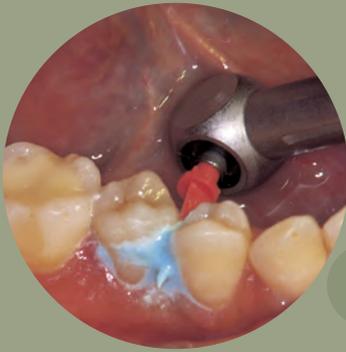


# Professional Mechanical Tooth Cleaning (PMTTC), Finishing and Minimally Invasive Treatment of Caries and Periodontal Diseases. – Materials, Methods and Effects –



By

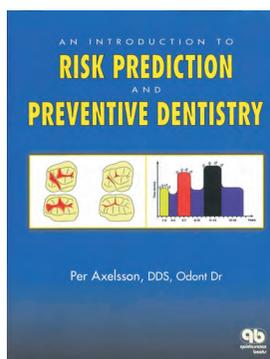
Professor Per Axelsson D.D.S, Ph.D. Sweden  
Dentatus AB, 2012

<b>Content:</b>	<b>Page no</b>
Chapter 1 - Introduction	3
Chapter 2 - Pattern of plaque reaccumulation, periopathogens and cariogenic microflora	6
Chapter 3 - "Key-Risk Teeth" and "Key-Risk Surfaces"	9
Chapter 4 - Professional Mechanical Tooth Cleaning (PMTC)	14
Chapter 5 - Effect of Mechanical Plaque Control by Self Care and PMTC on Caries, Gingivitis and Periodontitis	18
Chapter 6 - Removal of Plaque Retentive Factors and Finishing	33
Chapter 7 - Minimally Invasive Treatment of Caries	46
Chapter 8 - Minimally Invasive Treatment of Periodontal Diseases	49
References	60
Read more about Professor Per Axelsson	Back Cover

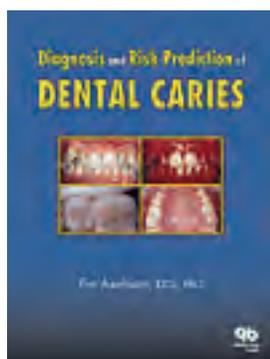
---

~

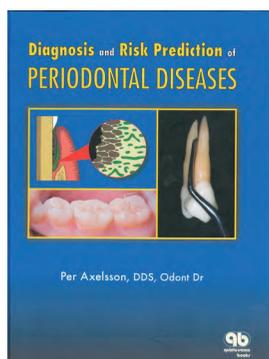
**Books written by Professor Per Axelsson, buy them on [www.quintpub.com](http://www.quintpub.com)**



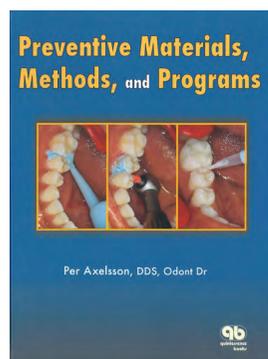
An Introduction to Risk Prediction and Preventive Dentistry



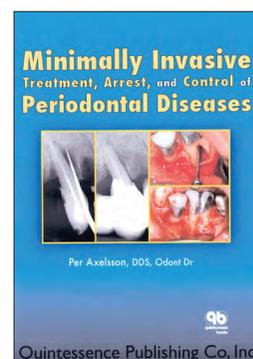
Diagnosis and Risk: Prediction of Dental Caries (Volume 2)



Diagnosis and Risk Prediction of Periodontal Diseases (Volume 3)



Preventive Materials, Methods, and Programs (Volume 4)



Minimally Invasive Treatment, Arrest, and Control of Periodontal Diseases (Volume 5)

## CHAPTER 1

### Introduction

Plaque control is the key to prevention and control of gingivitis, periodontitis, and dental caries. It is causally directed toward the sole etiologic factor in these diseases: the pathogenic microflora that colonize the tooth surfaces and form dental plaque (biofilm). Both animal and human studies have confirmed the role of plaque; germ-free animals frequently fed with sugar do not develop caries until they are infected by cariogenic microflora, which colonize the tooth surfaces (Orland et al 1954). Sugar is not an etiologic factor in dental caries, but an external modifying risk factor, as demonstrated in classic studies by Von der Fehr et al (1970) and Løe et al (1972). Under extreme experimental conditions (the absence of oral hygiene, ie, unrestricted plaque accumulation, and nine daily sucrose rinses), gingivitis and enamel caries were induced in healthy young adults within 3 weeks (Løe et al 1963; Von der Fehr et al 1970). When the same research team carried out the same study but introduced chemical plaque control, ie, twice daily mouthrinsing with 0.2% chlorhexidine solution, no gingivitis or caries developed (Løe et al 1972).

Fig 1, from a subject in the "experimental gingivitis" study by Løe et al (1965), shows the accumulated plaque and the resultant inflamed gingival margin, particularly at maxillary sites. Once adequate oral hygiene resumes, the gingival inflammation subsides within a week (Fig 2). The thickness of the gingival plaque gradually increases during the 3-week experimental period (Fig 3). For the first few days, this plaque is composed of gram-positive cocci and rods, representing the indigenous microflora of the tooth surface. After 4 to 5 days, filamentous organisms, gram-negative cocci, and rods "infect" the gingival plaque; nonattaching spirochetes gradually appear in the gingival sulcus; and the assortment of microorganisms in the gingival biofilm increases continuously. As a consequence, the first clinical signs of gingivitis develop within 2 to 3 weeks. When accumulated plaque is mechanically removed and daily oral hygiene is re-established, the gingivae heal within about 1 week. These findings have since been confirmed in many human and animal studies.



Fig 1 Plaque accumulation in a subject in an experimental gingivitis study. Note the relationship between the plaque and inflammation of the gingival margin. (From Løe et al 1965. Reprinted with permission.)



Fig 2, Resolution of the gingival inflammation shown in Fig 1, within 1 week of resumption of adequate oral hygiene. (From Løe et al 1965. Reprinted with permission.)

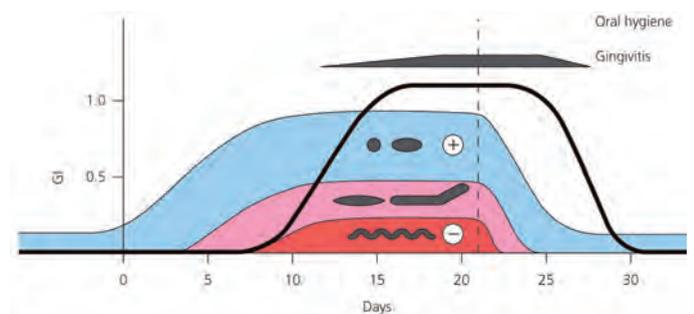


Fig 3, Increase in gingival plaque over the 3-week experimental period. For the first few days, this plaque is composed of gram-positive (+) cocci and rods, the indigenous microflora of the tooth. After 4-5 days, filamentous organisms and gram-negative (-) cocci and rods "infect" the plaque. Gradually, nonattaching spirochetes appear in the sulcus, while the assortment of microorganisms in the gingival biofilm increases continuously. As a consequence, the first clinical signs of gingivitis developed within 2-3 weeks. However, the gingiva healed when mechanical gingival plaque control was reestablished. (Modified from Løe et al 1965. Reprinted with permission.)

In a 6-week study in students, Lang and co-workers (1973) showed that if plaque was thoroughly removed at least every second day, no clinical signs of gingival inflammation appeared whereas gingivitis developed with plaque removal only every third or fourth day. Bosman & Powell (1977) induced experimental gingivitis in a group of students: with plaque removal only every third or fifth day, gingival inflammation persisted whereas healing occurred within 7-10 days in the two groups who cleaned their teeth at least every second day.

These studies provided evidence that prevention of gingivitis must be based on plaque control: thorough mechanical cleaning of all the tooth surfaces every second day is more effective than daily cosmetic brushing of the buccal and lingual surfaces which are not at risk. However such non-specific mechanical plaque control by self care has to be supplemented with needs-related intervals of professional mechanical toothcleaning (PMTc) and antimicrobial agents against specific periopathogens in individuals with progressive periodontitis.

Experimental animal studies have shown that untreated, plaque-induced gingivitis can eventually progress to periodontitis (Saxe et al 1967, Lindhe et al 1975). In humans, although gingivitis is very common, only a minority of individuals and sites develop progressive and severe periodontitis. That is because there are powerful external (environmental) as well as internal (endogenous) modifying factors. For example it is estimated that about 85% of severe periodontitis could be explained by the combination of genetic factors and smoking (Kornman & di Giovine 1998, Page & Kornman 1997). Thus non-smoking programs and development of specific anti-inflammatory medicines should be included in the assortment of methods for prevention and control of particularly the severe forms of periodontal diseases.

At the 1st European Workshop on Periodontology (Lang & Karring 1994), consensus was reached that periodontitis is always preceded by gingivitis. Prevention of gingivitis should therefore also prevent periodontitis. Longitudinal studies in humans have shown a close relationship between the standard of oral hygiene, gingivitis and loss of periodontal support (Lövdal et al 1961, Axelsson & Lindhe 1977, Axelsson & Lindhe 1981, Axelsson et al 1991, 2004.) For review see Garmyn et al 1998.

The telemetric method developed by Graf and Mühlemann (Graf 1966) allows in vivo measurement of the "true" pH on the tooth surface beneath the undisturbed plaque. The importance of the age, amount and composition of plaque as well as different concentrations of sugar can thereby be evaluated. Using the telemetric method, Imfeld (1978) showed that rinsing with 10% sucrose solution caused a dramatic drop in pH to below 4 in 3-day-old interdental plaque. Such plaque is typical for the approximal surfaces of the molars and premolars in a toothbrushing population. In contrast, the fall in pH in immature lingual plaque (12 hours old) was very limited (Fig 4).

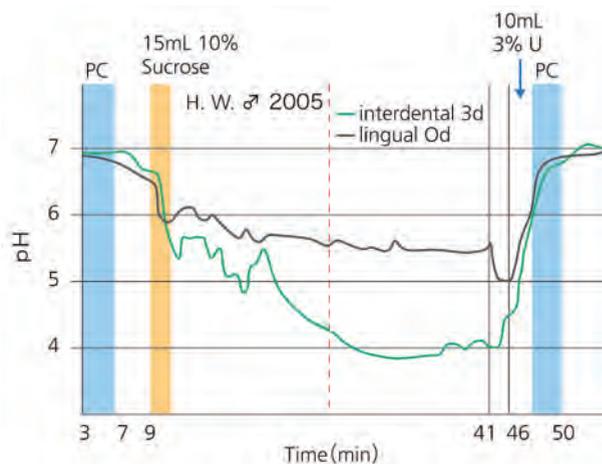


Fig 4, Limited drop in pH in 12-hour-old lingual plaque compared to critical drop in pH beneath 3-day-old (3d) interdental plaque after rinsing with 10% sucrose solution.

Firestone et al (1987) used the same telemetric test in vivo, measuring the drop in pH on molars after subjects rinsed with 10% sucrose solution. Four different sites with approximal plaque were compared to plaque-free approximal surfaces. (Fig 5). The authors concluded that "removing plaque from interdental surfaces significantly reduced the exposure of the surfaces to plaque acids following sucrose rinse. This further supports mechanical removal of plaque from interdental surfaces as a means of reducing dental caries".

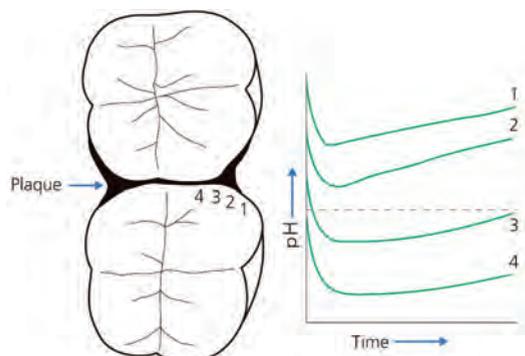


Fig 5, pH drop in molars with approximal plaque at four different sites after rinsing with sucrose solution. (From Firestone et al 1987.)

In toothbrushing populations, for those who have an established habit of using a toothbrush and fluoride toothpaste daily, dental plaque more than 2 days old is located mainly on the approximal surfaces of the molars and premolars, partly subgingivally. Access with a toothbrush to the wide approximal surfaces is limited by the buccal and lingual papillae. In European countries, although daily toothbrushing with a fluoride dentifrice is an established oral hygiene habit, approximal cleaning with interdental aids such as dental floss, dental tape, toothpicks and interdental brushes, are used daily by less than 10% of the population (Kuusela et al 1997). This explains why caries, gingivitis and marginal periodontitis are much more prevalent on the approximal surfaces of the molars and premolars than on the buccal and lingual surfaces of the dentition.

Two conclusions may be drawn from these studies:

1. Prevention of gingivitis and marginal periodontitis must be based on gingival plaque control.
2. Prevention of dental caries should be based on plaque control.

Plaque control can be achieved mechanically or chemically by self-care or by professionals (dentists or dental hygienists). Plaque control programs based on needs-related combinations of these methods are to date the most successful for prevention of gingivitis, marginal periodontitis and dental caries.

Plaque disclosure illustrates the close correlation between the sites of gingivitis and caries and the key etiologic factor: the dental plaque biofilm (Figs 6 and 7). Clean teeth will never decay.



*Fig 6, The anterior teeth of a 12-year-old boy with gingivitis at the following sites: 13 mesiobuccal (mb); 12 mb; 21 distobuccal (db); 22 mb, 23 mb; 43 mb; 42 db; 32 db, and 33 mb. Enamel caries is found at 13 mb, 43 mb, 42 b, 32 db, 33 mb, and 34 mb. There is a cavity on 21 d.*



*Fig 7, One minute later a disclosing agent was used to visualize plaque.*

## CHAPTER 2

### *Pattern of plaque reaccumulation, periopathogens and cariogenic microflora*

Plaque formation rate is influenced by factors such as the anatomy and surface morphology of the teeth, the stage of eruption and functional status of the teeth; the wettability and surface tension of the tooth surfaces (both intact and restored surfaces); and gingival health and volume of gingival exudate. The pattern of plaque reaccumulation will also be influenced by these factors, but may differ somewhat on tooth surfaces exposed to chewing forces; abrasion from foods, and friction from the dorsum of the tongue, the lips and the cheeks compared with the pattern on less accessible areas, such as approximal sites, along the gingival margin, and in irregularities such as occlusal fissures, particularly in erupting molars. These areas are often designated “stagnation areas” for plaque.

In the 6-week study by Lang et al (1973), plaque reaccumulation was registered in four groups of dental students who carried out oral hygiene procedures (mechanical toothcleaning by self-care) with different frequencies: twice daily or every second, third or fourth day. Fig 8 shows the pattern of reaccumulated plaque according to the Silness and Løe (1964) PI (scores 0 to 3). After only 12 hours of free plaque reaccumulation, there was visible plaque on some of the approximal surfaces of the molars and the lingual surfaces of the mandibular molars (score 2). After 48 hours, almost 100% of these surfaces and most of the remaining approximal surfaces had scores of 2 or 3. The pattern of visible plaque after 2 and 3 days seems to be similar, except for the facial surfaces.

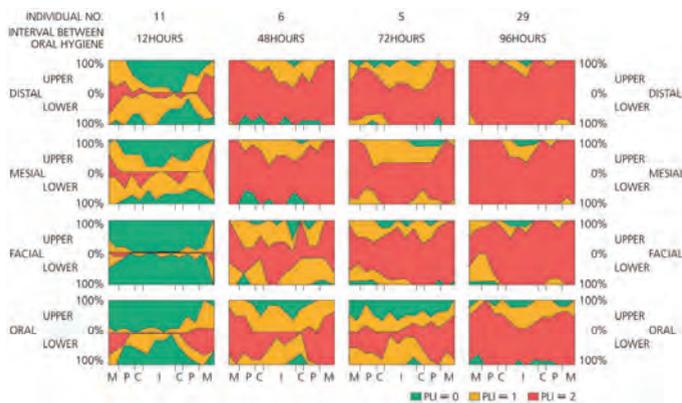


Fig 8, Patterns of plaque reaccumulation in subjects with various frequencies of plaque removal. Plaque was measured with the Silness and Løe (1964) PI. (Modified from Lang et al 1973. Reprinted with permission.)

According to Listgarten (1976), freely accumulated plaque is about five times thicker after 3 days than it is after 2 days (see Fig 9). This explains why gingivitis developed in the group of students cleaning only every third or fourth day but not in those who cleaned their teeth at least every second day.

Fig 10 presents the percentage of freely reaccumulated (de novo) plaque, 24 hours after Professional Mecha-

nical Tooth Cleaning (PMTC), in 667 children aged 14 years in the city of Karlstad (Axelsson 1987, 1991). Plaque reaccumulation was greatest on the mesiolingual and distolingual mandibular surfaces (33%), particularly on the molars, followed by the mesiobuccal and distobuccal surfaces on both maxillary and mandibular teeth, particularly the molars. There was almost no plaque reaccumulation (3%) on the palatal surfaces of the maxillary teeth, mainly because of friction from the rough dorsum of the tongue.

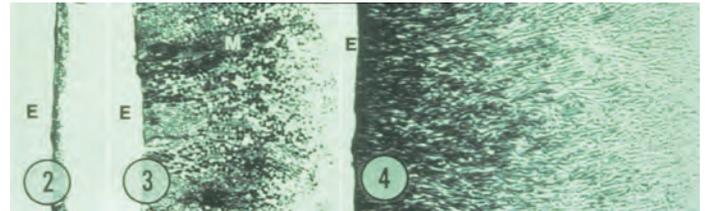


Fig 9, Thickness of gingival plaque: 2, 3, and 4 days old. (From Listgarten et al 1975. Reprinted with permission.)

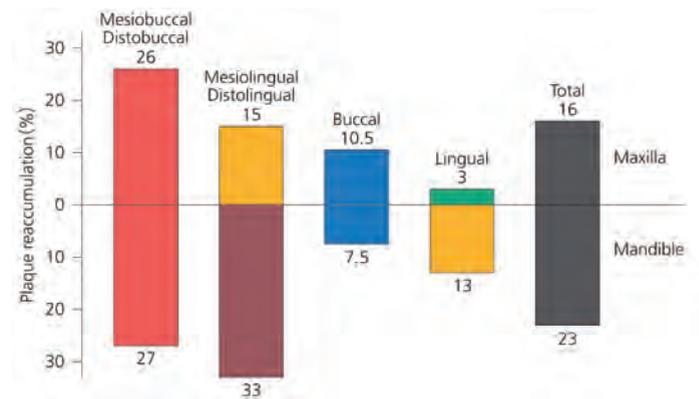


Fig 10, The pattern of plaque formation rate in 14-year-old subjects 24 hours after PMTC. (From Axelsson 1989, 1991. Reprinted with permission.)

In another study (Furuichi et al 1992), the pattern of de novo plaque formation after 1, 4, 7, and 14 days of undisturbed plaque accumulation was studied in 10 subjects, aged 24 to 29 years. At the beginning of the study, the subjects received a thorough PMTC and oral hygiene instruction. At the end of a 2-week preparatory phase, the subjects were examined to ensure that the gingivae were healthy at baseline. Mechanical toothcleaning was then discontinued, and plaque accumulation was recorded as PI (Silness and Løe 1964). During a 2-week period without oral hygiene, most plaque formed during the first 4 days. The amount of plaque was greater on mandibular than on maxillary teeth, greatest on the approximal surfaces, and least on the palatal surfaces. These differences, observed on day 4, persisted throughout the 2-week monitoring period. These findings verified the patterns of plaque formation described by Lang et al (1973) and Axelsson (1991).

In a microbiologic study, Mombelli et al (1990a) analyzed subgingival plaque samples from maxillary and mandibular right canines, premolars, and first molars (distal, midbuccal and lingual) in 10 healthy subjects

who had refrained from oral hygiene procedures for 4 days. The samples were examined by darkfield microscopy. Distobuccal samples contained more bacteria than did buccal samples, and buccal samples contained more than did lingual samples. Bacterial counts were higher in samples from posterior sites than they were in more anterior samples and significantly higher in maxillary samples than they were in mandibular samples (Fig 11). This microscopic study also appeared to confirm the distinct pattern of plaque development on clean tooth surfaces.

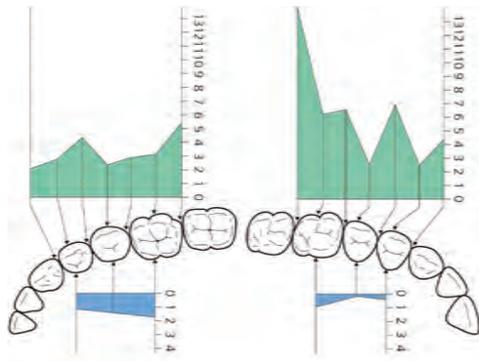


Fig 11, Bacterial counts in subgingival plaque from various intraoral sites. Numbers represent  $\times 10^6$  organisms/ml. (From Mombelli et al 1990. Reprinted with permission.)

These findings are supported by two studies on the role and pattern of approximal mutans streptococci colonization in a 13- to 16-year-old toothbrushing population (Axelsson et al 1987b; Kristoffersson et al 1984). During a 30-month period, mutans streptococci was studied on all the approximal surfaces in 187 subjects, aged 13 to 16 years, with more than 1 million colony-forming units of mutans streptococci per 1 ml saliva, selected from a population of 720 subjects aged 13 years. Every 6 months, mutans streptococci was sampled from saliva, the dorsum of the tongue, and every approximal tooth surface. Interproximal samples were obtained, as described by Kristoffersson and Bratthall (1982), with a sterile, wooden triangular pointed toothpick were then pressed directly against selective (mitis-salivarius-bacitracin) agar plates. After incubation, the number of colonies formed was evaluated for every approximal surface.

In 17 subjects, who consistently had a minimum of one surface highly colonized with mutans streptococci and a minimum of one mutans streptococci-negative or minimally colonized surface, about 50% of the highly colonized surfaces developed caries (Fig 12). Only 3% of the mutans streptococci-negative or sparsely colonized surfaces developed caries (Fig 13) (Axelsson et al 1987b).

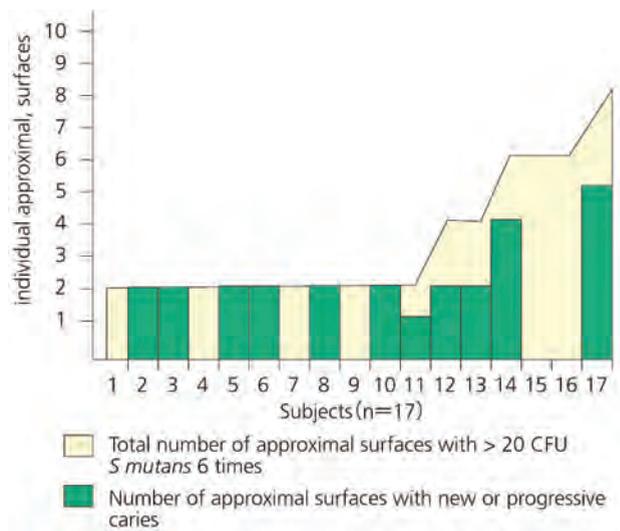


Fig 12, Development of carious lesions on surfaces highly colonized (above) and sparsely colonized (below) with MS. (From Axelsson et al 1987b.)

