hamp et al./78	76
Daily flossing	0.15	0.33	55%	No ex	No ex	No ex	No ex	6	20 mths	Wright et al./77/79	77,78

* Selected "risk children."

Two groups of individuals from one geographic site were recruited in 1971-72 for the trial; 375 were assigned to a test and 180 to a control group. A baseline examination revealed that the socio-economic status, the oral hygiene status, the incidence of gingivitis and the caries experience were similar among the test and control participants prior to the start of the study. During the subsequent six-year period, the control patients were seen regularly once a year and given traditional dental care. The test group participants, on the other hand, were seen once every two months during the first two years and once every three months during the following four years of the trial. They were taught a proper oral hygiene technique on an individual basis, and given a careful dental prophylaxis including scaling, root planing and PMTC. Each prophylactic session was handled by a dental hygienist.

A re-examination was carried out near the end of the third and sixth year of the trial.^{79,80} The results clearly showed that it is possible, by regularly repeated tooth cleaning instruction and prophylaxis, to stimulate adults to adopt proper oral hygiene habits. The findings also demonstrated that persons who utilized proper oral hygiene techniques during a six-year period had negligible signs of gingivitis, suffered no loss of periodontal tissue attachment, and developed practically no new carious lesions. The control patients who received merely symptomatic treatment during the same period, suffered from gingivitis, lost periodontal tissue support, and developed several new and recurrent carious lesions. These results indicate that traditional dental treatment is a highly ineffective means of curing caries and periodontal disease.

After six years with four prophylaxis visits per year for the test groups, the number of new DF-s per individual per six years was only 0.2 compared to 14 DF-s per individual per six years in the control group. In addition, the average cost for dental care in the control groups was around 400 Sw crowns (100 dollars) per-person-per-year, compared to 150-200 Sw crowns (50 dollars) per-person-per-year in the test groups.

After the six-year re-examination,^{79,80} the intervals between the prophylaxis visits were increased in the test groups on an individual basis because the selective oral hygiene habits had been successfully established. Now most of the patients visit the dental hygienist only once a year and still have the same high level of oral health. Out of 375 individuals in the test groups at baseline, around 300 individuals still remain in the trial.

Conclusion

The present study clearly demonstrates that proper plaque control measures are also highly effective in the prevention of caries as well as periodontitis. It is

important, however, to realize that toothbrushing is not synonymous with proper tooth cleaning. A proper plaque control program includes measures which remove plaque on all tooth surfaces.

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