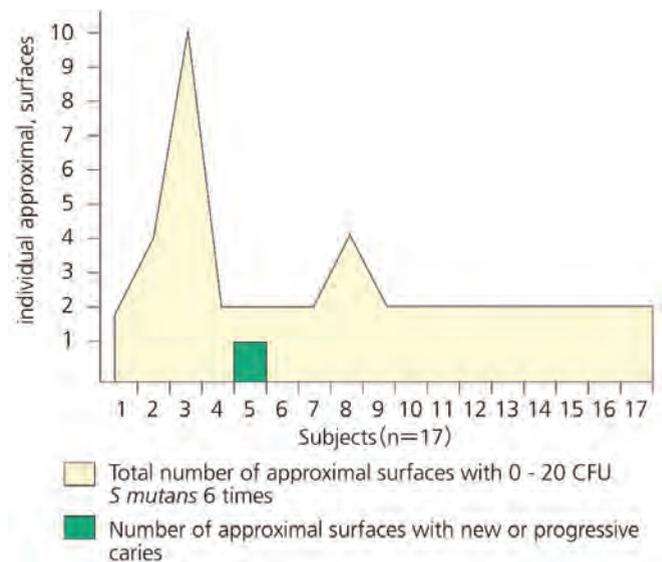


Fig 13

In a prior study of 14-year-old children with more than 1 million colony-forming units of mutans streptococci per 1 ml of saliva, the surfaces most heavily colonized with mutans streptococci were the approximal surfaces of the molars and the second maxillary premolars (Fig 14) (Kristoffersson et al 1984). In fact, the previously mentioned study of more than 600 subjects aged 14 years showed that the same surfaces also had the highest PFRI scores (see Fig 10).

By using the wire telemetric method, Igarashi et al (1989) showed that, after 1 minute rinse with 10% sucrose solution (Fig 15), the pH was much lower in 4-day-old approximal plaque than in the corresponding fissure plaque. In a toothbrushing population, such mature plaque would be found, if at all, only on the approximal surfaces of the molars and premolars. These observations explain why, in toothbrushing populations, the highest prevalence of decayed, or filled surfaces is recorded on these approximal surfaces, which will later be discussed.

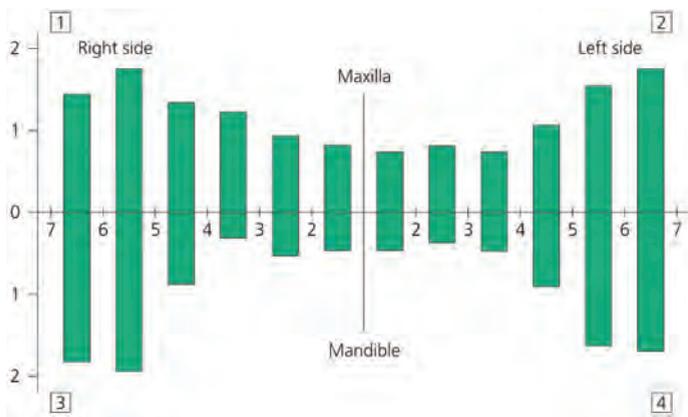


Fig 14, The approximal surfaces of molars and maxillary second premolars have been shown to be the most highly colonized with MS according to approximal MS scores 0-3. (From Kristoffersson et al 1984.)

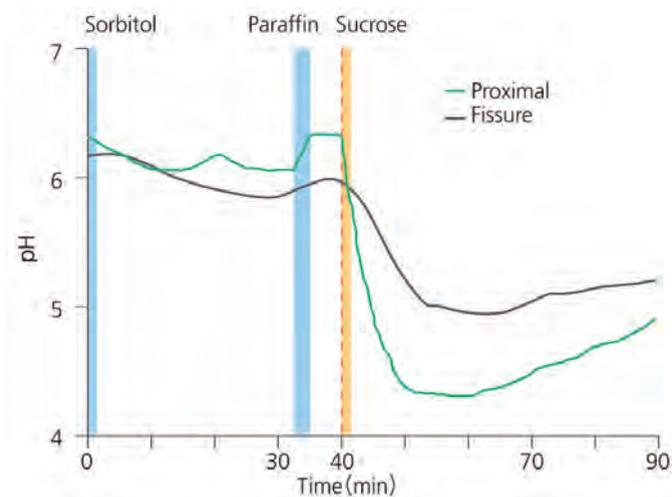


Fig 15, Results of the wire telemetric method show the low pH of approximal plaque compared to that of fissure plaque. (From Igarashi et al 1989. Reprinted with permission.)

Carvalho et al (1989) studied the pattern and amount of de novo plaque 48 hours after PMTC, on the occlusal surfaces of partially and fully erupted first molars. Fig 16 illustrates the heavy plaque reaccumulation, particularly in the distal and central fossae of the erupting maxillary and mandibular molars, in contrast to reaccumulation in the fully erupted molars, which are subjected to normal chewing friction. Abrasion from normal mastication significantly limits plaque formation; this explains why almost 100% of occlusal caries in molars begins in the distal and central fossae during the eruption period of 14 to 18 months.

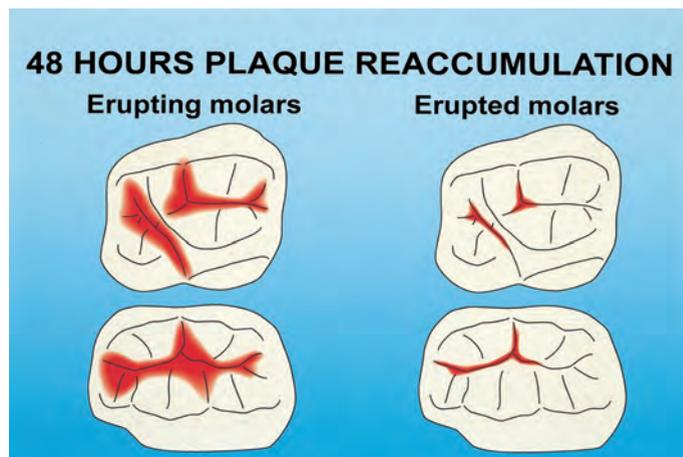


Fig 16, Reaccumulation of plaque (shaded area) at 48 hours in partially and fully erupted molars. (Modified from Carvalho et al 1989. Reprinted with permission.)

It is important to differentiate between plaque indices and the plaque reaccumulation rate (PFRI). For successful strategies for primary and secondary prevention of dental caries and periodontal diseases, an understanding of plaque formation rates and patterns is essential. Mechanical removal of dental plaque according to the non-specific plaque hypothesis is a rational method for prevention and control of periodontal diseases as well as dental caries, because it is directed toward the cause (etiology) of these diseases. However, for cost effectiveness, the program should be related to the rate and pattern of plaque reaccumulation, PFRI, and otherwise-predicted risk (for reviews on plaque formation, see Axelsson 1994, 1998; Lang et al 1997a; Listgarten 1994; and Straub et al 1998).

### CHAPTER 3

#### "Key-Risk Teeth" and "Key-Risk Surfaces"

##### Pattern of missing teeth

Figs 17-19 show the pattern of lost teeth (% lost teeth) in randomized samples of 50-, 65- and 75-year-old Swedish smokers and non-smokers almost 25 years ago (Axelsson et al 1988, 1998). Obviously the molars followed by the maxillary premolars are the "key-risk teeth". The cuspids and the mandibular incisors on the other hand exhibit the lowest percentage of lost teeth. It is also evident that smokers have lost significantly more teeth than non-smokers particularly among the maxillary teeth. Thus smoking seems to be a local risk factor for tooth loss.

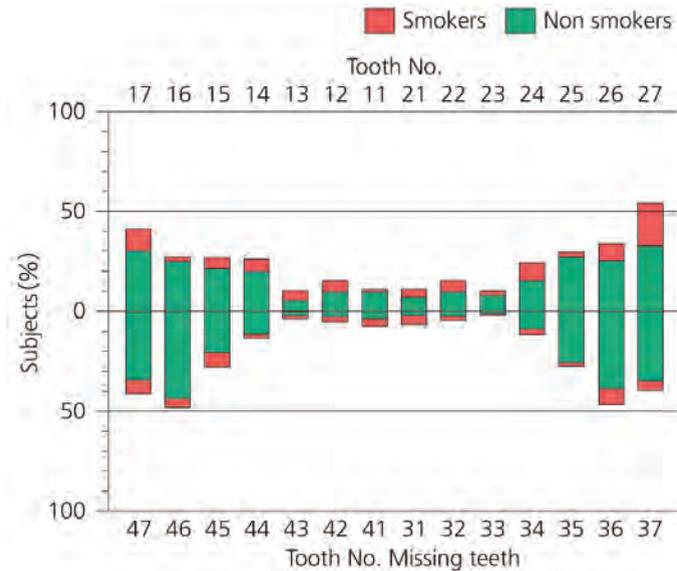


Fig 17, Pattern of tooth loss (%) in a randomized sample of 50-year-old smokers and nonsmokers (FDI tooth numbering system). (From Axelsson et al 1998. Reprinted with permission.)

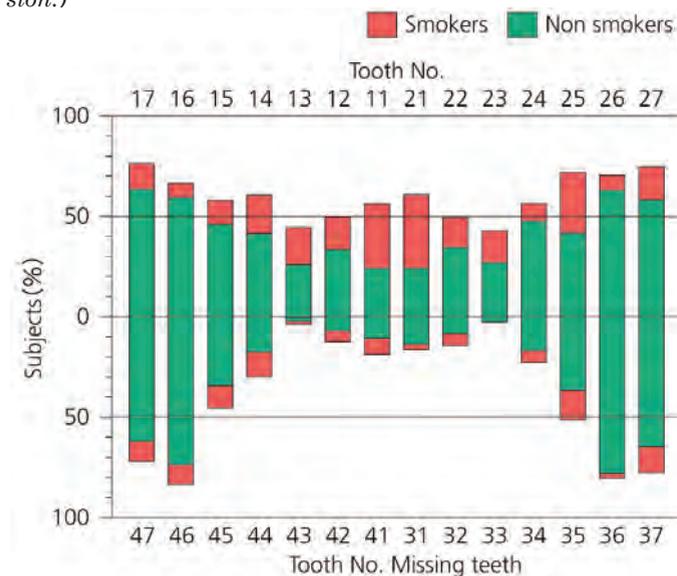


Fig 18, Pattern of tooth loss (%) in a randomized sample of 65-year-old smokers and nonsmokers (FDI tooth numbering system). (From Axelsson et al 1998. Reprinted with permission.)

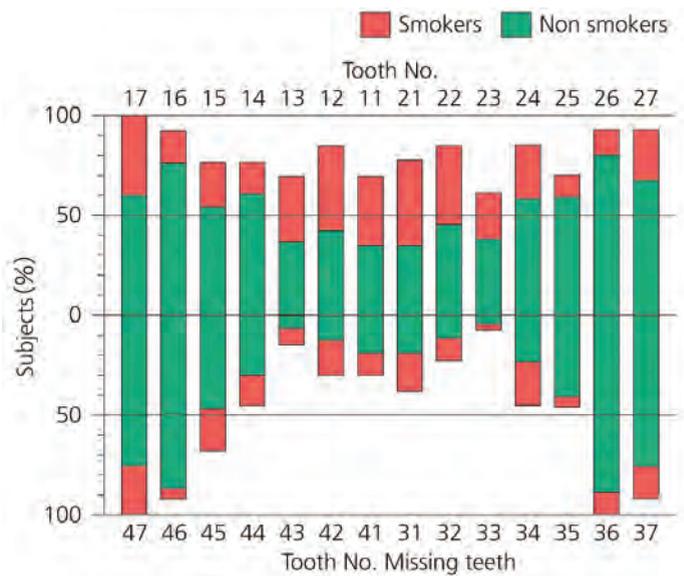


Fig 19, Pattern of tooth loss (%) in a randomized sample of 75-year-old smokers and nonsmokers (FDI tooth numbering system). (From Axelsson et al 1998. Reprinted with permission.)

##### Pattern of Dental Caries (DMF-s)

Fig 20 shows caries prevalence and the pattern of decayed or filled surfaces (DFSs) in 12-year-old children in the county of Värmland, Sweden in 1964, 1974, 1984 and 1994. The molars are clearly the key-risk teeth. In a toothbrushing population, the key-risk surfaces are the fissures of the molars and the approximal surfaces, from the mesial surface of the second molars to the distal surface of the first premolars. (Fig 20-21).

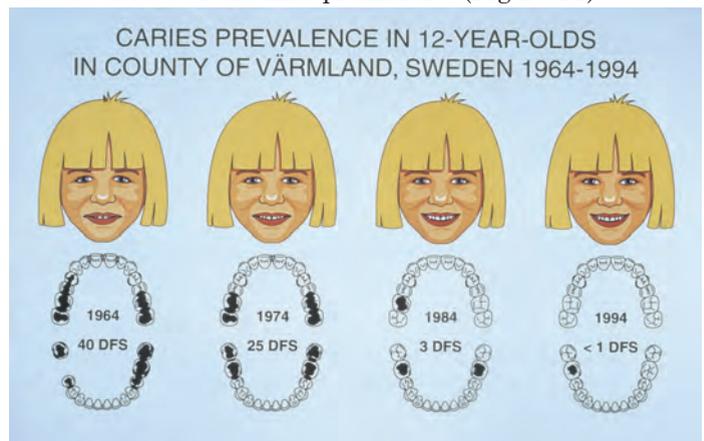


Fig 20, Caries prevalence in 12-year-olds in the county of Värmland, Sweden, 1964-1994. (From Axelsson 1998.)



Fig 21, In members of toothbrushing populations, dental caries is concentrated in the approximal surfaces of the posterior teeth. Therefore, supplementary plaque control methods should be performed on these high-risk surfaces. (From Waerhaug 1981. Reprinted with permission of the University of Oslo.)

The reason is that the buccal and lingual papillae block the accessibility for the toothbrush on the wide approximal surfaces of particularly the molars followed by the premolars (Fig 22). Thus the risk for development of approximal caries can be predicted by measuring the bucco-lingual width of the approximal surfaces in toothbrushing populations (Fig 23).

Integration of mechanical plaque control by self-care and the use of fluoride toothpaste, supplemented at needs-related intervals by professional mechanical toothcleaning (PMTC), fluoride varnish, and chlorhexidine varnish should therefore target these key-risk teeth and surfaces.

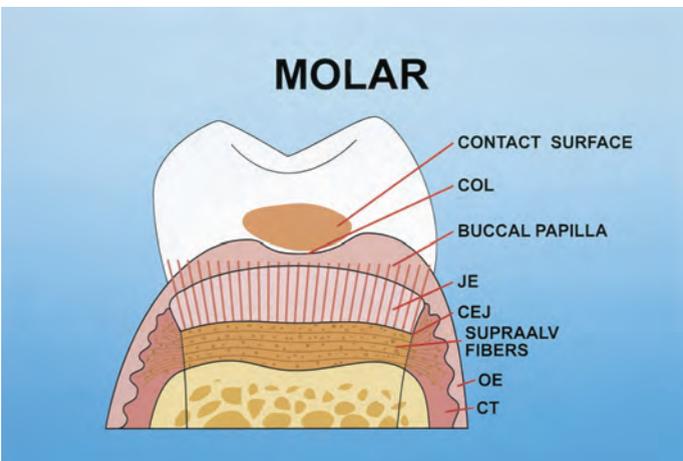


Fig 22, Cross section of hard and soft tissues in the approximal area of mandibular first molar contact surface. (JE) Junctional epithelium, which attaches to the tooth surface during healthy conditions; (CEJ) Cementoenamel junction; (OE) Oral epithelium; (CT) Connective tissue.

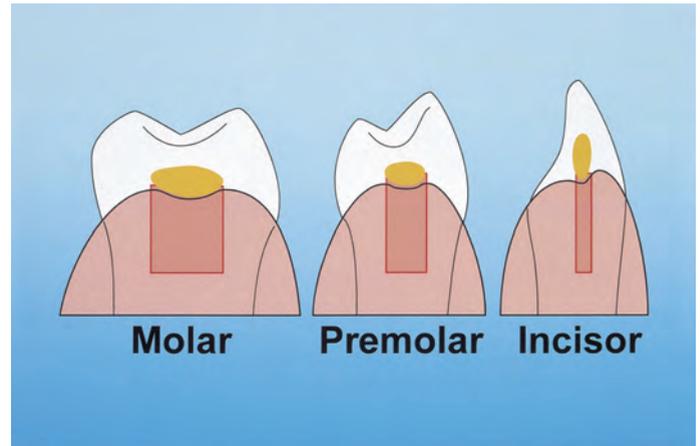


Fig 23, The width and shape of the approximal tooth surfaces and contact surfaces of molars, premolars and incisors.

As shown in Fig 20, the mean caries prevalence in 1964 was about 40 DFS, generally involving all the approximal and occlusal surfaces of the molars and premolars as well as some buccal and lingual surfaces. On average, one mandibular first molar was missing. Extracted because of caries. During the following 10 years, the use of the toothbrush and fluoride toothpaste were introduced. As a result the number of DFSs decreased to about 25. The reduction was mainly in caries on the approximal surfaces of the incisors and the buccal and lingual surfaces of the molars and premolars.

The separate effects of the toothbrush and fluoride toothpaste are difficult to estimate. In 1975 a needs-related plaque control program (both PMTC and home care), combined with fluoride toothpaste and fluoride varnish, was gradually introduced, targeting the key-risk surfaces of schoolchildren. The number of DFSs decreased to 3.0. The reduction occurred on the approximal surfaces of the molars and the premolars. The remaining caries, it is suggested, represents mainly overtreatment of first molar fissures.

For comparison, Fig 24, from a randomized sample of 19-year-old residents of other counties of Sweden, shows the mean pattern of manifest caries and restorations with or without incipient (enamel) caries lesions of the approximal surfaces of the posterior teeth. For optimal caries prevention in such populations, plaque control and topical application of fluorides should target these key-risk surfaces.

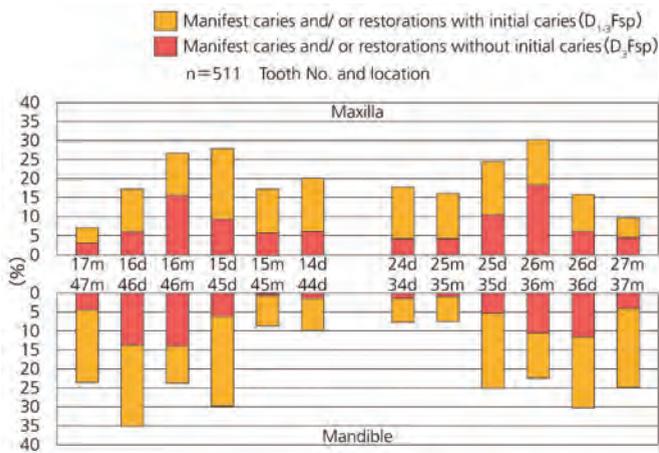


Fig. 24, Mean pattern of manifest caries or restorations with or without initial caries (enamel caries) included on the posterior approximal surfaces of 19-year-olds. (D1, D2) enamel caries lesion; (D3) dentin caries; (FS) filled surface; (p) posterior; (m) mesial; (d) distal. (From Forsling et al 1999. Reprinted with permission.)

Figs 25-27 show the pattern of Intact-, Decayed-, Filled and Missing tooth surfaces mesially (Fig 25), buccally (Fig 26) and lingually (Fig 27) in a randomized sample of 50 year-old Swedes in 1988. Obviously the mesial surfaces of the posterior teeth exhibit the highest prevalence of DMF-s, while the buccal and lingual surfaces of the mandibular incisors and cuspids exhibit the highest percentage of intact surfaces.

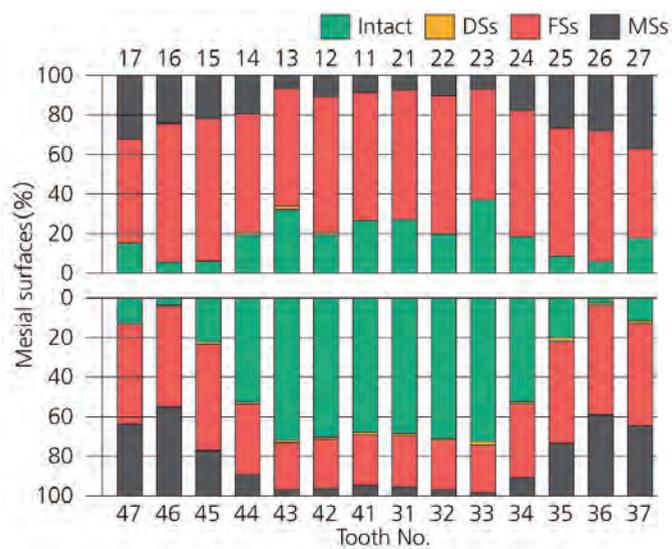


Fig 25, Caries prevalence in 50-year-old subjects: Frequency distribution of intact, decayed (DSs), filled (FSs), and missing surfaces (MSs) mesially (FDI tooth-numbering system). (From Axelsson et al 1988, 1990. Reprinted with permission.)

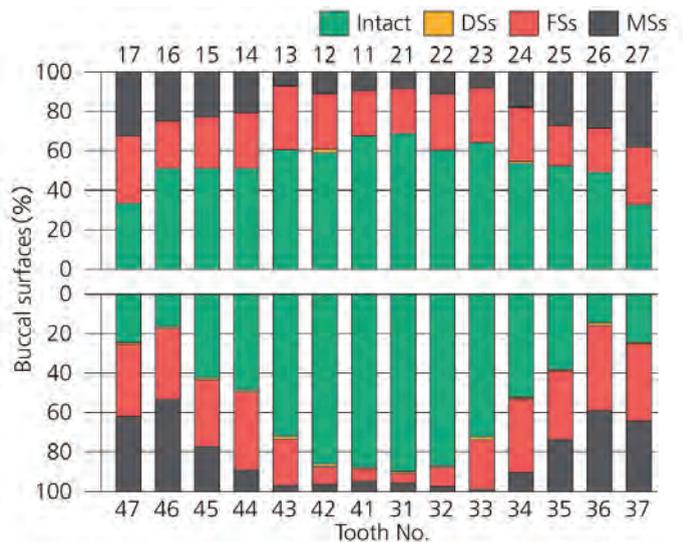


Fig 26, Caries prevalence in 50-year-old subjects: Frequency distribution of intact, decayed (DSs), filled (FSs), and missing surfaces (MSs) buccally (FDI tooth-numbering system). (From Axelsson et al 1988, 1990. Reprinted with permission.)

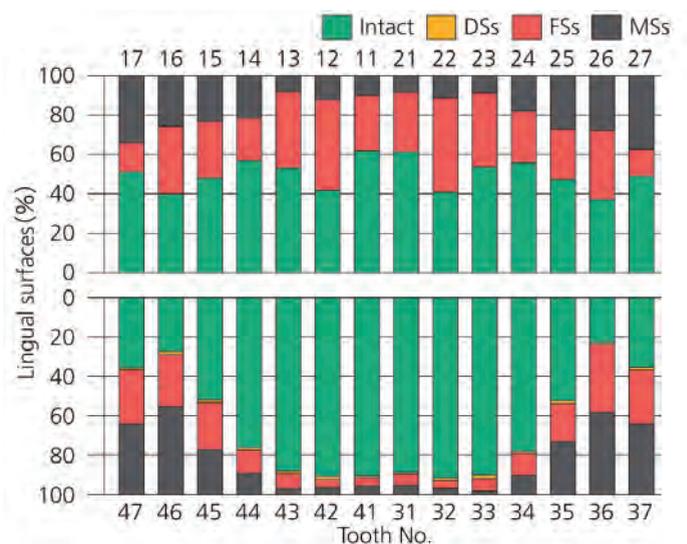


Fig 27, Caries prevalence in 50-year-old subjects: Frequency distribution of intact, decayed (DSs), filled (FSs), and missing surfaces (MSs) lingually (FDI tooth-numbering system). (From Axelsson et al 1988, 1990. Reprinted with permission.)

### Pattern of Periodontal Disease

Löe et al (1978) showed in their classical study “The Natural History of Periodontal Disease” that 40-year-old tea-workers in Sri Lanka, without any dental care exhibited advanced loss of periodontal support. In particularly the maxillary molars had advanced loss of periodontal support resulting in furcation involvement grade 2 and 3 (Fig 28).

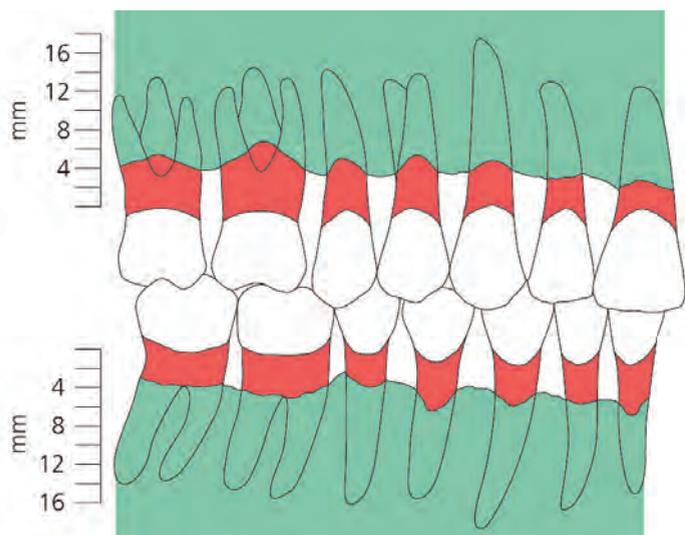


Fig 28, Average pattern of attachment loss in Sri Lankan tea workers. At 40 years of age, the mean loss of attachment is 4.5 mm. (Modified from Loe et al 1978. Reprinted with permission.)

From our own analytical epidemiology studies (Axelsson et al 1988) it was shown that already in randomized samples of 35-year-olds, the distal surfaces of the maxillary first molars exhibited twice as much periodontal attachment loss (PAL) compared to the mesial surfaces, implying greater risk for furcation involvement on the “inaccessible” distal surfaces in “tooth-brushing” populations. These “key risk surfaces” should have been targeted for mechanical gingival plaque control by self care and PMTC from early childhood (12 years of age). As a consequence of more advanced PAL on the distal surfaces of the maxillary first molars, the highest prevalence of furcation involvement is found on these particular surfaces from 50 years of age (Axelsson et al 1988, 2000).

Treatment of teeth with furcation involvement is much more complicated than treatment of diseased pockets in single-rooted teeth. Therefore, diagnosis and analytical epidemiology on the pattern of furcation involvement is important.

Figs 29-31 show the pattern of “Community Periodontal Index of Treatment Needs (CPITN)” scores 0, 1, 2, 3, 4 and missing surfaces at mesial- (Fig 29), buccal- (Fig 30) and lingual (Fig 31) sites in a randomized sample of 50-year-old Swedish subjects in 1988. (Axelsson et al 1988)

- CPITN score 0 = healthy sites
- CPITN score 1 = gingivitis
- CPITN score 2 = calculus
- CPITN score 3 = 4-5 mm deep diseased pockets
- CPITN score 4 = > 5 mm deep diseased pockets

Score 4 is almost negligible. Score 3 is concentrated to the mesial sites of the maxillary molars, followed by the maxillary premolars and the mandibular molars, the “key risk surfaces” (Fig 29). The mesial and lingual sites of the mandibular incisors exhibit the highest percent of score 2 (supra gingival calculus to be removed). The highest percentage of healthy sites (score 0 = non risk surfaces) is found on the buccal sites of the

incisors, cuspids and first premolars (Fig 30) followed by the lingual maxillary incisors and cuspids and the mandibular cuspids and first premolars (Fig 31).

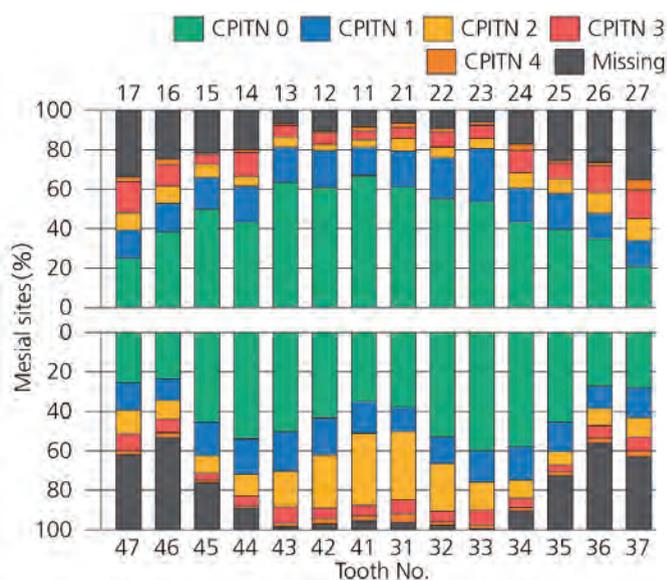


Fig 29, Frequency distribution of missing teeth and mesial surfaces with CPITN scores 0-4 in 50-year-old subjects (FDI tooth-numbering system). (From Axelsson 1988. Reprinted with permission.)

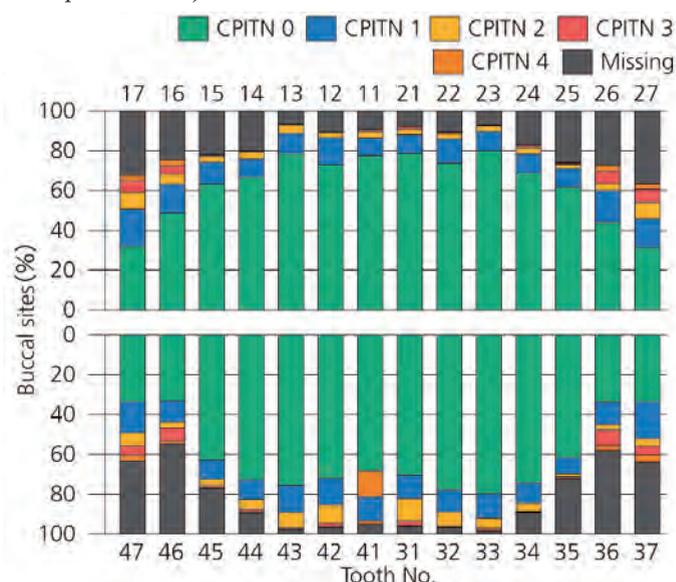


Fig 30, Frequency distribution of missing teeth and buccal surfaces with CPITN scores 0-4 in 50-year-old subjects (FDI tooth-numbering system). (From Axelsson 1988. Reprinted with permission.)

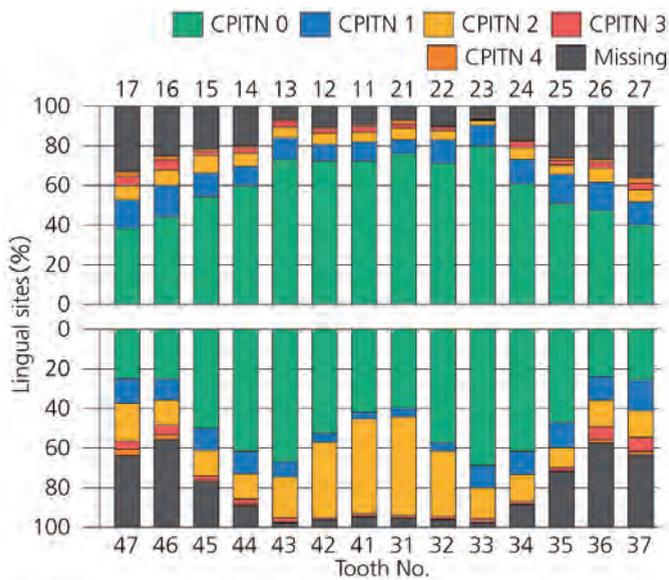


Fig 31, Frequency distribution of missing teeth and lingual surfaces with CPITN scores 0-4 in 50-year-old subjects (FDI tooth-numbering system). (From Axelsson 1988. Reprinted with permission.)

Information with respect to which teeth are most frequently missing and the reason for extraction as well as the tooth surfaces most frequently attacked by caries and periodontitis is important for planning appropriate preventive measures. Important questions that arise are:

- 1) Why are the maxillary molars the most frequently missing teeth?
- 2) Why are maxillary premolars missing more frequently than mandibular premolars?
- 3) Why are the mandibular canines the most resistant of all the teeth?
- 4) Why is the difference in prevalence of both caries and periodontitis between the distal surface of the maxillary first molars and distal surface of the mandibular canines more significant than the difference in total prevalence between individuals in "tooth brushing" populations?

As clean teeth never decay and periodontitis will never develop around clean teeth, the most important answer is:

The mechanical cleaning of the wide approximal surfaces of the posterior teeth and the fissures of erupting molars has been failing. In order to solve this problem, mechanical tooth cleaning by self care, supplemented with needs related intervals of Professional Mechanical Tooth Cleaning (PMTTC) has to be focused on the above "Key Risk" tooth surfaces. From caries preventive point of view, topical use of fluoride by self care and professionals must also be supplemented on the same tooth surfaces. For details see Axelsson 2000, 2002, 2004, 2009.

## CHAPTER 4

### Professional Mechanical Tooth Cleaning (PMTC)

#### Definitions

As earlier discussed, plaque control may be performed according to the following methods:

- Mechanical tooth cleaning by self care
- Mechanical tooth cleaning by professionals (PMTC)
- Chemical plaque control by self care
- Chemical plaque control by professionals

Needs-related combinations of the above four methods should be the most efficient prevention of dental caries as well as periodontal diseases.

Professional mechanical toothcleaning (PMTC) is a service provided by dental personnel (specially trained dental nurses, dental hygienists, and dentists) and is defined as the selective removal of plaque biofilms from all tooth surfaces. Gingival plaque located up to 1 to 3 mm subgingivally is removed with mechanically driven instruments and fluoride prophylaxis paste. Therefore, the procedure is more correctly described as gingival plaque control rather than supragingival plaque control. If deep subgingival plaque biofilms are also removed, the procedure is referred to as debridement or “extended” PMTC, and may be carried out only by dentists and dental hygienists. In new patients with untreated diseased periodontal pockets, debridement may have to be supplemented with removal of calculus (scaling), other plaque retentive factors (restoration overhangs etc) and root planing. Professional mechanical toothcleaning should not be confused with so-called prophylaxis or polishing, which involves the use of a rotating rubber cup and prophylaxis paste on the buccal, lingual and occlusal surfaces, ie, the non risk surfaces, which mostly are cleaned twice a day by self care in “tooth brushing” populations. Such prophylaxis or polishing should be regarded as “humbug”.

#### Materials and methods for PMTC

In the so-called Karlstad studies in adults (Axelsson and Lindhe 1978, 1981a, 1981b; Axelsson et al 1991, 2004) and children (Axelsson and Lindhe 1974, 1977, 1981c; Axelsson et al 1976; for review see Axelsson 1981, 1993a, 1994, 1998, 2004), standardized procedures were adopted for PMTC. The following materials are required:

- 1) Plaque-disclosing pellets (Fig 32)
- 2) A prophylaxis contra-angle handpiece for reciprocating triangular-pointed or spatula-shaped tips (Figs 33 and 34)
- 3) A prophylaxis contra-angle handpiece for rotating rubber cups and pointed brushes (Figs 33 and 35)
- 4) Fluoride-containing prophylaxis pastes (Figs 33 and 36)
- 5) A syringe for injecting the paste interproximally (Figs 33 and 36)

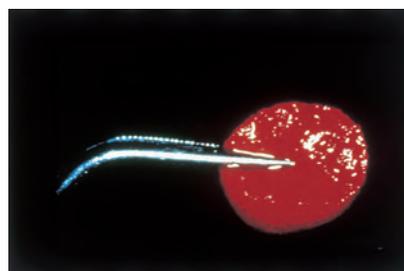


Fig 32, A plaque-disclosing pellet is used with tweezers.



Fig 33



Fig 34



Fig 35, Close-up of the prophy contra-angle handpiece and the supplementary rotating rubber cup and pointed brush.



Fig 36, The syringe filled with fluoride prophy paste for interdental application.

Professional mechanical toothcleaning (PMTc) is carried out in the following needs-related sequence: 1) plaque is disclosed; 2) prophylaxis paste is applied to interproximal areas; 3) interproximal areas are cleaned; and 4) lingual, buccal and occlusal surfaces are cleaned.

#### Plaque disclosure

Because PMTC must target the tooth surfaces normally neglected by the patient, disclosure of plaque is the first step. Application of a disclosing pellet takes less than 1 minute using the following procedure.

1. It is best to start where the plaque deposits are often heaviest, ie, in the mandibular lingual embrasures, where abundant saliva makes disclosure difficult (Fig 37a).
2. Plaque in the mandibular buccal embrasures is then disclosed by pressing the pellet lightly into each interproximal space.
3. Finally, the plaque on the maxillary palatal and buccal surfaces is disclosed.



Fig 37a, Lingual-approximal plaque visible by red staining on the right mandibular posterior teeth in a right-handed patient.

Interproximally, the presence of plaque should be verified by probing; it is invariably present if continuous plaque is visible in the line angles or if the approximal surfaces are carious or restored and the interproximal space is completely occupied by the gingival papilla.

#### Application of prophylaxis paste to interproximal areas

Use of a disposable syringe facilitates the application of fluoride polishing paste to the interproximal areas (see Figs 33, 36 and 37b). A rational procedure is to start from the lingual aspect of the mandibular teeth, before the floor of the mouth is filled with saliva. The gingival papillae are pressed down with the point of the syringe before injecting the polishing paste. When paste is already applied to the surfaces requiring most attention, interproximal mechanical cleaning can be carried out very quickly.



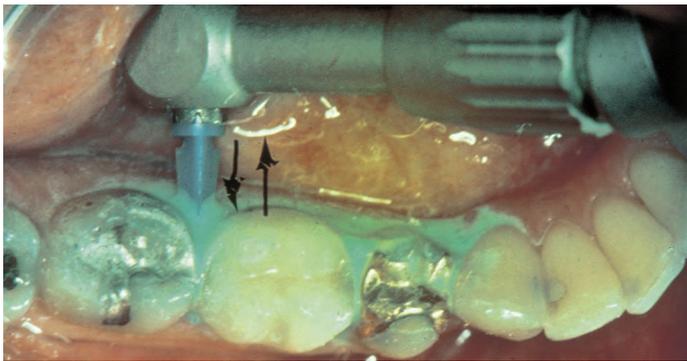
Fig 37b, Application of the prophy paste interdentally by using a syringe.

#### Interproximal PMTC

The EVA-Profin contra-angle handpiece and the triangular-pointed tips are used for interproximal PMTC (see Figs 33 and 34). An alternative is the EVA spatula-shaped tip (Fig 34), which is suitable on exposed root surfaces.

The tips are self-steering and reciprocating with 1.2mm strokes. For children with partially erupted teeth, a special dental tape holder may be available for the Profin contra-angle handpiece. The double-tape design will clean the approximal surfaces subgingivally on both sides of the papilla at the same time.

Professional mechanical toothcleaning should start at the right linguoapproximal surfaces of the mandibular molars because the right-handed average patient usually fails to clean this area properly. In left-handed vice versa procedure. This also reinforces the principle that cleaning should always be started where it is most needed to improve motivation for both the patient and the operator (Fig 37c). Entering the interproximal space the tip will have a 10-degree coronal angle until the papilla is depressed. Because of the resilience of the papilla, a subgingival cleaning effect can be expected at least 2 to 3 mm subgingivally (see Fig 38).



*Fig 37c, PMTC interproximally from the lingual direction on the right mandibular posterior teeth by using the EVA-Profin prophylaxis contra-angle handpiece and the reciprocating triangular-pointed EVA-tip. This should be the first and most important step of needs-related PMTC in a right-handed patient.*



*Fig 38, (Left) Bitewing radiograph of a 50-year-old Scandinavian in 1971. The location of the gingival margin and papillae is marked. Placement of two pointed (wedge-shaped and triangular) EVA-tips is illustrated.*

*(Right) Triangular-pointed tip inserted interdentally. Because of the resilience of the papillae, plaque biofilms can be removed 2-3 mm subgingivally. Delivery of fluoride from prophylaxis paste is also enhanced by depression of the gingival papilla. (Illustration by Waerhaug, courtesy of the University of Oslo.)*

A suitable speed for the contra-angle handpiece is approximately 8,000 rpm (ie 16,000 strokes per minute or 250 per second). At very low speeds, (less than 5,000 rpm), vibration will cause discomfort to the patient. The direction of the tip should continually be adjusted in both the vertical and horizontal directions to reach all the approximal surfaces. At the same time, the fluoride polishing paste is applied to all the cleaned surface. As described previously, PMTC should always commence from the lingual aspect of the mandibular molars, in accordance with how needs-related tooth cleaning by self care should be performed. Thus also a motivating effect on the patient should be achieved. When the approximal surfaces have been carefully cleaned from the fairly easily accessible lingual side, they are then cleaned from the buccal direction. The maxillary interproximal surfaces are cleaned next in the same order: lingual embrasures first and then the buccal embrasures. (for details see Axelsson 1969, 1981, 1993a, 1994, 2004, 2009b).

### *Lingual, buccal and occlusal PMTC*

A regular prophylaxis contra-angle handpiece and a rotating rubber cup are recommended for PMTC on the lingual and buccal surfaces (Fig 35). The same medium-abrasive prophylaxis paste used for approximal PMTC is used for these surfaces also. This step should also start on the surfaces most often neglected by the patient, ie, the right mandibular lingual surfaces. The rubber cup should clean the line angles and the subgingival surfaces also. It is possible to remove plaque to a depth of at least 1 to 2 mm subgingivally. To remove plaque from the fissures of erupting molars in particular, a rotating-pointed brush is used in the prophylaxis contra-angle handpiece.

After meticulous PMTC, plaque-disclosing pellets are used again to ensure that all tooth surfaces are plaque free.

The pellicle functions as a non-frictional layer on the tooth surface. For example, in vivo studies by Saxton (1975) established that it takes approximately 5 minutes per surface to remove the pellicle completely from the tooth enamel using a rubber cup and pumice. With an average treatment time of 3 to 7 seconds for each surface, needs-related professional toothcleaning there is minimal risk of abrasive damage to the tooth surface. However resin composite restorations should not be cleaned with heavy abrasive prophylaxis paste.

If some mineralized plaque remains after the above described PMTC, supplementary scaling instrumentation has to be carried out, which will be discussed later.

During the past 10 years, air polishing devices have been introduced for removal of supragingival plaque and stains (Fig 39a). The instruments are efficient, except on the key-risk surfaces, ie, the approximal surfaces of the molars and premolars, because the buccal and lingual papilla impede access of the abrasive powder. There is also a risk of substantial abrasion on exposed root surfaces and resin composite restorations (Boyde 1984; Horning et al 1987; Weeks et al 1984). However, air abrasion is useful for removing extrinsic stains from enamel – particularly smoking- and chlorhexidine-induced stains (Figs 39b and 39c). Hand instruments, such as curettes, may also supplement the reciprocating and rotating instruments for PMTC to remove partly mineralized plaque in the gingival sulcus or remove deeply located subgingival plaque biofilms. As earlier discussed, this “extended” PMTC procedure is also known as debridement.



Fig 39a, EMS AirFlow air abrasion handpiece (Electro Mecial Systems, Nyon, Switzerland).



Fig 39b, Staining on the lingual surfaces of the mandibular incisors in a heavy smoker before air abrasion.



Fig 39c, Result after airabrasion.

### Preventive Effects of PMTC

After PMTC, re-formation of perceptible complex plaque in the dentogingival region is normally retarded for several days, compared to about 1 to 2 days after oral hygiene measures carried out by the patient. Professional mechanical tooth cleaning should completely remove supragingival plaque from all tooth surfaces and plaque to at least 1 to 3 mm subgingivally; ie, it provides gingival plaque control.

Frequent PMTC also influences the composition of the subgingival microflora and reduces the number of periopathogens (Dahlén et al 1992; Hellström et al 1996; Katsanoulas et al 1992; McNabb et al 1992; Siegrist and Kornman 1982; Smulow et al 1983; Ximénez-Fyvue et al 2000). After subgingival root surface instrumentation, frequent PMTC can prevent recolonization by subgingival microflora (Magnusson et al 1984; Mousqués et al 1980). Some effect could also be expected on caries-inducing pathogens, such as *Streptococcus mutans*, on the approximal surfaces of the molars, which are inaccessible to the toothbrush (Axelsson et al 1987b).

Experimentally, it has been shown that after a single PMTC, the volume of gingival exudate decreased continuously during the first 24 to 28 hours and does not regain the pre-experimental level until 1 week later (Gwinnett et al 1975). Three sessions of PMTC, at 2-day intervals will normally induce healing of inflamed gingivae within 1 week. Indirectly, this results in a reduction in plaque formation rate. Studies have shown that the reaccumulation rate of gingival plaque is directly correlated to the degree of gingival inflammation (Axelsson 1987; Ramberg et al 1995a) and the quantity of gingival exudate (Saxton 1975). Therefore, frequent initial PMTC, followed up at needs-related intervals in the maintenance program, enhances the patient's own oral hygiene efforts by removal of mature, partially mineralized plaque and reduces the rate of formation of new plaque.

The flouride ions in the prophylaxis paste gain access to the cleaned approximal surfaces, even subgingivally, increasing the potential for remineralization of enamel caries and root caries on these key-risk surfaces. This reduces the risk for future plaque-retentive factors such as secondary caries, restoration overhangs, and unfinished subgingival margins.

Professional mechanical toothcleaning may also be expected to have a strong patient-motivating effect if it is carried out in a needs-related fashion, similar to how oral hygiene procedures should be carried out from cost/effectiveness point of view in "tooth-brushing populations". That means starting to clean the approximal surfaces of the posterior teeth – the "key risk surfaces" – before the remaining buccal and lingual surfaces – the "low or non risk" surfaces are cleaned. The patient experiences PMTC as a positive treatment form and attempts to maintain the feeling of cleanliness with his or her own efforts (Glavind 1977).

## CHAPTER 5

### *Effect of Mechanical Plaque Control by Self Care and PMTC on Caries, Gingivitis and Periodontitis*

#### *Effect of PMTC on Caries and Gingivitis in Children and Young Adults*

Although the preventive effect of mechanical plaque control programs on gingivitis and periodontitis is generally accepted, the preventive effect of mechanical plaque control on the development of caries has been questioned. Therefore, a series of longitudinal plaque control programs, including PMTC, were initiated to test the effect of mechanical plaque control on gingivitis and dental caries in schoolchildren.

In 1971, a longitudinal clinical trial (Axelsson and Lindhe 1974, 1977) was initiated to test the hypothesis that gingivitis and dental caries do not develop in schoolchildren maintained on an oral hygiene program that includes PMTC and oral hygiene education once every 2 weeks. The subjects were 216 children, aged 7 to 8, 10 to 11 and 13 to 14 years at the beginning of the study. All children were from the same elementary school in the city of Karlstad, Sweden, and had the same socioeconomic background. All were randomly assigned to a test or a control group that means a RCT study.

During a 4-year period, a preventive dentistry assistant carried out PMTC on the test group 16 times a year for the first 2 years and then 4 to 6 times a year for the following 2 years. The control group received ordinary dental treatment once a year, supervised toothbrushing instructions, using the Bass method, and fluoride rinsing 10 times a year for the entire trial period. Thus, there were no true negative controls. For ethical reasons, the subjects in the control group were maintained on the regular dental care schedule.

Fig 40a shows the effect of treatment on the amount of plaque according to the Silness and Løe Plaque Index (PI), and the development of gingivitis according to the Løe and Silness Gingival Index (GI). There were no differences between the two groups at baseline. After 1 year, there was a marked reduction in both plaque and gingivitis in the test group, but in the control group, PI and GI remained persistently high. The test group succeeded in maintaining low scores for the following 3 years, but the high plaque and gingivitis scores in the control group did not improve.

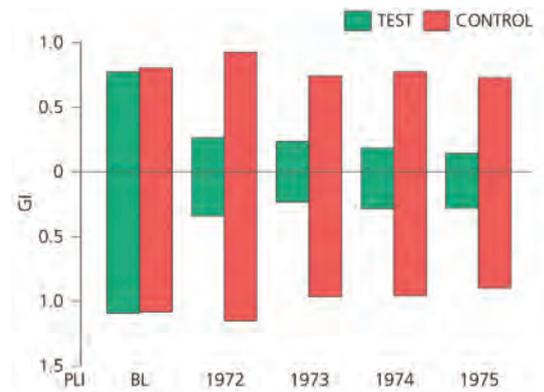


Fig 40a, Diagram representing annual variation of mean Gingival Index (GI) and mean Plaque Index (PI) of the test- and control-group children. The average values for groups 1, 2, and 3 have been used. (BL) Baseline. (Modified from Axelsson and Lindhe 1977, with permission.)

More pronounced was the effect on the development of dental caries (Fig 40b). During the entire 4-year trial, the test group developed only 62 new decayed or filled surfaces in all, while the control group developed 941 (Axelsson and Lindhe 1974, 1977).

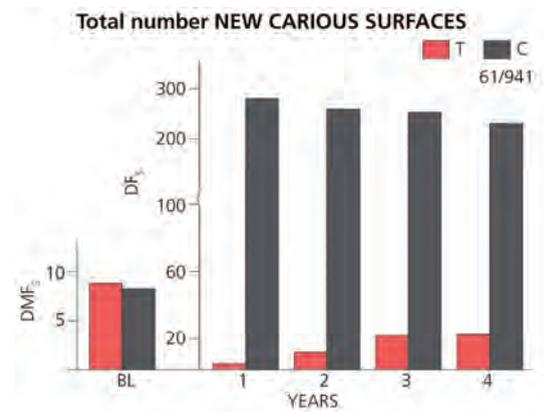


Fig 40b, The mean number of new decayed or filled surfaces (DFSs) in the three control groups compared to the three test groups during the 4-year trial. (DMFSs) Decayed, missing or filled surfaces; (BL) Baseline. (Modified from Axelsson and Lindhe 1977 with permission.)

The long-term benefits of this early introduction of a program of meticulous mechanical plaque control on dental caries (Figs 40c to 40f) and standard of self-performed oral hygiene and gingival health (Figs 40h to 40l) should not be underestimated. Fig 40g shows a typical status of the control group at the age of 19. The long-term caries preventive effect of initial frequent PMTC in young children was later reconfirmed in another Swedish study (Klock 1984).



Fig 40c, Patient in preventive dentistry test group at baseline, aged 7 years.



Fig 40d, The Patient in 40c at the age of 18 and still no more DF-s.



Fig 40 e, A high caries risk patient at the age of 7 with advanced caries cavities in the primary dentition



Fig 40f, Patient shown in Fig 40e, aged 12 years. All permanent teeth are caries free.



Fig 40g, Typical patient in control group, aged 18 years. All the permanent premolars and molars have restorations.



Fig 40h-40l, Typical excellent standard of oral hygiene and gingival health in 5 subjects of the youngest test group (7 years old at baseline) at the age of 18 years (7 years after the study was finished).



Fig 40i



Fig 40j



Fig 40k



Fig 40l, This pioneer study in school children was followed up with some more randomized controlled studies (RCT) in order to compare the separate effect of PMTC on caries with other preventive measures such as oral hygiene training, chemical plaque control and topical use of fluorides. (Axelsson et al 1976, Axelsson & Lindhe 1981c).

The first Karlstad study, based on PMTC, aroused interest in other countries such as Norway, Denmark, Great Britain and Brazil. Researchers in these countries also followed up by carrying out PMTC-based studies, most of which had results similar to those of the original study (Agerbaek et al 1977; Gisselsson et al 1980; Hamp et al 1978, 1982; Kjaerheim et al 1980; Klimek et al 1985; Karlsson and Larsson 1976; Klock and Krasse 1978; Poulsen et al 1976; Talbott et al 1977; for reviews see Axelsson 1981, 1993a, 1994, 2004; Bellini et al 1981; Gjermo 1986; and Hotz 1998). The only study that failed to reveal a significant effect was that carried out by Ashley and Sainsbury (1981) in 100 schoolchildren with very low caries incidence. For cost effectiveness, it is important that, under field conditions, the frequency of PMTC be based on individual needs (Axelsson 1998, 2004).

Table 1 presents a review of the caries-preventive effect of PMTC in different clinical studies. Direct comparison of the studies is difficult because they differ in frequency of PMTC, concomitant preventive measures, caries prevention in the control groups, and caries risk in the selected populations. All PMTC trials included use of fluoride prophylaxis paste, fluoride rinsing after PMTC, or application of fluoride varnish at least twice a year. With one exception (Westergaard et al 1978), caries reductions in the test groups were always more than 40% (41% to 97%). This remarkable caries-preventive effect achieved by PMTC contrasts with the modest achievements attained by supervised toothbrushing. In several of the trials, subjects in the control groups were also in a fluoride program. Nevertheless, the test groups showed significant caries reduction compared to the “positive” control groups, confirming that meticulous professional mechanical plaque control (PMTC), is an efficient caries-preventive measure.

For comparison the following caries reductions may be achieved based on meta analyzes of randomized controlled trials (RCT) and at least controlled trials:

- 1) Frequent Professional Mechanical Tooth Cleaning (PMTC) - 60-90%
- 2) Needs Related Mechanical Tooth Cleaning by self care - 50%
- 3) Chemical Plaque Control – 45%
- 4) Fluoride Toothpastes – 20-30%
- 5) Fluoride Varnishes – 20-30%

Thus it may be concluded that frequent complete mechanical removal of cariogenic plaque is most efficient as “clean teeth never decay” followed by chemical plaque control with chlorhexidine (CHX). Causative prevention by mechanical and chemical plaque control is superior to fluoride. However, topical use of fluoride is also an important caries preventive method by enhancing remineralization and retarding demineralization.

*Table 1*

*The caries-preventive effects shown in professional mechanical toothcleaning (PMTTC) trials\**

Frequency of cleaning <sup>†</sup>	Control <sup>^</sup>	Annual caries increment (New DS)		Caries reduction	Age group (Y)	Length of trial (Y)	Study
		Test	Control				
Every 2 wk (F)	F rinse, OHI	2.06	2.38	13%	5-13	2	Westergaard et al (1978)
Every 2 wk (F) (half mouth)	OHI	0.6 §	2.6 §	77%	13-14	1.5	Axelsson & Lindhe (1981a)
Every 2 wk (F)	F rinse, OHI, monthly (F)	0.1	3.0	96%	7-12	2	Axelsson & Lindhe (1974)
Every 3-4 mo (F)	F rinse, OHI, monthly (F)	0.15	3.0	95%	9-14	2	Axelsson & Lindhe (1978)
Every 2 wk (F)	F rinse, OHI, monthly (F)	0.18	2.75	90%	13-16	2	Karlsson & Larsson (1976)
Every 2 wk (øF)	0,5% CHX gel every 2 wk (øF)	0.4	4.3	90%	13-14	1	Axelsson et al (1976)
Every 2 wk (F)	F rinse OHI (F)	0.94	3.40	73%	9-12	2	Klock & Krasse (1978)
Every 2 wk (F)	OHI (F)	0.43	1.42	70%	7	1	Poulsen et al (1976)
Every 3 wk (F)	F rinse 2wk	2.10	4.26	51%	7-16	3	Hamp et al (1978)
Every 3 mo (F)	OHI (F)	1.2	3.0	60%	17-19	3	Malmberg (1976)
Every 6 mo (y3)	None	0.33	1.10	70%	16-19	3	Hamp & Johansson (1982)
Monthly (øF) <sup>†</sup>	Placebo	1.6	2.7	41%	13-14	2	Zickert et al (1982)
Every 3 mo (øF) <sup>†</sup>	Placebo	1.9	3.5	43%	13-14	2	Zickert et al (1982)
Every 2 mo (F) <sup>††</sup>	F brushing	0.26#	0.11#	57%	6-8	2	Kaerheim et al (1980)
	F brushing	0.15#	0.66#	78%	10-12	2	Kaerheim et al (1980)
	F brushing	0.66#	1.48#	54%	13-15	2	Kaerheim et al (1980)
Every 2 mo (øF)**	None	1.35	2.50	46%	12-14	2	Klimek et al (1985)
Every 2 mo (F) <sup>††</sup>	None	0.57	1.43	60%	7-8	3	Kerebel et al (1985)
Every 2-3 mo (F)	None	0.07	2.47	97%	<35	6	Axelsson & Lindhe (1981a)
	None	0.07	1.80	96%	36-50	6	Axelsson & Lindhe (1981a)
	None	0.07	1.40	95%	>50	6	Axelsson & Lindhe (1981a)
Every 6 mo (F) <sup>^^</sup>	F water	0.35	0.89	61%	5-12	5	Bagramian (1982)
Yearly <sup>††</sup>	None	0.32	1.02	69%	11-12	6	Lallo & Solanski (1994)

\*Data from Axelsson (1981) and Hotz (1998).

<sup>†</sup> (F) Fluoride; (øF) No fluoride.

<sup>^</sup> (OHI) Oral hygiene instruction

§ 18 months

<sup>†</sup> Fluoride rinse after cleaning

# Without occlusal surface

\*\* Fluoride varnish every 6 months

<sup>††</sup> Daily toothbrushing with fluoride paste (additionally)

<sup>^^</sup> Fluoride water, sealants

### *Effect of Frequent PMTC on Periodontal Health and Subgingival Microflora in Adults*

Gingival plaque control has been considered to have little effect on the subgingival microflora of deep periodontal pockets. However, this may not apply to moderately deep pockets (4 to 6 mm), which may represent an intermediate pathologic state between gingivitis and advanced marginal periodontitis. In a study by McNabb et al (1992), the subjects had poor oral hygiene and severe gingival inflammation. Four matched sites (one in each quadrant) that harbored at least 20% spirochetes and 15% black-pigmented gram-negative bacilli were selected. During the first 12 weeks (phase 1), supragingival calculus was removed from the right half of the mouth and then the teeth were cleaned by PMTC three times a week. At the beginning of phase 2, supragingival calculus was also removed from the left quadrants, and the entire mouth was subjected to the same protocol used in phase 1. At no time did patients receive oral hygiene instruction. Clinical variables were assessed and microbiologic samples were taken at 3-week intervals.

Significant changes occurred in the composition of the subgingival microflora at cleaned sites. While gram-positive organisms increased proportionally, the number of putative periodontal pathogens, such as *Porphyromonas gingivalis* and spirochetes, decreased. Both PI and GI scores also decreased during the total experimental period of 30 weeks (Mc Nabb et al 1992).

In a study by Katsanoulas et al 1992, the effect of mechanical gingival plaque control by PMTC on the composition of the subgingival microflora in untreated 4- to 6-mm-deep periodontal pockets was investigated in subjects with chronic periodontitis. Periodontally diseased sites were subjected to PMTC three times weekly for 3 weeks. Contralateral sites received no prophylaxis and served as controls. No instructions in oral hygiene procedures were issued; the patients continued with their usual oral hygiene routines during the observation period. Clinical examination and darkfield microscopic analysis of bacterial samples were performed every week.

The PI scores decreased markedly for the experimental sites but remained unchanged for the control sites throughout the observation period. The composition of the subgingival microflora at the control sites did not change during the experimental period. At the test sites, the proportion of spirochetes and motile rods decreased continuously. The results indicate that, at periodontally diseased sites with an established subgingival ecosystem, gingival plaque removal may influence the composition of the subgingival microflora (Katsanoulas et al 1992).

The effect of meticulous gingival plaque control by PMTC on the subgingival microbiota has also been investigated in a long-term study (Dahlén et al 1992), in which 300 subjects were examined for periodontal disease and monitored, without treatment, for 2 years. After the 2-year examination, 80 subjects were invited to participate in a treatment program intended to

improve the standard of plaque control. Of these 80 subjects, 40 had gingivitis and only minor attachment loss, and 40 had moderate periodontitis, 23 with several sites with deep pockets (greater than 4 mm).

After the clinical examination, samples of the subgingival microbiota were harvested. The patients were then recalled for oral hygiene training and PMTC at needs-related intervals. Two years after the year 2 examination, the subjects were reassessed clinically and microbiologically.

The findings demonstrated that meticulous gingival plaque control changes the quantity and the composition of the subgingival microbiota. Two years after initiation of the improved gingival plaque control programs, the total viable counts of bacteria in both deep and shallow pockets were markedly reduced. The number of subjects and sites harboring periodontogens such as *P. gingivalis* and *Aggregatibacter actinomycetemcomitans* had also decreased markedly between years 2 and 4 (Dahlén et al 1992).

Hellström et al (1996) investigated the possible influence of careful PMTC on the subgingival microbiota at periodontal sites with suprabony, infrabony, or furcation pockets. None of the participants in the study had undergone periodontal therapy during the previous 12 months or used antibiotics during the 3 months preceding the study. Following a screening examination, 6 to 8 sites per subject were selected, all with probing depths greater than 5 mm: 1 to 3 sites with infrabony lesions, and 1 to 3 sites with furcation defects. For each of these sites, a bacterial sample was taken and the following variables were recorded at baseline: plaque, gingivitis, probing depth and probing attachment level. The case findings were then presented to each subject, followed by thorough supragingival scaling, and instruction in proper plaque control with a toothbrush and a dentifrice. During the subsequent 30 weeks, the subjects were recalled two or three times a week for PMTC by a dental hygienist, about 15 minutes per session. The subjects were reexamined after 30 weeks.

The findings indicated that PMTC, combined with careful self-performed plaque control, had a marked effect on the subgingival microbiota of moderate-to-deep periodontal pockets. Thus, at sites with suprabony and infrabony pockets, as well as at furcation sites, the meticulous, prolonged gingival plaque removal by frequent PMTC reduced the total number of microorganisms that could be harvested, as well as the percentage of sites with *P. gingivalis* (Hellström et al 1996).

Ximénez-Fyvie et al (2000) reported a study on the effect of repeated gingival PMTC on the composition of the supra- and subgingival microbiota. Eighteen adult maintenance subjects with periodontitis were clinically and microbiologically examined at baseline examination, the subjects initially received scaling and root planing followed by PMTC every week for 3 months. Clinical measures of plaque accumulation – bleeding on probing (BOP), gingival redness, suppuration, pocket depth, and attachment level – were carried out at 6 sites per tooth at each visit.

Separate supragingival (n = 1,804) and subgingival (n = 1,804) plaque samples were taken from the mesial aspect of all teeth in each subject at each time point and evaluated for their content of 40 types of bacteria using a checkerboard DNA-DNA hybridization technique.

The results showed that the mean percent of sites exhibiting plaque, gingival redness, and BOP were significantly reduced during the course of the study. Significant decreases in mean bacterial counts were observed in both supra- and subgingival samples and maintained 9 months after the 3-month treatment period. For example, at baseline, 3, 6 and 12 months respectively, the subgingival samples contained a mean count (x10<sup>5</sup>) of 2.0, 0.4, 0.4 and 0.1 of *Tanerella forsythia* (P <.001); and 3.4, 0.8, 0.4 and 0.3 of *Treponema denticola* (P <.01). Similar reductions were also seen in supragingival samples. While counts were markedly reduced by PMTC, the proportions of the 40 test species were only marginally affected (Fig 40).

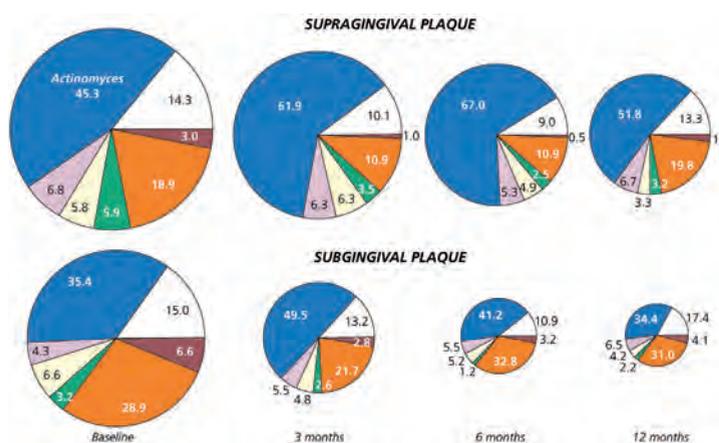


Fig 40, Pie charts of the mean DNA probe count (%) of microbial groups in supra- and subgingival plaque samples at baseline 3, 6 and 12 months. The species were grouped into microbial groups based on the description by Socransky et al (1998). The areas of the pies were adjusted to reflect the mean total counts at each of the time points relative to the mean count at baseline for the supragingival and subgingival plaque samples. (From Ximénez-Fyvie et al 2000. Reprinted with permission.)

In conclusion, the study showed that PMTC profoundly diminished counts of both supra- and subgingival bacterial species, creating a microbial profile comparable to that observed in periodontal health. This profile was maintained at the final examination, 9 months after completion of weekly PMTC.

Frequent PMTC also has been successfully used in maintenance programs following initial nonsurgical or surgical treatment of marginal periodontitis. In a study by Rosling et al (1976), patients with a high prevalence of infrabony pockets were randomly allotted to a test or

a control group. After initial open flap surgery, scaling and root planing, the test group received PMTC every 2 weeks for 2 years. At the re-examination, about 95% of the infrabony pockets had healed, and the condition of the gingiva was excellent. Among the patients in the control group there were some nonresponders with very significant loss of periodontal attachment and some lost teeth (Nyman et al 1977). In an investigation by Nyman et al (1975) of 20 surgically treated patients with advanced periodontitis, an experimental group subsequently received thorough PMTC and oral hygiene education every 2 weeks; no further clinical loss of attachment could be demonstrated after 2 years. The patients in the control group received the same initial treatment, including surgery, and were recalled for debridement and scaling 6 months postoperatively; but no other attempts were made to maintain gingival plaque control. After 2 years, the control patients exhibited an average clinical loss of attachment of about 2 mm. This very rapid periodontal destruction suggests that, in the absence of proper supportive care based on excellent gingival plaque control, periodontal surgery may in fact do more harm than good. At the re-examination, about 95% of the intrabony pockets had healed in the test group and the condition of the gingival health was excellent. Among the patients in the control group there were some non-responders with very significant loss of periodontal attachment and some lost teeth (Nyman et al 1977).

In a split-mouth study, Lindhe et al (1984) found excellent healing of marginal periodontitis, irrespective of the initial treatment method – nonsurgical or different types of flap surgery – when this was followed by frequent PMTC for 2 years.

Even in patients with aggressive periodontitis, no recurrence was observed over a 5-year period when initial nonsurgical or surgical treatment was followed by frequent PMTC during the first 2 years (Wennström et al 1986).

In a split-mouth study of flap surgery, one test quadrant was scaled and all root cementum was removed, exposing root dentin. The root surfaces of the contralateral quadrant were carefully cleaned by PMTC; visible calculus was gently removed with a curette, and removal and planing of cementum were avoided. The flaps were then replaced and sutured. The patients received PMTC every 2 weeks for 24 months. The same gain in clinical probing, attachment was observed with both methods, indicating that, when excellent gingival mechanical plaque control is maintained, remaining “diseased” root cementum and possibly some calculus will not interfere with healing (Nyman et al 1988).

### Effect of combined self-care, PMTC, and debridement on periodontitis

Magnusson et al (1984) observed that, in the presence of supragingival plaque, a subgingival flora with large numbers of motile rods and spirochetes re-formed in 4 to 8 weeks, whereas sustained reductions in motile rods and improved periodontal conditions were achieved following scaling plus supervised oral hygiene and PMTC. Similarly, Sbordone et al (1990) reported that subgingival debridement without gingival plaque control was insufficient to maintain a healthy subgingival microflora.

Axelsson and Lindhe (1981b) also demonstrated the value of a carefully designed maintenance program, based on meticulous gingival plaque control by selfcare and PMTC, for patients who had been treated for advanced periodontal disease: 77 patients were examined before treatment, 2 months after the last surgical procedure, and after 3 and 6 years. Two thirds (52) of the patients were placed on a supervised maintenance program that included oral hygiene education, meticulous PMTC, and needs-related debridement every 2 months for the first 2 years and every 3 months for the last 4 years of the observation period (re-call group). The remaining (25) patients resumed care by the referring dentist, who was informed of the importance of checking their oral hygiene, calculus formation, and gingival and periodontal conditions (nonrecall group).

The data from the second examination showed the positive effect of the initial treatment in both groups. Subsequently, the recall patients were able to maintain excellent gingival health and unaltered attachment levels as an effect of proper oral hygiene and supportive PMTC. In the nonrecall group, plaque scores increased markedly from baseline values, as did the number of inflamed gingival units (Fig 41). Concomitantly, there were obvious signs of recurrent periodontitis. The mean values for probing depth and attachment levels at the 3- and 6-year examinations were higher than at baseline (Fig 42). Approximately 99% of the tooth surfaces showed improvement, no change, or less than 1 mm of attachment loss in the recall group compared to 45% in the non-recall group. In the latter group, 55% of the sites showed 2 to 5 mm of further attachment loss at the 6-year examination, and 20% of the pockets were more than 4 mm deep (Axelsson and Lindhe 1981b).

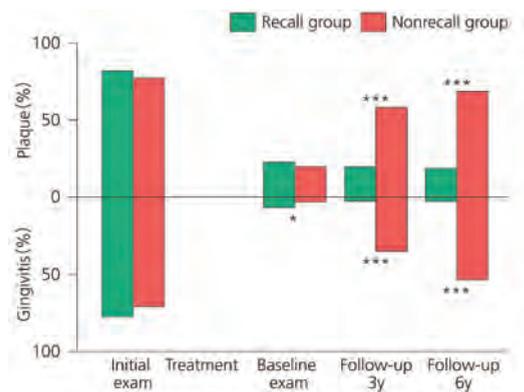


Fig 41, Percentage of tooth surfaces with plaque and inflamed units in the two groups of patients at the initial, baseline, and follow-up (3 and 6 years after the baseline) examinations. \* $P < .05$ ; \*\*\* $P < .001$ . (Modified from Axelsson and Lindhe 1981b, with permission.)

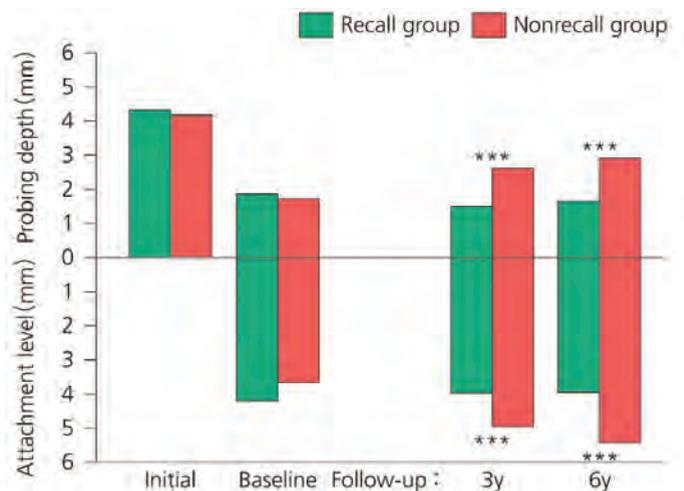


Fig 42, Individual mean pocket (probing) depth and probing attachment level data from the initial, baseline and follow-up (3 and 6 years after the baseline) examinations. \*\*\* $P < .001$ . (Modified from Axelsson and Lindhe 1981b, with permission.)

### Effect on tooth loss, periodontal disease and dental caries in adults

The overall goals for maintenance programs in randomized samples of adults should be to prevent tooth loss and the recurrence of dental caries and periodontitis after initial active treatment of the diseases, ie, secondary prevention and control. However, for cost effectiveness, such programs must be based strictly on individual needs.

There are few longitudinal clinical studies in adults on prevention of recurrence of both periodontal disease and dental caries. In 1971 to 1972, a clinical study was initiated in the city of Karlstad, in the county of Värmland, Sweden, to determine whether the development of caries and the progression of periodontitis could be prevented in adults and whether a high level of mechanical plaque control could be maintained by regularly repeated self-care education based on self-diagnosis, PMTC, and needs-related subgingival debridement. An attempt was also made to study the progression of dental disease in individuals who did not receive special self-care education but who regularly received conventional dental care. Two groups of subjects from the same region were recruited for the study.

Of these, 375 were assigned to test groups and 180 to control groups, stratified by age: 20 to 35 years (group 1), 36 to 50 years (group 2), and 51 to 65 years (group 3). The baseline examination included the following variables:

1. Plaque index (% according to O'Leary)
2. Gingival and pocket bleeding indices (%)
3. Community Periodontal Index of Treatment Needs (CPITN): probing pocket depth (mm), calculus and restoration overhangs
4. Clinical probing attachment loss (PAL)
5. Alveolar bone loss
6. Numbers of decayed, missing, or filled teeth and surfaces
7. History taking: eg, general diseases, medications, socioeconomic condition, body mass index, lifestyle, dental care and oral hygiene habits, and dietary and smoking habits

During the first 6-year period, the control patients were examined regularly once a year for conventional dental care. After initial scaling and root planing, and caries treatment the test group participants were recalled once every other month during the first 2 years and once every third month during the following 4 years of the study for education in selfcare, PMTC and needs-related subgingival debridement by a dental hygienist.

The oral hygiene education program was based on emphasis on self-diagnosis and interproximal cleaning with wooden, triangular-tipped toothpicks and fluoride toothpaste on the approximal surfaces of the posterior teeth. At each visit, a plaque-disclosing pellet was used to detect any residual gingival plaque (Fig 43a). Supplementary interdental probing was used for the posterior teeth. After discussion with the patient about any sites with residual plaque, needs-related PMTC was carried out. The first step after plaque disclosure was the application by syringe of fluoride-containing prophylaxis paste to the interdental areas of the mandibular posterior teeth (Fig 43b). This was followed by careful approximal PMTC with the Profin prophylaxis contra-angle handpiece and reciprocating flexible pointed EVA tips (Fig 43c). The PMTC usually also included use of a rotating rubber cup and prophylaxis paste, particularly on the lingual surfaces of the mandibular posterior teeth, and was supplemented, as necessary, by non invasive subgingival debridement or topical application of fluoride to specific keyrisk surfaces.



Fig 43a, Plaque disclosed before PMTC.



Fig 43b, Application of fluoride prophylaxis paste by using a syringe interdentally between right mandibular posterior teeth.

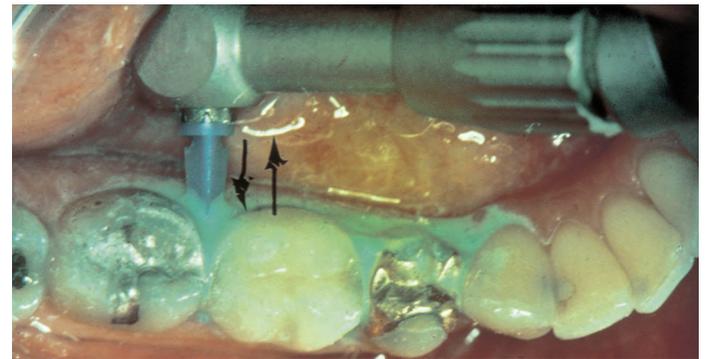


Fig 43c, Mean number of new DSs per subject per 6 years in the control groups compared with the test groups. Modified from Axelsson and Lindhe 1981a with permission.)

The subjects were re-examined toward the end of the third and sixth years of the study. Figs 43d illustrate the mean values of caries incidence (new carious surfaces) and marginal periodontal incidence (vertical loss of attachment), respectively, for the test and control groups over 6 years. After 6 years, the number of new carious surfaces per subject was 14.0 in the control groups and only 0.2 in the test groups. On average, patients in the control groups lost 1.2 mm of periodontal attachment during the 6-year period, while those in the test groups had an average gain of 0.2 mm. It is important to note, however, that most of the subjects and sites in the control groups did not loose any or very limited periodontal attachment; the mean data reflect that there were a number of extreme “downhill” cases and sites (Axelsson and Lindhe 1981a).

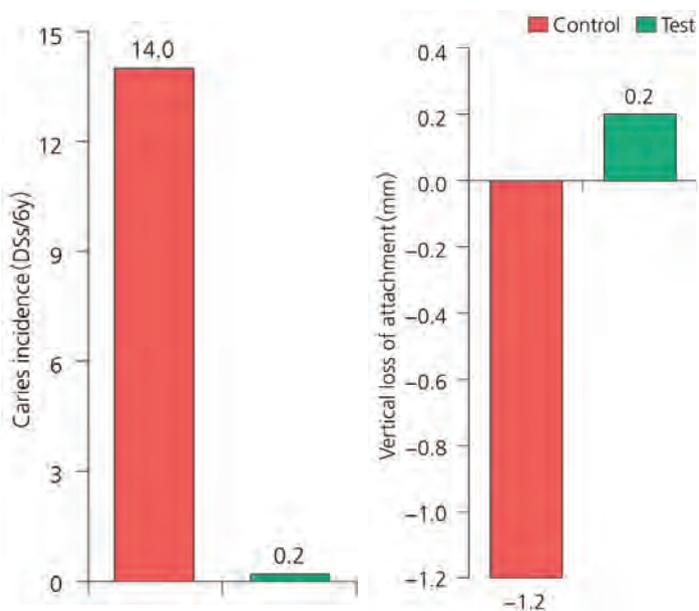


Fig 43d, Mean number of new caries lesions per subject during 6 years. Mean probing attachment loss per subject per 6 years in the control and mean probing attachment gain per subject per 6 years in the test groups. (Modified from Axelsson and Lindhe 1981a with permission.)

After the 6-year re-examination, the control groups were disbanded: for ethical reasons, these subjects were also offered needs-related preventive programs, and most accepted. The few subjects in the test groups who developed new caries lesions and/or lost periodontal attachment during the 6-year period were classified as high-risk or at-risk individuals for caries and/or periodontitis.

During the following years, up to 15- and 30-year re-examinations, all subjects in the test groups received a needs-related maintenance program from the same dental hygienist. To ensure maximum cost effectiveness, the recall intervals, as well as the preventive measures used, were based strictly on individual need. Approximately 60% visited the dental hygienist only once a year, 30% twice a year, and 10% (the at-risk and high-risk individuals) 3 to 6 times a year; the average annual number of visits for age groups 1, 2, and 3 was 1.2, 1.5, and 1.8 respectively.

They were re-examined by a dentist on an average of only once every 3 to 4 years, including the compulsory 15- and 30-year re-examinations.

At the 15- (1987) and 30-year (2002) re-examinations, 317 and 258, respectively, of the original 375 test subjects from the baseline examination in 1972 were available for re-examination. Less than 10 subjects were unwilling to continue in the study, confirming high patient acceptance of the maintenance program. The main reason for drop-outs in group 1 (50 to 65 years of age in 2002) and group 2 (66 to 80 years of age in 2002) was moving to other areas of Sweden. In group 3 (81 to 95 years of age in 2002), most drop-outs were a result of death. Only 0.2 teeth per individual were lost over 15 years (70% because of root fractures). During the same period, it was estimated that the randomized samples of the Swedish adult population lost, on average, three teeth per individual (Håkansson 1991) (Fig 43f).

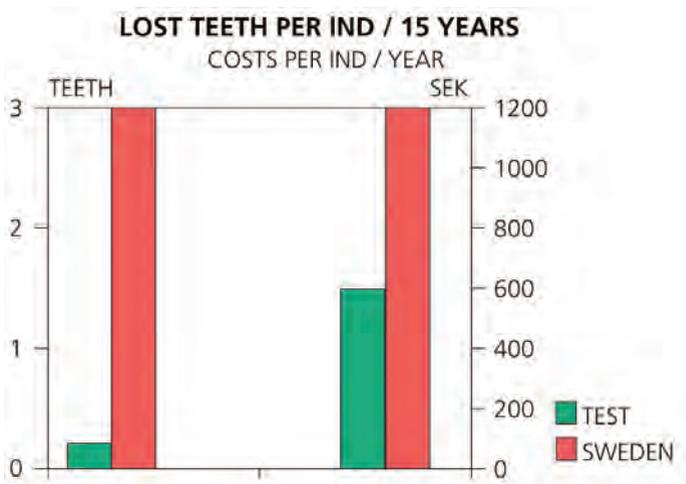


Fig 43f, Mean number of lost teeth per subject per 15 years (left) and the mean yearly cost for dental care (right) in the test groups compared to randomized samples of adult Swedes. (Modified from Axelsson et al 1991 with permission.)

From 1978 until 1987, the total cost per individual per year in the test groups was approximately 50% of the cost per Swedish adult recall patient (see Fig 43f). From 1978 until 1987, the mean treatment time by a dentist (including examination) was less than 20% of the average for recall patients in Sweden (Axelsson et al 1991).

#### Effect on plaque values

As an effect of self-care education based on self-diagnosis, supplemented with needs-related intervals of PMTC, stained plaque was almost non-existent at the 30 year re-examination compared to the baseline examination (Fig 43g).

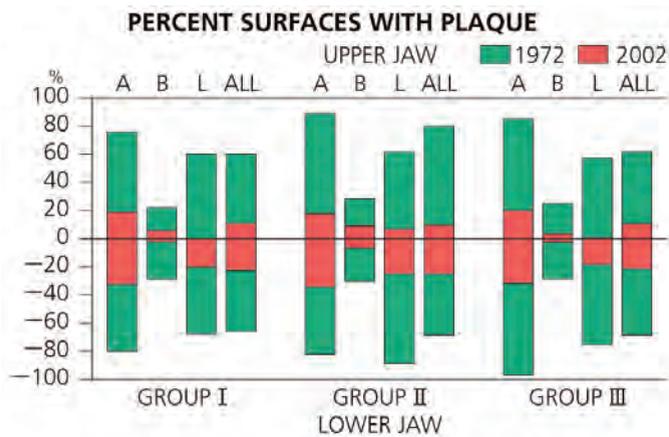


Fig 43g, Percentage of disclosed plaque on approximal (A), buccal (B), lingual (L), and mean values for all tooth surfaces in the maxilla and mandible in 1972 and 2002 in age groups 1, 2, and 3. (Modified from Axelsson et al 2004 with permission.)

**Effect on tooth loss**

Fig 43h shows the mean number of teeth per individual in age groups 1, 2 and 3 and in all groups at the baseline examination in 1972 and the 30-year re-examination in 2002. Because the third molars were excluded, the maximum number of teeth is 28. At the 30-year re-examination, groups 1, 2, and 3 were 50 to 65, 66 to 80, and 81 to 95 years old.

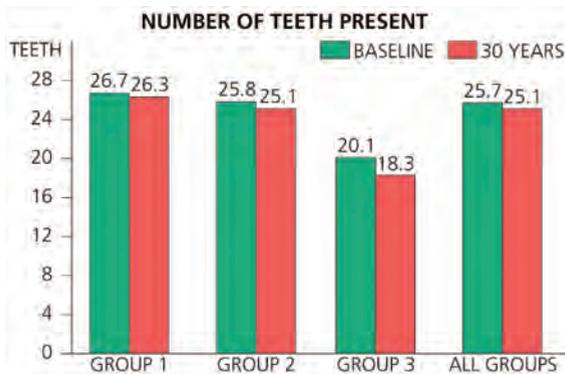


Fig 43h, Mean number of teeth (third molars excluded) per individual in age groups 1, 2 and 3 and all groups at the baseline examination and the 30-year re-examination. (Modified from Axelsson et al 2004 with permission.)

As an average, groups 1, 2, and 3 lost only 0.4, 0.7 and 1.8 teeth per subject respectively. About 70% of these few lost teeth were lost because of root fractures in teeth with posts. In comparison, randomized samples of 45- to 50-year-old Swedes lost almost 3 teeth per subject per 11 years (ie, almost 10 teeth per 30 years) (Håkansson 1991). Almost 75% of subjects in group 1 and 60% in group 2 did not lose a single tooth, and 15% to 20% lost only one tooth during the 30-year trial (Fig 43i).

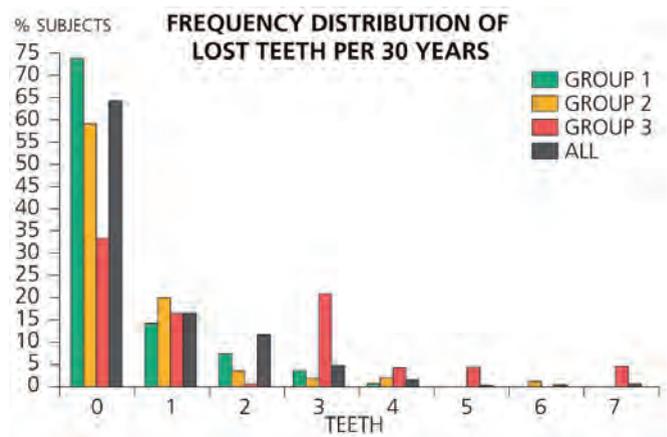


Fig 43i, Frequency distribution of lost teeth per 30 years in age groups 1, 2 and 3 in all groups. (Modified from Axelsson et al 2004 with permission.)

In contrast, among a randomized sample of adults in the county of Stockholm, Sweden, during the 20 years from a mean age of 35 years to 55 years, the mean number of lost teeth was 5 (ie, 7.5 lost teeth per subject per 30 years). Only 27% did not lose any teeth, 38% lost 1 to 2 teeth, 18% lost 3 to 4 teeth, 7% lost 5 to 6 teeth, 3% lost 7 to 8 teeth, 15% lost 9 to 16 teeth, and 2% lost more than 16 teeth (Jansson et al 2002).

For ethical reasons, the control groups were offered needs-related preventive dentistry after 6 years; therefore, the baseline data of group 3 (51 to 65 years old in 1972) were used as a cohort control group to group 1 (50 to 65-year-old in 2002) at the 30-year examination. Fig 43j shows that 50- to 65-year-old subjects in 2002 (group 1) exhibited an average of 26.3 remaining teeth compared to only 20.1 in 50- to 65-year-old subjects in 1972. The frequency distribution of remaining teeth in 50- to 65-year-old subjects in 1972 compared to 2002 is shown in Fig 43k. Only 40% of the 50- to 65-year-old subjects in 1972 exhibited 25 to 28 remaining teeth compared to about 85% in 50- to 65-year-old subjects in 2002. Fig 43l illustrates the pattern of remaining teeth (%) in 50- to 65-year-old subjects in 1972 compared to 2002.

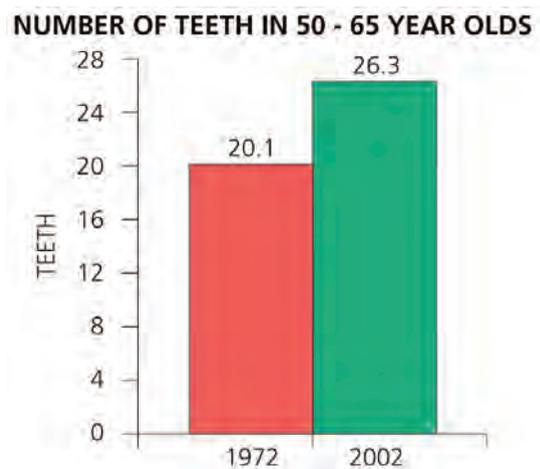


Fig 43j, Mean number of remaining teeth in 50- to 65-year-old subjects in 1972 compared to 2002. (Modified from Axelsson et al 2004 with permission.)

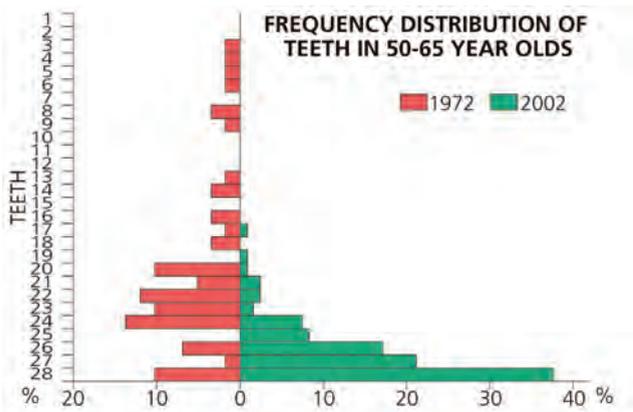


Fig 43k, Frequency distribution of remaining teeth in 50- to 65-year-old subjects in 1972 compared to 2002. (Modified from Axelsson et al 2004 with permission.)

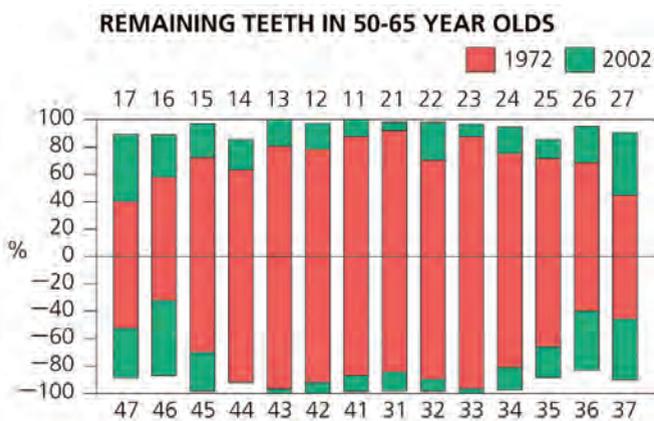


Fig 43l, Mean percentage of remaining individual teeth (Fédération Dentaire Internationale [FDI] tooth-numbering system) in 50- to 65-year-old subjects in 1972 compared to 2002. (Modified from Axelsson et al 2004 with permission.)

**Effect on dental caries**

Fig 43m shows the mean values of new carious surfaces per subject per 30 years (primary as well as recurrent caries lesions). In each group, recurrent caries predominated.

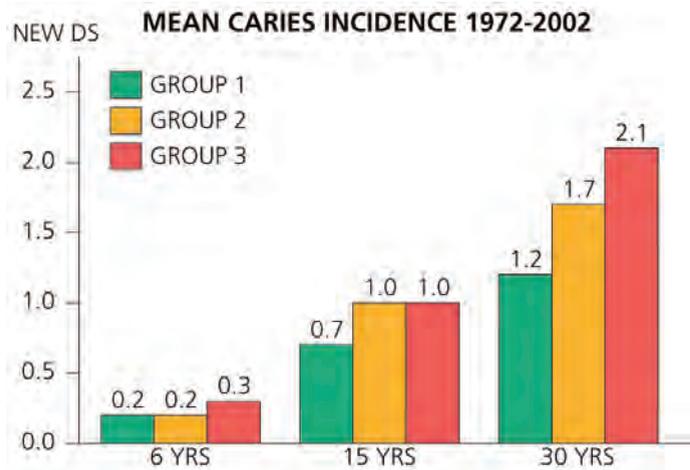


Fig 43m, Mean caries incidence after 6, 15 and 30 years, by age group (Group 1) 50-65 years; (Group 2) 66-80 years; (Group 3) 81-95 years. (DS) decayed surfaces. (Modified from Axelsson et al 2004 with permission.)

Fig 43n shows the the frequency distribution of new caries lesions. Of 257 subjects, 107 developed no new caries lesions, 47 developed only one new caries lesion, and 47 developed two new caries lesions. Only 10 subjects exhibited >6 new DS. In this context it must be realized that Swedish subjects who are not enrolled on preventive programs, experience a much higher incidence of caries than carefully maintained patients. Thus, Fure (2003) showed that in randomized samples of 55-, 65- and 75-year-olds from the city of Göteborg, Sweden, the average number of new coronal DF surfaces during a 10-year interval were 6.0, 3.8 and 1.8 while the mean number of root caries lesions in the same period amounted to 5.5, 8.1 and 14.3 respectively in the three age groups.

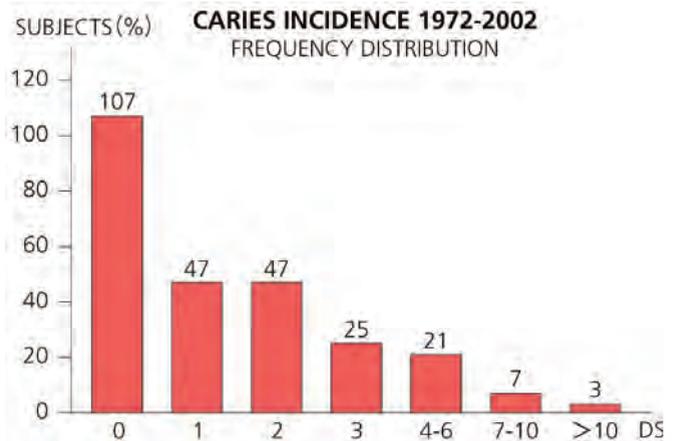


Fig 43n, Frequency distribution of new DFs among the 257 subjects from 1972 to 2002. (Modified from Axelsson et al 2004 with permission.)

The percentage of intact, decayed and filled and missing surfaces in 50- to 65-year-old subjects in 1972 compared to 2002 is shown in Fig 43o. In particular, the percentage of intact surfaces increased from less than 35% to more than 50%, and the percentage of missing surfaces was reduced from almost 30% to only about 5%. Fig 43p shows the frequency distribution of 50- to 65-year-old subjects with specific numbers of intact tooth surfaces in 1972 compared with 2002.

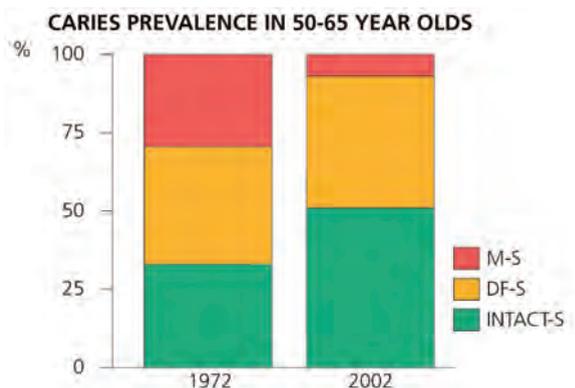


Fig 43o, Caries prevalence in 50- to 65-year-old subjects in 1972 compared to 2002. (DFs) Decayed and filled surfaces; (MS) Missing surfaces. (Modified from Axelsson et al 2004 with permission.)

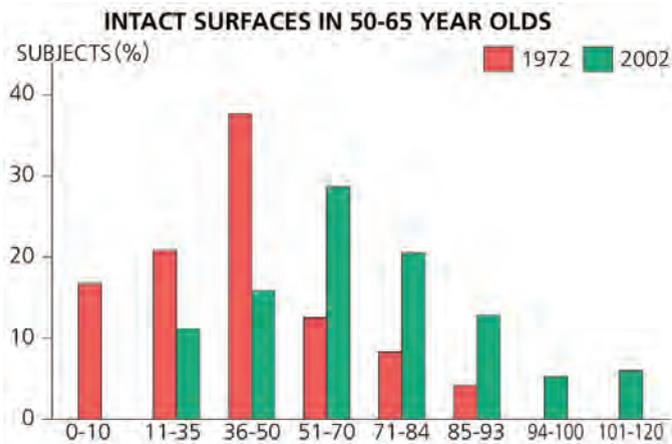


Fig 43p, Frequency distribution of 50- to 65-year-old subjects with specific numbers of intact tooth surfaces in 1972 compared to 2002. (Modified from Axelsson et al 2004 with permission.)

### Effect on periodontal disease

Fig 43q shows the changes in mean probing attachment level that occurred at different sites and in different age groups between 1972 and 2002. Except for a mean loss of 0.2 mm buccally in group 1 as an iatrogenic effect, there was no marked change in probing attachment level on the buccal and lingual surfaces, but on the approximal surfaces, gains ranging from 0.3 to 0.4 mm were recorded. Most likely several approximal intrabony pockets at baseline had been “repaired” during the study. Although there was an overall gain of attachment in the sample, further attachment loss of > 2 mm had occurred on a few of the sites (2% to 8%), mainly buccally as an iatrogenic effect of frequent mechanical cleaning. For comparison, the annual mean loss of periodontal support was 0.1 mm in an 11-year longitudinal study in a randomized sample of Swedish adults (Håkansson 1991) and two 20-year longitudinal studies in adults in the counties of Jönköping (Hugoson and Laurell 2000) and Stockholm (Jansson et al 2002) in Sweden (ie, an average of 3 mm of periodontal support loss over 30 years).

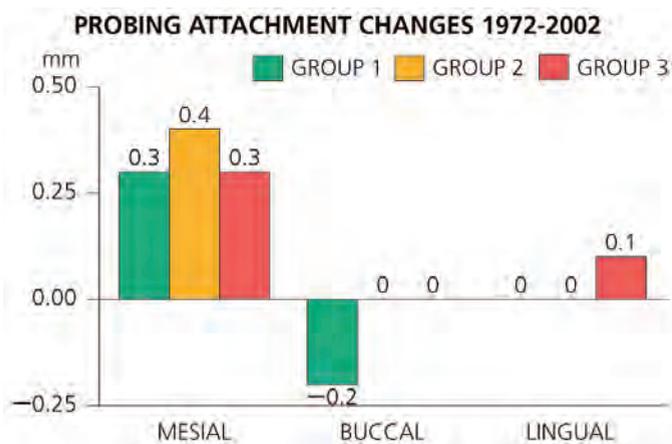


Fig 43q, Mean Periodontal Attachment (PAL) changes in the three age groups at mesial, buccal and lingual sites from 1972 to 2002. (Modified from Axelsson et al 2004 with permission.)

Only the buccal surfaces in group 1 exhibit attachment loss (PAL), which can be explained by iatrogenic trauma caused by mechanical cleaning, as discussed earlier. Therefore, in order to eliminate the iatrogenic effect on PAL, only approximal PAL should be presented as resulting from periopathogens.

The frequency distribution of 50- to 65-year-old subjects with specific mean mesial PALs in 1972 and 2002 is shown in Fig 43r. Fig 43s shows the frequency distribution of mesial sites with PAL in 50- to 65-year-old subjects in 1972 compared to 2002. The pattern of PAL mesially, buccally and lingually in 1972 compared to 2002 showed that most improvement was achieved mesially and lingually in 2002, particularly in the maxillary teeth. The frequency distribution of periodontal treatment needs according to the CPITN at the site level in each age group at the baseline examination in 1972 compared to the 30-year re-examination is shown in Fig 43t. Irrespective of age, almost 100% of the sites were healthy (score 0) in 2002.

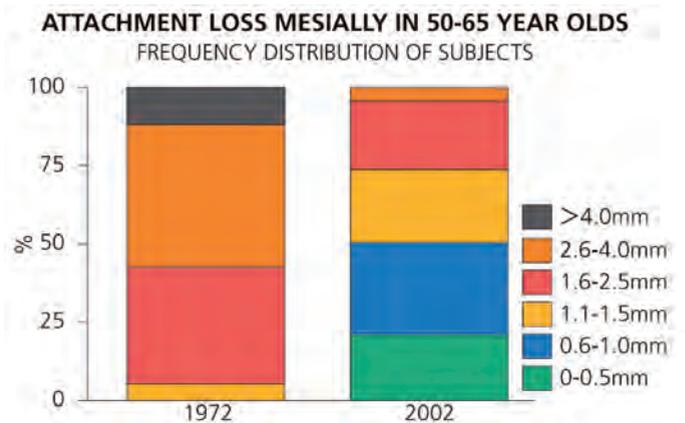


Fig 43r, Frequency distribution of 50- to 65-year-old subjects with specific mean PALs mesially in 1972 and 2002. (Modified from Axelsson et al 2004 with permission.)

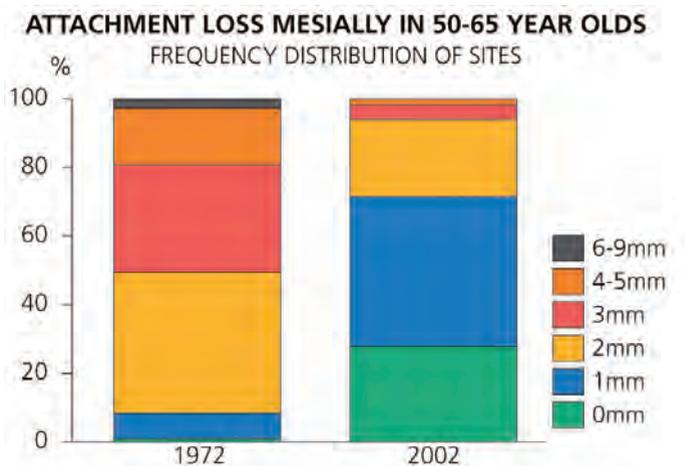


Fig 43s, Frequency distribution of PAL on mesial sites in 50- to 65-year-old subjects. (Modified from Axelsson et al 2004 with permission.)

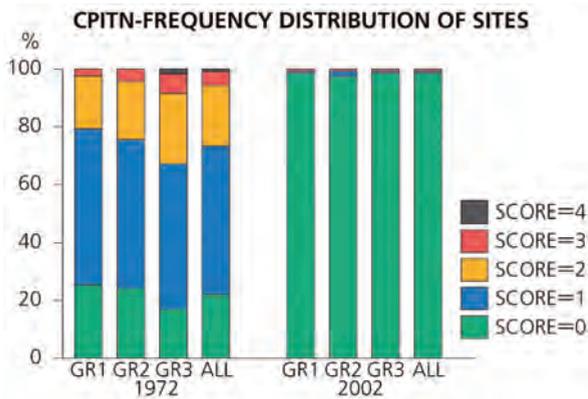


Fig 43t, Frequency distribution of sites with CPITN scores 0 to 4 in 50- to 65-year-old subjects 1972 and 2002. (Modified from Axelsson et al 2004 with permission.)

Missing sites and teeth do not have any periodontal treatment needs. Thus, periodontal treatment needs CIPTN should take into account missing sites when the “true” treatment need is estimated. Fig 43u shows the frequency distribution of sites in 50- to 65-year-old subjects in 1972 compared to 2002. In 2002, almost 95% of the sites were healthy and only 5% were missing, compared to only 10% healthy sites and more than 30% missing sites in 1972.

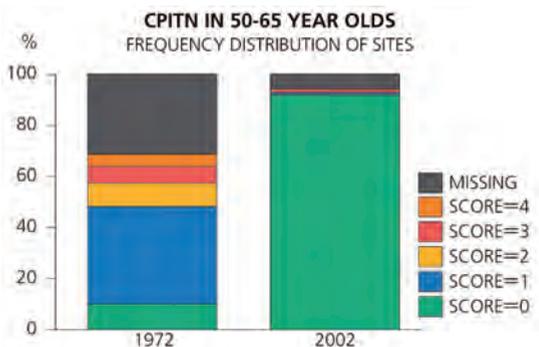


Fig 43u, Frequency distribution of missing sites and sites with CPITN scores 0-4 in 50- to 65-year-old subjects. (Modified from Axelsson et al 2004 with permission.)

Figs 43v-43z show the pattern of missing sites and sites with CPITN score 0 to 4 mesially, and lingually in 50- to 65-year-old subjects in 1972 and 2002. Most missing sites were found in the maxillary and mandibular molar regions of the 50- to 65-year-old subjects in 1972. In 1972, most CPITN scores 3 and 4 were found mesially and distally in the maxillary posterior teeth, and most CPITN score 2 (calculus) was found lingually in the mandibular teeth, while almost 100% of all sites were healthy in 2002.

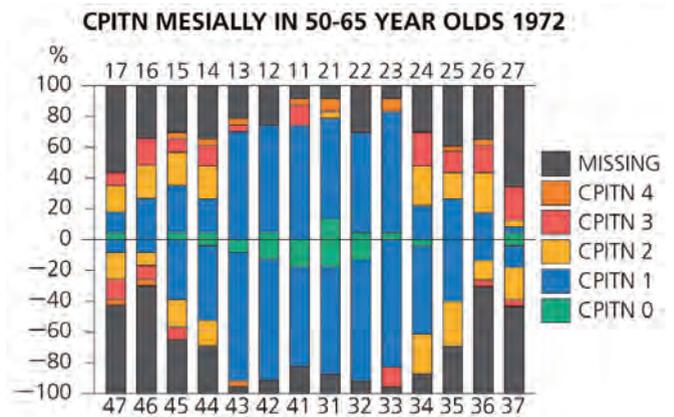


Fig 43v, Pattern of missing sites and sites with CPITN score 0 to 4 mesially in 50- to 65-year-old subjects in 1972. (Modified from Axelsson et al 2004 with permission.)

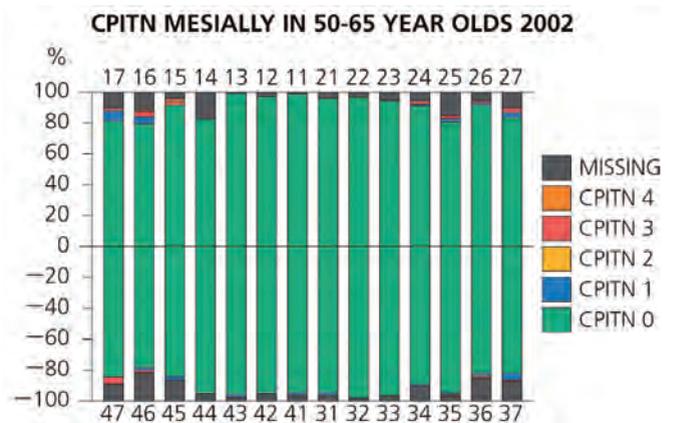


Fig 43x, Pattern of missing sites and sites with CPITN score 0 to 4 mesially in 50- to 65-year-old subjects in 2002. (Modified from Axelsson et al 2004 with permission.)

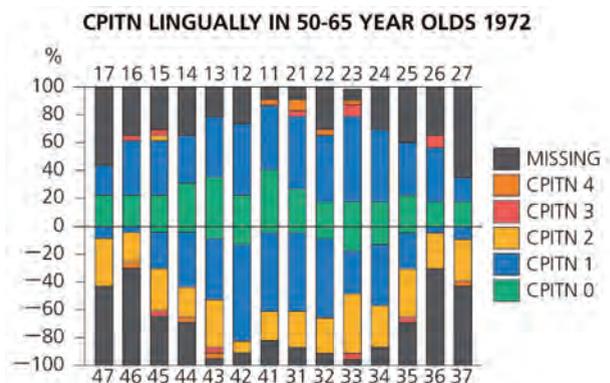


Fig 43y, Pattern of missing sites and sites with CPITN score 0 to 4 lingually in 50- to 65-year-old subjects from 1972. (Modified from Axelsson et al 2004 with permission.)

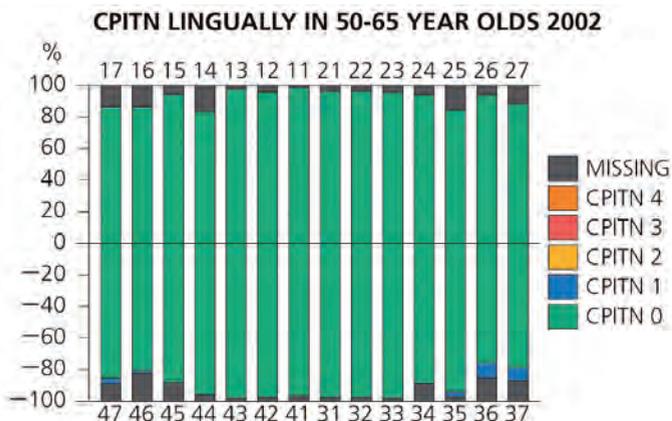


Fig 43z, Pattern of missing sites and sites with CPITN score 0 to 4 lingually in 50- to 65-year-old subjects in 2002. (Modified from Axelsson et al 2004 with permission.)

The long-term effect on tooth loss, caries prevalence, loss of periodontal support, gingival health status, and standard of oral hygiene may be illustrated by a subject from age group 2 who exhibited more loss of periodontal support than the average for his age group at the baseline examination in 1972. Fig 43a2 shows complete-mouth radiographs of this 50-year-old man at baseline in 1972. Fig 43b2 presents the radiographs taken at the 30-year re-examination in 2002. In 1972, the patient exhibited greater-than-average loss of periodontal attachment for his age, especially in the maxillary teeth. During the following 30 years, no teeth were lost, there was no further loss of attachment, and no new carious lesions developed. The buccogingival status and standard of oral hygiene at the 30-year re-examination are shown in Figs 43c2 and 43d2. Figs 43e2-43h2 show two other cases from group 3, who exhibited advanced localized alveolar bone loss in 1972, which were still stable or somewhat repaired in 2002.



Fig 43a2, Complete-mouth radiographs of a 50-year-old man in test group 2 at baseline examination (1972). He has greater-than-average PAL for his age, especially in the maxillary teeth.



Fig 43b2, Complete-mouth radiographs of the patient in Fig 43a2, aged 80 years, at the 30-year re-examination (2002). No teeth have been lost, there has been no further loss of probing attachment level, and no new caries lesions have developed. Note the well-mineralized margin of the alveolar bone, indicating an absence of active periodontitis.



Fig 43c2 (above) and Fig 43d2 (below), Buccogingival health and oral hygiene status of the same patient in Figs 43a2 and 43b2 at the 30-year re-examination (2002).



Fig 43e2, (left) Radiograph of the maxillary right second premolar in 1972.

Fig 43f2, (right) Radiograph of the same maxillary right second premolar 30 years later. Observe the gain of alveolar bone mesially compared to 1972.



*Fig 43g2, (left) Advanced loss of alveolar bone mesially of the right maxillary central in 1972.*

*Fig 43h2, (right) 30 years later no further loss of alveolar bone was observed compared to 1972.*

This study indicated that a well-trained dental hygienist supervised by a dentist and using established professional preventive measures (PMTTC etc) to complement improved self-care, was able to prevent further loss of periodontal attachment and reduce the development of new caries lesions to less than one carious surface per subject over 30 years, in all age groups. It was also shown that excellent self-care habits, including self-diagnosis, can be successfully established in adults, age does not matter. At the 30-year re-examination, 92% brushed their teeth 2 times per day and 8% either

in the morning or before going to bed. In addition, 70% used toothpicks daily, 44% used dental tape daily, and 35% used interdental brushes daily. In addition, the percentage of smokers was reduced from 46% in 1972 to only 10% in 2002.

Experience gained from this study is applied in the 2-year training program for dental hygienists at the dental hygiene school in Karlstad and in preventive programs for adults at public dental health clinics and private dental practices in the county of Värmland, which has the highest ratio of dental hygienists per dentist (1:1) in Sweden.

As a consequence, dental health status has improved considerably in the adult population during the last decade, as shown in analytical epidemiologic studies in randomized samples of 35-, 50-, 65- and 75-year-old adults in 1988 and 1998, (for details see Axelsson 2004, Axelsson et al 2004).

## CHAPTER 6

### *Removal of Plaque Retentive Factors and Finishing*

The role of plaque retentive factors must not be underestimated. Complete removal of gingival plaque biofilms can not be performed by self care or PMTC without removal of existing plaque retentive factors. Therefore initial removal of plaque retentive factors are of greatest importance for successful outcome of PMTC as well as mechanical plaque control by self care. Plaque retentive factors may be located supra- as well as subgingivally. Table 2 exemplifies important supra- and subgingival plaque retentive factors.

Table 2

Supragingival plaque-retentive factors:

- Cavitated caries lesions
- Carious restorations
- Restoration overhangs and defective margins
- Ill-fitting margins of crowns and inlays
- Unpolished restorations
- Resin composite restorations
- Supragingival calculus
- Exposed, unplanned root surfaces

Subgingival plaque-retentive factors:

- Cavitated caries lesions
- Deep, narrow bony pockets
- Furcation involvement
- Root grooves
- Rough, unplanned cementum
- Cementum hypoplasia
- Root resorption
- Calculus
- Iatrogenic effects of subgingival scaling, such as grooves and exposed dentinal tubulus on the root surfaces, restoration overhangs, defective and ill-fitting margins of crowns, unpolished restorations, recurrent caries, root caries etc.

#### *Prevalence and consequences of restoration overhangs*

Analytical epidemiological studies show that when the occlusal surfaces of the molars are excluded, the highest prevalence of decayed, filled surfaces (DFS), and loss of periodontal attachment occurs on the approximal surfaces of the molars and premolars (Axelsson et al 1988, 2000, 2004). In industrialized countries, most of the remaining approximal surfaces in adults aged 50 and over are restored on the posterior (see chapter 3, Fig 25).

Fig 38 shows a bitewing radiograph from a 50-year-old patient with amalgam restorations on all approximal surfaces in the posterior teeth 40 years ago. The estimated gingival margin is marked. Obviously the margins of the approximal amalgam restorations are located subgingivally. Some small subgingival excess are also observed as well as a secondary carious lesion (distally at tooth 25).



*Fig 38*

The margins of such approximal restorations are not accessible for cleaning by the use of a toothbrush because the buccal and lingual papillae fill up and block the entrances of the interproximal spaces. In contrast triangular-pointed toothpicks for selfcare and reciprocating triangular-pointed EVA-tips for professional mechanical toothcleaning (PMTC) can achieve accessibility because of the recession of the papillae as shown in Fig 38.

Early studies in animals (Waerhaug 1960) and humans (Silness 1970; Waerhaug 1975) showed that the most favourable periodontal response is attained when the margins of dental restorations are placed at, or coronal to, the gingival margin. Furthermore, these findings have been corroborated by more recent findings (Kois 1996).

In the early 1970s, epidemiological studies in Sweden showed that most approximal restorations of molars and premolars had subgingival defects. In addition, there was a strong correlation between the size of overhangs and loss of adjacent alveolar bone (Björn et al 1969a, b, 1970). Similar results have been found in other studies.

In 18 dental students, 314 class II amalgam restorations were examined by probe and mirror as well as by radiographs. Defects were found at the cervical margin of 50% of the fillings. Three out of four defects were overhangs. Overhangs, deep pockets and gingivitis were often recorded when the fillings extended beyond the gingival margin (Arneberg et al 1980).

In a retrospective study, Jansson et al (1994) evaluated the influence of overhangs on periodontal status and whether any such influence is modified by the patient's oral hygiene level and the degree of radiographic attachment loss. In patients with a mean radiographic attachment loss of less than 5 mm, an overhang was associated with significantly greater loss of attachment. However, in periodontitis-prone patients, a decrease in the influence of marginal overhangs on probing depth and attachment loss was noted as the loss of periodontal attachment increased, ie, as the distance between the overhang and the base of the pocket increased.

Schätzle et al (2000) showed similar results from a 26-year longitudinal study. Surfaces with subgingival restoration margins showed significantly more periodontal attachment loss than did intact tooth surfaces or supragingivally located restorations (>1 mm from the gingival margin). However, when the attachment loss resulted in a gradually more coronal location of the former subgingival restoration margins, a “burn-out” effect was observed.

In particular, subgingival approximal overhangs tend to retain heavy deposits of subgingival plaque biofilms and calculus, inaccessible to oral hygiene in a tooth-brushing population, which result in localized loss of periodontal support, as illustrated in Figs 44-45. Fortunately such extreme overhangs from the 60s were very seldom occurring also at that time. However, most of the 50-year-olds and older in the industrialized countries still exhibit too many approximal surfaces restored with amalgam in the posterior teeth. It must also be observed that very few of such subgingival restored surfaces are optimally finished and polished. (fig 46)

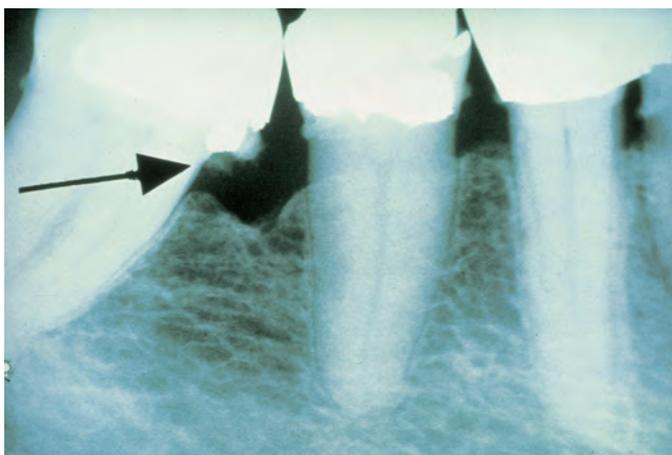


Fig 44, Overhanging restorations (arrow), related to the localized loss of periodontal support



Fig 45, By using a curette the calculus attached apically to the filling overhang in Fig 44 was removed. Observe that the calculus was completely covered with a thick plaque biofilm.

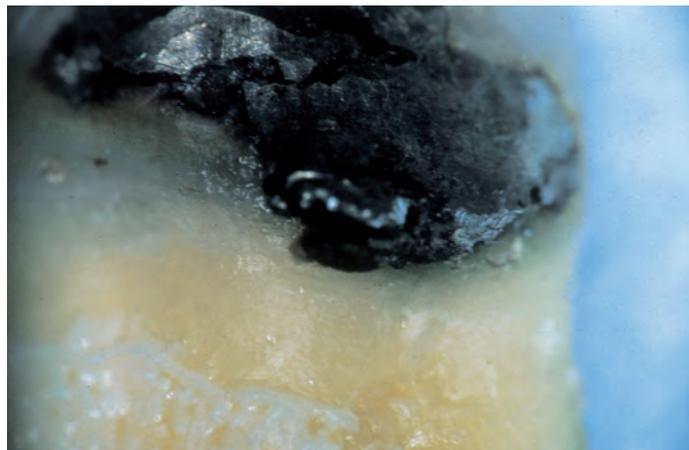


Fig 46, Extracted untreatable tooth exhibiting approximal amalgam filling with subgingival rough overhang, secondary caries and calculus. A very unhealthy environment for the periodontal tissue.

The prevalence of overhangs has been reported in many different patient populations. The reported range on restored teeth is between 18% (Jansson et al 1994) and 87% (Lervik et al 1984). Criteria used to determine the presence of an overhang differ from study to study, which likely accounts for most of this variation. Lervik et al (1984) employed bitewing radiographs, a microscope and magnifying glass. They reported 96% of overhangs extended less than 0.5 mm from the tooth. This indicated that studies using the criterion of >0.5 mm have most likely underestimated overhangs prevalence. Pack et al (1990) found that the use of bitewing radiographs and clinical exploration detected only 35% of interproximal overhangs. Of these, 74% were found with radiographs alone, while 62% were found using only clinical inspection.

Than et al (1982) evaluated the relationship between restorations and the level of the periodontal attachment. 240 stained extracted teeth with a restoration on one proximal surface and with no restoration on the opposite surface were investigated for the position and quality of the restoration and the position of the periodontal attachment. Only 27% of restorations were of good quality, 60% had overhangs and 13% deficiencies. The mean difference in loss of periodontal attachment between the two surfaces for all teeth was 0.36 mm when the distance from the cemento-enamel junction to the periodontal membrane on the unrestored surfaces was subtracted from that on the restored surfaces.

Pack et al (1989) evaluated the prevalence of overhanging margins and associated periodontal status in 100 patients who had received completed treatment by final year dental students. Pockets, bleeding on probing and clinically detectable overhanging margins were recorded on all posterior teeth. Overhanging margins on approximal restorations were detected by use of bitewing radiographs. 2117 restored surfaces were evaluated. Of these, 1186 (56%) had overhanging margins. 62% of all approximal restorations had overhanging margins while 35% of buccal and 40% of lingual restorations had overhanging margins. 59% of new approximal restorations placed in previously unrestored surfaces had overhanging margins, and 595 overhanging

margins identified on pre-treatment radiographs were still present on post-treatment radiographs. 64.3% of pockets adjacent to overhanging margins were >3 mm, compared with 23.1% of pockets adjacent to unrestored surfaces and 49.2% of pockets adjacent to restorations without overhanging margins. A similar association existed between restorative status and bleeding. 32% of pockets adjacent to overhanging margins bled on probing compared with 10.5% of pockets adjacent to unrestored surfaces and 21.6% of pockets adjacent to restorations without overhanging margins. Periodontal disease was more severe when overhangs were present. However, when approximal overhanging margins were adjacent to an edentulous space, the periodontal effects were lessened. When adjacent to neighbouring teeth, overhanging margins also significantly affected the periodontal status of those teeth.

Mora recently Broadband et al (2006) evaluated the role of approximal restorations as a local risk factor for periodontal attachment loss. Approximal tooth surfaces of 884 study members were evaluated for restorations and caries at age 26 and again at 32 years, and probing depth and gingival recession were recorded in millimetres at age 32. Attachment loss was computed as the sum of pocket depth and gingival recession. Data were analysed using generalized estimating equations. The results showed: where a caries/restorative event had occurred on an inter-proximal tooth surface before age 26, the age 32 attachment loss at the corresponding periodontal site was approximately twice more likely to be >3 mm than if the adjacent tooth surface had remained sound to age 32. This was also true where a caries/restorative event had occurred subsequent to age 26. The association remained after controlling for potential confounders, including smoking. The authors concluded: Site-specific periodontal attachment loss due to dental caries or restorative events occurs in adults in their third and fourth decades of life.

Even in Brazilian schoolchildren (12-15 years old) we have shown a significant association between the presence of untreated approximal manifest caries lesions, non-defective and defective approximal amalgam restorations and the progression of alveolar bone loss during a 3-year period. There was also a significant correlation between the presence of defect approximal restorations and the incidence of gingival inflammation. Consistently, factors detected at the involved site ( $P < 0.000001$ ) and at the adjacent site ( $P < 0.02$ ) had significant effect (Albandar et al 1995). Our study indicates that untreated approximal manifest caries lesions and dental restorations are predisposing factors with a significant negative effect on periodontal health in adolescents. Young individuals with multiple such sites, should be considered at risk of developing destructive periodontal lesions and treated accordingly. As a consequence "prevention instead of extention" must be prioritized from the eruption of the teeth.

In a review paper by Brunsvold and Lane (1990) on the prevalence of overhanging approximal dental restorations and their relationship to periodontal disease, the prevalence of overhangs ranged from 25% - 76%

of restored surfaces, which was related to diagnostic method and cut off for the size of the overhang. Only radiographs showed the lowest value (25%) and mirror + probing + radiograph resulted in the highest prevalence (76%). At least 35% of the adults exhibited overhangs.

There was a general consensus that tooth surfaces with overhangs exhibited significantly greater severity of periodontal disease (loss of alveolar bone and probing attachment, deep pockets and gingival inflammation) compared to homologous surfaces without filling overhangs.

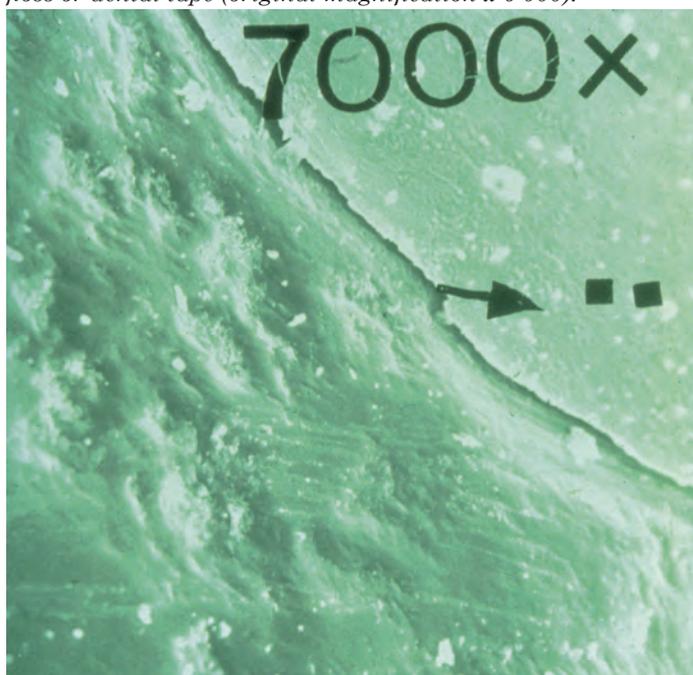
The severity of periodontal disease was also related to the size of the overhang and the exposal time (more or less than two years). On the other hand, removal of an overhang results in improved plaque control (Rodriguez-Ferrer et al 1980) and restoration of gingival health (Gorzo et al 1979). These studies confirm that removal of overhanging margins should be part of initial periodontal therapy. As well, it is obvious that early detection of overhanging dental restorations is an important part of preventive dental care. A sensitive tactile instrument, such as a fine explorer, should be used in conjunction with radiographs to facilitate this detection.

### *The role of unfinished restorations*

It has been estimated that an unpolished amalgam restoration will retain about 50 times more dental plaque than an optimally finished and polished restoration. Fig 47a shows a scanning electron micrograph (SEM) of an approximal amalgam filling which has been condensed against a new matrix band (magnification x 6 000). Each black square is equivalent to 50 microbes which means that each pit on the rough surface can retain hundreds of microbes inaccessible to toothpicks, dental floss or –tape. Such a subgingival unpolished approximal filling will significantly increase the risk of secondary caries, gingivitis and periodontitis.



*Fig 47a, SEM of an unpolished approximal amalgam restoration that has been condensed against a new matrix band. Each black square is equivalent to 50 microbes, which means that each pit on the rough surface can retain hundreds of microbes that are inaccessible to cleaning by toothpicks, dental floss or dental tape (original magnification x 6 000).*



*Fig 47b, Well-finished and polished approximal amalgam restoration. Each square is equivalent to 50 microbes. The area is now accessible to oral hygiene aids (original magnification x 7 000).*

By contrast, Fig 47b shows a well-finished and polished approximal amalgam filling at SEM x 7 000 magnification. Again, each square is equivalent to 50 microbes. But now the area is accessible to oral hygiene aids and PMTC.

In addition, in vitro studies have shown that optimally finished amalgam restorations have four times the plaque reaccumulation (wet weight) of intact enamel that has been topically treated with stannous fluoride, because of highly significant differences in surface free energy and wettability (Glantz 1969). In addition it should be observed that resin composite materials accumulate much more plaque than does amalgam, porcelain, or gold. The emphasis should therefore again be on “Prevention instead of extension”. In vivo studies have shown that surface roughness has a greater influence on early plaque formation and plaque composition than do surface free energy (Quirynen et al 1990). For review see Quirynen (1995). Other local risk factors related to particularly amalgam restoration and posts may be corrosion products.

Early studies by Waerhaug (1960) indicated that the downgrowth of plaque into the subgingival area occurs more quickly on unpolished surfaces of restorations than on enamel or cementum. As mentioned earlier, the margins of almost 100% of approximal restorations on the molars and premolars are located subgingivally (see Fig 38). In addition subgingival approximal restorations are poorly finished and have persistent overhangs as earlier discussed. To prevent and control secondary caries and periodontitis by self care and PMTC, optimal finishing and repeated polishing are much more important for subgingival approximal restorations than for occlusal, buccal and lingual restorations.

### *Materials and methods for recontouring, finishing and polishing of dental restorations*

There are mainly two different types of mechanically driven instruments for recontouring, finishing and polishing of dental restorations; reciprocating (oscillating) and rotating instruments. In addition there are some manual aids such as different types of strips and knives. Out of these different types, rotating aids are most well known and used.

However, the approximal surfaces of the posterior teeth exhibit the outstanding highest prevalence of restored surfaces, mostly unfinished with overhangs subgingivally located as earlier discussed. In addition excess dual resin composite cement may remain interdentially after cementation of indirect all ceramic restorations (see Fig 48).

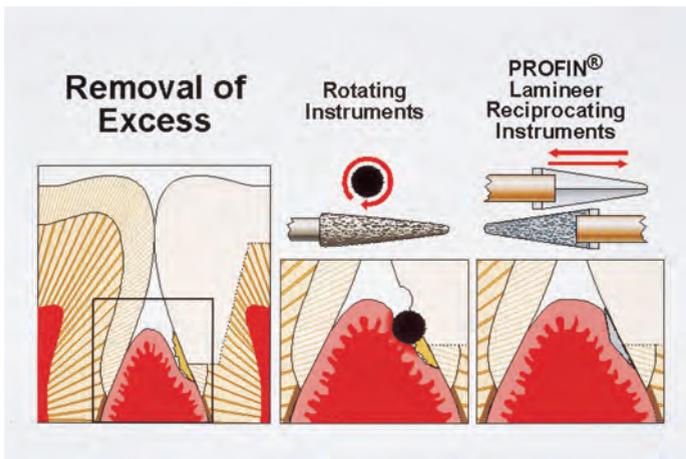


Fig 48, Difference in removal of subgingival excess cement with the use of rotating instruments and reciprocating thin, double-knife-edged safe-sided instruments. Observe the risk for horizontal iatrogenic roughness caused by rotating instruments.

The interproximal space between the crowns of the posterior teeth is triangular in cross-section and concave in long section. That is because of the slightly convex approximal tooth surfaces. The interdental spaces in the posterior regions are normally filled up with a buccal and lingual papillae (see Fig 22, 23), which often are infectiously inflamed particularly if subgingival overhangs persist. Only a few exposed root surfaces may be concave (especially the mesial root surfaces of the maxillary first premolars). That means rotating instruments are unsuitable for approximal recontouring, finishing and polishing because of very limited accessibility. In addition rotating instrument may cause horizontal iatrogenic scratches (see Fig 48). In contrast safe sided double-knife edged reciprocating instruments offer optimal accessibility. Because of the resilience of the papillae such instruments achieve accessibility at least 2-3 mm subgingivally (see Fig 48).

#### *Mechanically driven reciprocating instruments EVA-Profin® Directional System*

The original EVA-system developed in the late 60s (Axelsson 1969) was the first and so far the only innovation with reciprocating instruments for efficient contouring, finishing and polishing of restored approximal surfaces in the posterior regions as well as interproximal PMTC. The system was based on a prophylaxis contra angle handpiece and an assortment of reciprocating triangular-pointed or spatula-shaped tips. The length of the reciprocating stroke is 1.2 mm. In the original EVA-handpiece the tips could be completely rotated through 360°. Thus a self steering effect was achieved and the tip was automatically adjusted to the most suitable position during the reciprocating strokes.

The original EVA-system has continuously been improved and updated. Now the handpiece is modified. The new handpiece (Profin® Directional Dentatus AB, Sweden) is supplemented with the possibility to lock the reciprocating tips in six different positions, which is beneficial for delicate precise preparing, recontouring and use of asymmetrical instruments. For Professional Mechanical Tooth Cleaning (PMTC), finishing and polishing the tip is used according to the original concept with self steering function, which is the most frequent procedures (Axelsson 1994). Figs 49, 50 show the most recent design of the EVA-Profin® handpiece.



Figs 49,50, The most recent design of the EVA-Profin® contra angle handpiece with a double-knife edged safe-sided diamond-coated tip inserted (Lamineer® LTA-S30, Dentatus AB, Sweden).

The assortment of tips has continuously been increased in order to optimize the possibilities to solve most problems related to recontouring, finishing and polishing. Fig 51 shows a sample of the assortment. For example there are thin spatula-shaped and pointed double-knife edged safe sided tips with diamond grit 15, 30, 50, 75, 100 or 150 microns as well as wolfram-coated. (Lamineer LTA spatula-shaped tips and Lamineer LTA-s double-knife edged tips.)

Particularly useful are the pointed double knife-edged tips (Fig 52). This well-balanced symmetrical pointed tip gives optimal access subgingivally between the tooth surface and the papillae (see Fig 48) as well as around the contact-areas horizontally, vertically and diagonally (see Figs 53 and 54), and offers unlimited access to any hard to reach intra-oral areas for finishing and reshaping restorations and natural teeth.

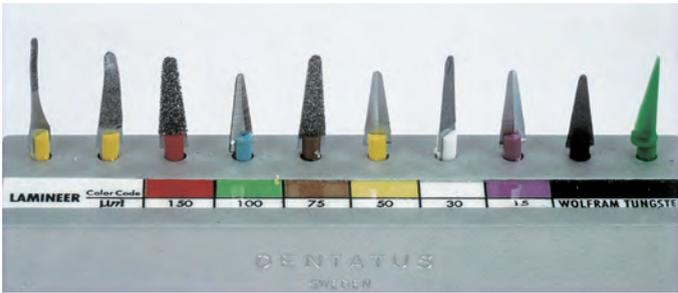


Fig 51, A sample of different diamond- or wolfram-coated safe-sided spatula- or double knife-edged instruments.



Fig 52, The pointed double knife-edged safe sided diamond-coated tip (Lamineer® LTA-S30).

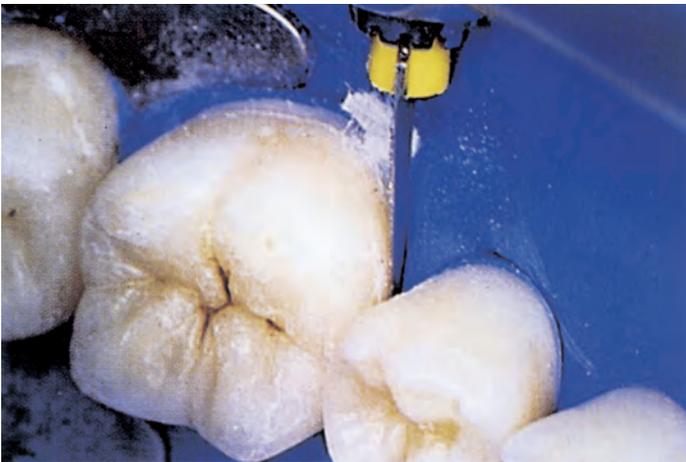


Fig 53 & 54, The reciprocating tips can be used vertically (Fig 53) as well as horizontally (Fig 54) even when rubberdam is placed in contrast to rotating instruments.

In contrast to rotating instruments these reciprocating instruments can be used even when rubberdam is placed (Figs 53 and 54). For polishing and PMTC, pointed triangular plastic tips and wooden tips (EVA-7) are available to be used in combination with fluoride polishing pastes with different abrasiveness as earlier discussed (see Figs 37b, c).

Other special designed diamond-coated tips are available for preparing laminers and striping. It should also be observed that the reciprocating PER-IO-TOR 1-6 instruments for non invasive scaling, root planing and debridement are used in the EVA-Profin contra angle. In addition a cut wooden tip is very useful for vibrating the cement, when placing inlays, onlays, crowns and bridges. This procedure facilitates correct placement and minimizes the thickness of the cement layer.

Instructions and maintenance recommendations for the EVA-Profin® Directional System

- The speed range is from 6 000 up to 8 000 RPM for PMTC and polishing and from 12 000 up to 15 000 RPM for finishing, scaling and root-planing.
- Uncomfortable vibrations during clinical use are usually caused by a too low speed (<4 000 rpm).
- To reassure the patient of the safety and gentle motion of the EVA-Profin® system, before any clinical procedures, allow him or her to touch and hold the tips while the handpiece is in motion.
- For approximal treatment it should be observed that the tip has to be placed in correct position into the interproximal space before it is put in motion.
- The point of triangular pointed tips has to be placed in about 20-30° coronal direction initially and than gradually to a more horizontal position in order to press papillae apically and achieve more subgingival accessibility.
- The EVA-Profin® contra-angles made by Dentatus, W & H and NSK are available with internal water spray: cooling is unnecessary because of the low speed, but the water spray is useful for elimination of debris from the tooth surfaces and tips.
- For disinfection of the surface, use a suitable liquid. Dry the instruments. Never put the contra-angles into an ultrasonic cleaner. The instruments should be heat sterilized in an autoclave at 120° or 135°.
- Diamond-coated, colour-coated tips (LTA and LTA-S):  
Remove debris clogging by scrubbing the diamond coated side against the included cleaning stone, or preferably, clean the tips in an ultrasonic cleaner. Sterilize the tips in an autoclave maximum 135°. The wolfram coated tips (LTA-39 and LTA-S36) are cleaned and sterilized in a similar procedure.
- Both the diamond or wolfram-coated spatula shaped tips and plastic tips can be reshaped at chairside to adapt to the most extreme requirement.

### Removing overhangs and recontouring

Still amalgam overhangs represent the outstanding highest prevalence of subgingival approximal overhangs in most countries. Removing subgingival approximal filling overhangs is a technically advanced procedure. Retrospectively lots of material and methods have been used.

By using the combined scanning electron microscope (SEM) technique and a profilogram, Vale & Caffesse (1979) evaluated the effect of rotating instruments, amalgam knives and reciprocating triangular diamond points (EVA-tips, Dentatus AB, Spånga, Sweden) for removing filling overhangs.

Scanning electron micrographs from this study show that rotating instruments and amalgam knives result in a narrow gap between the tooth surface (T) and the amalgam filling (Fig 55). Such a gap will retain lots of bacteria and increase the risk for secondary caries. When the reciprocation LTA-diamonds were used, no fractured margin and gap occurred (Fig 56). The same effect was confirmed in the profilograms. Fig 57 after using rotating instruments and Fig 58 the LTA-reciprocating diamond tips (50 microns).

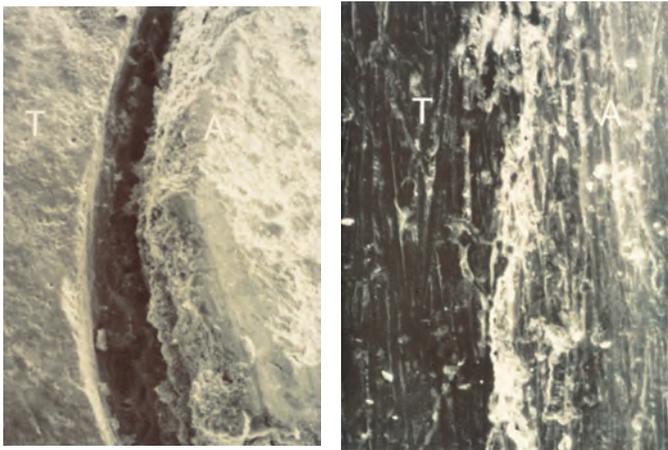


Fig 55, SEM revealing a narrow gap between the tooth surface (T) and the amalgam (A). The gap was caused by fracture of the restoration margin, which arose from the use of rotary instruments and amalgam knives (original magnification x 140). (From Vale and Caffesse 1979. Reprinted with permission.)

Fig 56, SEM revealing no fracture of the amalgam (A) margin or removal of tooth (T) substance after instrumentation with reciprocating EVA diamonds (original magnification x 140). (From Vale and Caffesse 1979. Reprinted with permission.)

T= Tooth, A= Amalgam



Fig 57, Profilogram after use of rotary instruments. T = tooth, A = amalgam. (From Vale and Caffesse 1979. Reprinted with permission.)

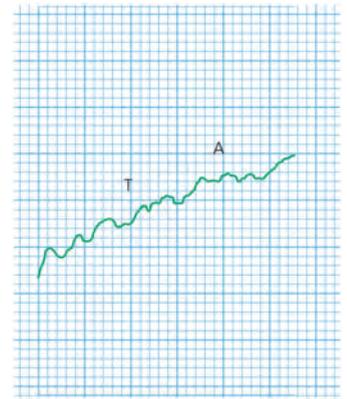


Fig 58, Profilogram after use of EVA reciprocating diamond tips (50 µm). T = tooth, A = amalgam. (From Vale and Caffesse 1979. Reprinted with permission.)

T= Tooth, A= Amalgam

In another study, Spinks et al (1985) showed that removal of overhangs with hand instruments (curettes) or sonic scalers was 2.5 and 5 times more time consuming, respectively, than the EVA-Profin reciprocating diamond tips. In addition, the sonic scaler resulted in significantly more instances of iatrogenic roughness on the root surfaces apically of the restorations.

If the overhangs are large, the reciprocating double knife-edged safe-sided tip coated with 30 and 50 micron diamond particles (LTA-S 30®, LTA-S 50® see Fig 52) is recommended for removal of the bulk of the overhang. Final removal of the overhang, and finishing of the filling is carried out with a double-knife edged tungsten-coated wolfram tip (LTA-S 36®). The wolfram/tungsten-coated tips have no effect on enamel. Therefore, the enamel surface can be used as a guide for final finishing of the filling. Finally, the filling and the surrounding enamel margins are polished with the EVA triangular-pointed tips and fluoride-containing prophylaxis-paste.

Figs 59-61 show overhangs, which were initially removed by using the reciprocating 30 µm diamond tip (LTA-S30). Smaller overhangs can easily be removed by using tips coated with 15 micron diamond particles or tungsten-coated (wolfram) tips only. For removing gold overhangs or recontouring crowns, reciprocating double knife edged, tips coated with 75 or minimum 50 micron diamond particles (LTA-S75 or LTA-S50) are recommended as a first step.

The reciprocating diamond coated safe-sided tips are also suitable for reducing the length of pontics as well as recontouring pontics in old bridges. For porcelain or gold pontics diamond tips coated with 75 or 100 micron particles (LTA-75 or LTA-100) are recommended initially.

Case 1

Fig 62 shows a new unfinished class 2 amalgam filling. Initial finishing of the occlusal surface was carried out by using a rotating pear-shaped finishing bur. Note the rough still unfinished mesial surface of the filling. See the SEM pictures of a new amalgam filling condensed against a new matrix band in x6000 compared to an optimal finished and polished in x7000 (Fig 47a and 47b).



Fig 62, Initial finishing of the occlusal surface has been carried out with a pear-shaped finishing bur. Observe the rough unfinished mesial surface.

In new approximal fillings, correctly designed and condensed against a new matrix band, the double-knife edged 15 µm diamond-coated (LTA-S15) and wolfram tips (LTA-S36) are recommended as the first steps of the finishing procedure. Thanks to the negligible effect on enamel of the wolfram tips, so-called enamel-steering can be used when finishing fillings. Initially, the line angles and the outer sides of the marginal ridges are finished by using the tip in a vertical direction. Then the approximal surface is finished with the tip in a diagonal position which gradually turns to a horizontal direction.

As the margin of the approximal filling is generally located subgingivally, this step of the finishing procedure must be considered the most important from plaque retention point of view. The final polishing of the approximal surface was carried out by using the triangular pointed wooden tip EVA-7 and fluoride containing polishing pastes. Finally the occlusal surface was polished with a rotating rubber cup and the same type of polishing pastes. Fig 63 shows the final result.

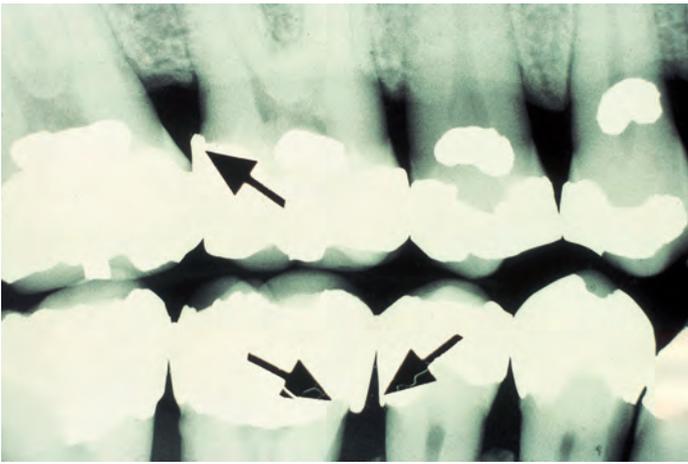


Fig 59, Large subgingival amalgam overhangs according to the arrows.

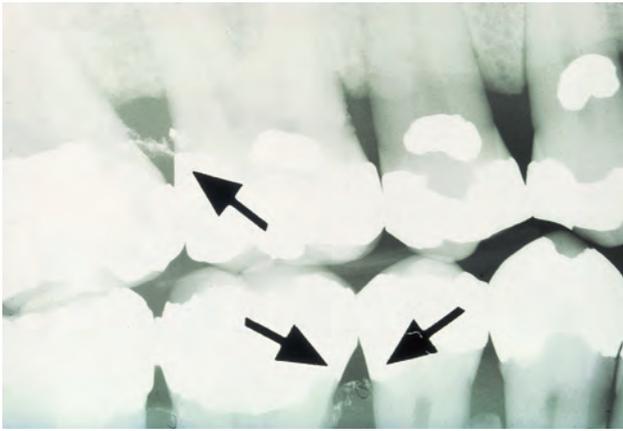


Fig 60, The overhangs in Fig 59 were removed by using the reciprocating diamond-coated double knife edged safe sided Lamineer LTA-S50 and LTA-S30 tips. The final finishing and polishing was carried out with the wolfram coated Lamineer LTA-S36 tip and EVA-2000 triangular pointed tip + fluoride polishing pastes.



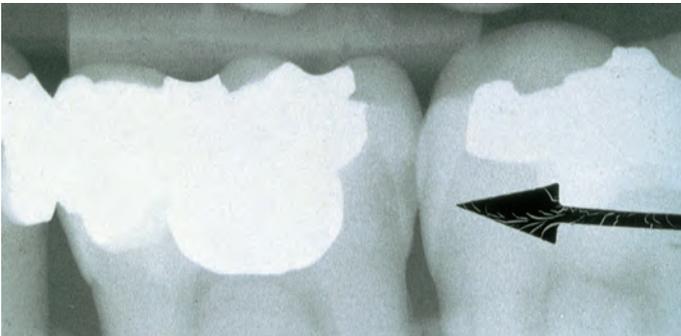
Figs 61a, 61b, Show approximal amalgam overhang (arrow-top) which also was removed and smoothed according to the same methods as described for Fig 59-60.



*Fig 63, The approximal surface and line angles were stepwise finished with reciprocating 15  $\mu$ m diamond- and wolfram-coated safe-sided tips. The final polishing were the triangular pointed wooded tip (EVA-7) and fluoride polishing paste.*

### Case 2

A dentin carious lesion on the distal surface of the left mandibular first molar was visible on the radiograph (Fig 64). As the lesion was cavitated into the dentin a Class 2 amalgam restoration was made. Fig 65 shows the new filling, which was finished and polished according to the same methods, as shown in Figs 62 and 63. The final result is shown in Fig 66. Radiograph control after treatment is shown in Fig 67.



*Fig 64, Radiograph showing a dentin carious lesion at the distal surface of the left first mandibular molar (arrow). Cavitation into the dentin was diagnosed clinically.*



*Fig 65, A Class 2 amalgam filling was made.*



*Fig 66, The filling was finished and polished in similarity to the filling in Figs 62 and 63.*



*Fig 67, Radiographic control of the filling.*

These amalgam restorations made more than 40 years ago are still remaining in good condition and because of needs-related maintenance care no secondary caries has developed. From an esthetic point of view, but more costly, all ceramic inlays should have been a more recent therapy. However, it must be observed that there are still tremendous amounts of Class 2 amalgam restorations, which are poorly finished, particularly on the approximal surfaces. Therefore the above finishing methods should have to be implemented.

### *Recontouring and finishing of resin composite restorations*

#### Case 3

Fig 68 shows a diastema between the maxillary centrals, which the patient wanted to have closed. The approximal surfaces were briefly prepared with a 50  $\mu$ m diamond coated reciprocating tip (LTA-50) prior to etching the enamel. After bonding, a resin composite was placed and cured mesially of the right central (Fig 69). Thereafter a similar restoration was placed mesially of the left central. Thus the diastema was closed. A 50  $\mu$ m diamond coated reciprocating tip was used initially to shape the mesiobuccal and gingival areas (Fig 70) followed by a 15  $\mu$ m fine diamond reciprocating tip providing a smooth, continuous interface for the restorations. Final polishing was carried out with rotating rubber cup, triangular pointed reciprocating tips and fluoride containing polishing pastes. Fig 71 shows the final result.



Fig 68, A diastema between the maxillary centrals, which the patient wanted to be closed.



Fig 69

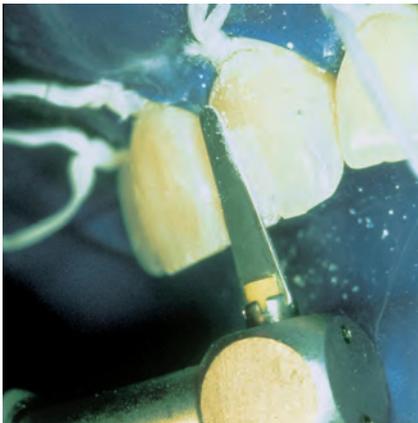


Fig 70, After closing the diastema with resin composite restorations, the diastema, was contoured and finished with reciprocating diamond-coated (50 µm and 15 µm – Fig 70) and wolfram-coated Lamineer tips. Polishing was carried out with rubber cups and triangular pointed reciprocating EVA-tips with polishing paste.



Fig 71, The final result. (Figs 68-71 – courtesy S Toreskog.)

For final finishing and polishing of resin composite restoration fine grit rotating discs (Figs 72 and 73) and rotating diamond impregnated, rubber instruments (Figs 74-76) could also have been used on the accessible surfaces. High speed rotating diamonds and finishing burs must not be used. In addition microfilled and hybrid composites must not be finished with fluted burs.



Fig 72

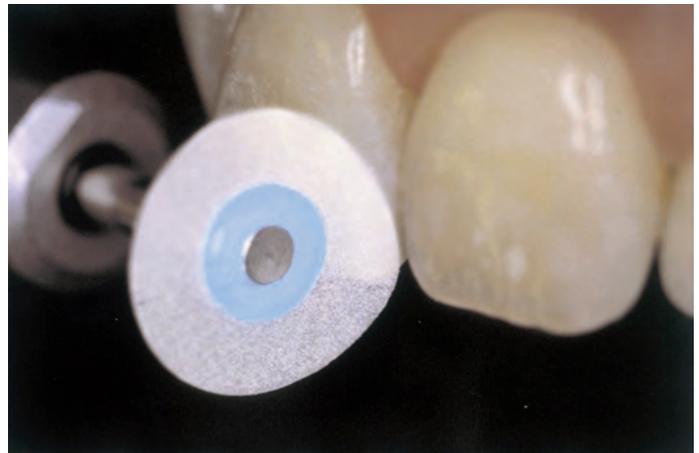


Fig 73, Flexible rotating discs with different abrasiveness for finishing and polishing of resin composites-, compomers and resin modified glassionomer restorations (OptiDisc®, Kerr Hawe Neos Dental, Switzerland).

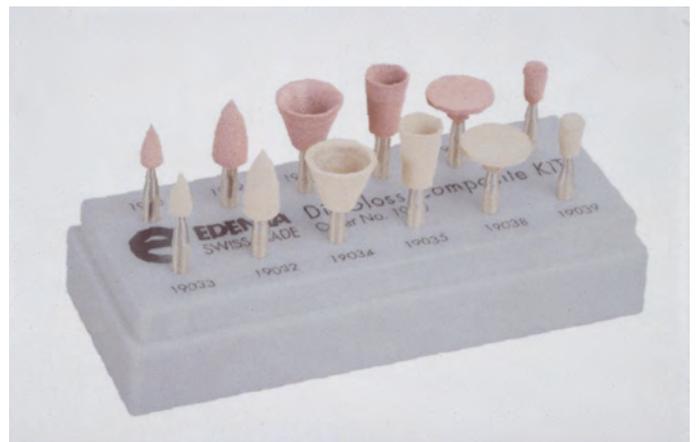


Fig 74



Fig 75



Fig 76, Assortment of elastic diamond impregnated points, cups and discs for finishing and polishing of resin composites (Dia Gloss® - Fig 74), extra fine polishing of composites (Top Gloss – Fig 75) and 3-step finishing and polishing of indirect restorations (Cera Gloss – Fig 76) by Edenta, Switzerland.

However it must be observed that all direct composite restorations have microscopic defects and porosities. Penetrating surface sealants (like the bonding agents) that are actually intended to seal the marginal gaps can also seal surface defects.

Therefore after finishing and polishing is completed, the entire surface of the filling and the margins are etched, washed, and dried. Then a thin film of composite surface sealants is placed and air dried, the contact points are cleaned with dental floss, and the resin is cured. Remains of the sealer at the gingival margin or in the proximal spaces must be removed.

*Finishing and polishing of indirect resin composite, all ceramic restorations and dual resin composite cement*

The following cases will exemplify material and methods for finishing and polishing related to indirect restorations.

#### Case 4

Fig 77 shows two mandibular molars which exhibited occlusal amalgam restorations and advanced secondary caries as shown in Fig 78 after removal of the fillings and excavation of caries. The floors of the deep cavities were filled up with resin composites (Fig 79). Then the height of the thin lingual cups was reduced in order to prevent from fracture and the teeth were prepared for indirect resin composite onlays.



Fig 77, Preoperative view of a mandibular quadrant. The two molars include extensive secondary caries.

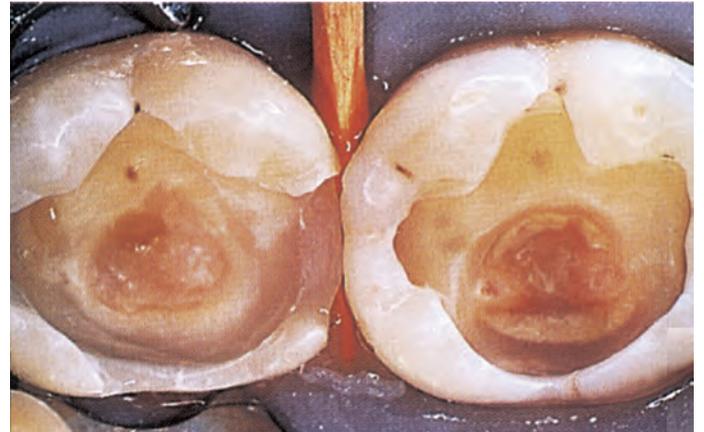


Fig 78, The cavities were prepared to receive a composite base. Given the reduced thickness of the lingual walls, these cusps were reduced in order to prevent from fractures.

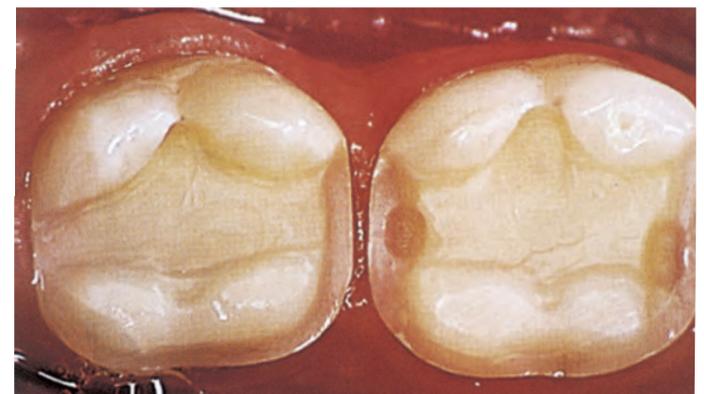
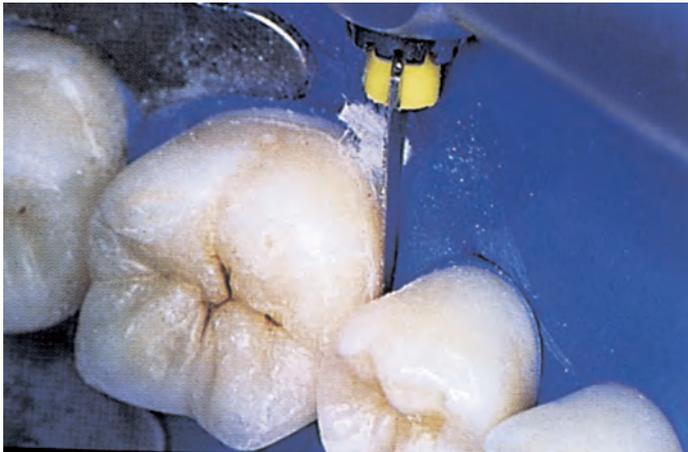


Fig 79, The completed preparations for two composite onlays.

After trying the onlays were placed with dual resin composite cement. The removal of excess luting cement, finishing and polishing of the approximal margins was carried out with the reciprocating Lamineer® extra fine diamond-coated (15 µm) tip (Fig 80) followed by a wolfram-coated (LTA-S36) and a reciprocating triangular-pointed plastic tip (EVA-2000) with fluoride polishing paste. At accessible surfaces rotating finishing discs and polishing brushes with fluoride polishing paste were used.



*Fig 80, After cementation of the onlays, the cervical luting excess was removed and the cervical margin finished with reciprocating extra fine diamond-coated (Lamineer LTA-15) and wolfram-coated safe sided tips. The margins occlusally, buccally and lingually were finished with rotating abrasive discs.*

As a contrast the reciprocating double knife-edged safe sided diamond and wolfram-coated tips (LTA-S – see Figs 51 and 52) have optimal accessibility between the papillae and the restoration for non-traumatic finishing, as shown in Fig 48. Subgingival approximal dual cured resin composite cement excesses are difficult to remove with rotating instruments and hand instruments without causing iatrogenic scratches (Fig 48). However, by using wolfram-coated reciprocating double-knife edged tips, the surfaces of the restoration and the natural tooth can be used as a guide until the luting excess is completely removed. That is because these tips are non-traumatic for the indirect restorations and the tooth enamel. The tips can be used horizontally as well as vertically (see Figs 81 and 82).



*Fig 82, The reciprocating safe-sided diamond- and wolfram-coated Lamineer tips can be used horizontally (Fig 81) as well as vertically (Fig 82) and diagonally.*



*Fig 81*

The margins of indirect restorations at approximal surfaces frequently have a subgingival location. That is because - particularly among posterior teeth with no or limited attachment loss the buccal and lingual papillae completely fill up the interproximal space, as earlier discussed (see Figs 22, 23, 48). Therefore rotative instruments have limited accessibility at approximal surfaces for recontouring, finishing and polishing the margins of the approximal surfaces of indirect restorations. In addition rotating diamond- and finishing burs may cause uncontrolled iatrogenic horizontal defects on the restoration as well as the natural tooth substance. (see fig 48)

On the occlusal, buccal and lingual surfaces the earlier discussed rotating discs, elastic instruments (tips, cups and disks) impregnated with diamond particles with different abrasiveness and cups or brushes with polishing pastes can be used for finishing and polishing.

#### Case 5



*Fig 83, An unesthetic temporary composite restoration on the buccal surface of a maxillary right central.*

The right maxillary central exhibited an old unesthetic temporary composite restoration (Fig 83). The tooth was prepared for a laminate veneer (Fig 84). After cementation of the porcelain laminate veneer with dual cured resin composite cement, the luting excess was removed and the margins finished by using the reciprocating lamineer diamond- and wolfram-coated tips (Fig 85). Fig 86 shows the final result after finishing and polishing.



Fig 84, The tooth was prepared for a ceramic laminate veneer.



Fig 85, The porcelain laminate veneer was placed with dual-cured composite cement. The luting excess was removed and the margin finished by using reciprocating safe-sided diamond- and wolfram-coated Lamineer tips.



Fig 86, The final result after finishing and polishing of the margins.

#### Case 6

Fig 87 shows a left maxillary central which was scheduled for a laminate veneer restoration for esthetic reason. After preparation a porcelain ceramic laminate veneer was made. Removal of cement excess, finishing and polishing of the margins was carried out in similarity to case 5 (Figs 87 and 90). Fig 90 shows the final result after removal of luting excess, finishing and polishing.



Fig 87, The left maxillary central scheduled for a laminate veneer restoration. A porcelain laminate veneer was made.



Fig 88

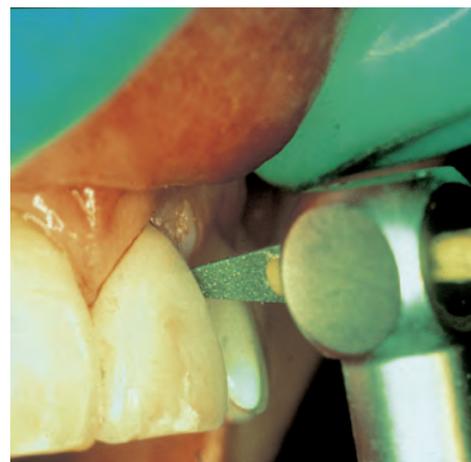


Fig 89, Removal of luting excess and finishing of the margin after cementation in similarity to Figs 85 and 86.



Fig 90, The result after finishing and polishing of the margins. (Figs 83-90 courtesy S Toreskog.)

It is recommended to apply fluoride varnish along the margins of direct as well as indirect restorations after finishing and polishing from caries preventive point of view.

## CHAPTER 7 Minimally Invasive Treatment of Caries Lesions

In order to minimize future plaque retention because of restoration overhangs, defect margins and unfinished fillings, we have to focus on the following principles: “prevention instead of extension” or at least “prevention before extension”. In determining whether invasive therapy is indicated the clinician must address the following questions:

1. How rapidly is the lesion progressing?
2. What is the size or depth of the enamel or dentin lesion?
3. Is the lesion non-cavitated or cavitated on approximal surfaces? This may be determined by temporary tooth separation. If no cavity is found by meticulous clinical examination on the approximal surfaces, there is no indication for invasive therapy.
4. What is the patient’s predicted caries risk and risk profile?
5. Why have the patient’s self-care and the professional preventive measures failed to prevent development of the lesion?
6. How can combined preventive efforts be improved to remineralize or at least arrest the lesion?
7. How much time should elapse before the outcome of preventive efforts is evaluated?

The final decision for invasive therapy should not be carried out until the lesion exhibits cavitation into the dentin on approximal and occlusal surfaces.

**RADIOGRAPHIC V/S CLINICAL CARIES LESIONS**

Clinical Score

		Clinical Score						Total
		1	2	3	4	5	6	
Radiographic Score	0	2	4					6
	1	6	21	16	5	2		50
	2	1	11	16	7			35
	3	1	5	22	23	7		58
	4				1	6	2	9

Fig 91, Comparison of radiographic and clinical scoring of approximal carious lesions. Radiographic scoring (Möller and Poulsen 1973; Gröndahl et al 1977): 0) no radiographic changes in enamel; 1) radiographic changes in enamel; 2) radiolucent lesion that has reached the dentinoenamel junction; 3) radiolucent lesion penetrating approximately halfway through dentin; 4) radiolucent lesion close to the pulp. Clinical scoring: (1, 2) progressive changes in enamel; 3) changes in dentin without cavitation in the enamel; 4, 5) changes in dentin and progressive cavitation in the enamel, ie, still no bacterial invasion of the dentinal tubules and no indication for invasive tooth preparation; 6) cavitation into dentin – possible indication for tooth preparation and restoration. (Modified from Bille and Thylstrup 1982.)

The second and third points in the above list were evaluated by Bille and Thylstrup (1982) in a study of 8- to 15-year-old children. The subjects were examined clinically and radiographically before undergoing regular dental care, including restorations. Approximal lesions were scored on the radiographs according to the following system, which is similar to the diagnostic scales proposed by Möller and Poulsen (1973) and Gröndahl et al (1977):

- Score 0: enamel with no radiographic changes
- Score 1: radiographic changes in enamel
- Score 2: radiolucent lesion reaching the dentinoenamel junction
- Score 3: radiolucent lesion penetrating approximately halfway through dentin
- Score 4: radiolucent lesion close to the pulp

During cavity preparation, drilling was discontinued when the maximal extent of the lesion could be seen on the base of the approximal box, cervical to the interproximal contact area according to the bitewing radiograph. With the help of an intraoral mirror and probe in normal clinical lighting, the tissue changes observed at the base of the approximal box were classified according to the 6-point clinical scoring system.

This became the "gold standard" for diagnosis of the approximal lesions:

- Score 1 and 2: progressive changes in the enamel
- Score 3: changes in dentin, without cavitation in the enamel
- Score 4 and 5: changes in dentin and progressive cavitation in the enamel (ie, at this stage no bacterial invasion of the dentinal tubules has occurred, and there is not indication for invasive intervention)
- Score 6: cavitation involving dentin (possible indication for "drilling, filling and billing")

The relationship between radiographic and clinical scores is shown as a cross-tabulation in Fig 91. Of 158 lesions, radiolucencies penetrating approximately halfway through the dentin (radiographic score 3) were found in only 58, and none of these exhibited clinical cavitation into the dentin (clinical score 6). Only two of nine lesions with a radiographic score of 4 had a clinical score of 6 (Bille and Thylstrup 1982). Other studies have shown similar results (Mejåre and Malmgren 1986; Pitts and Rimmer 1992).

These studies confirm the importance of not interpreting radiographic findings in isolation, to ensure that appropriate treatment decisions are made about approximal lesions. Rather, radiographic findings must be assessed in the context of data from other sources: temporary tooth separation and meticulous clinical visual examination as well as careful consideration of each of the seven questions listed earlier.

Of the 158 carious lesions scheduled for restoration, cavity preparation disclosed that 66% were without macroscopic cavitation. The changes observed by direct clinical inspection of the tissues during cavity preparation correlated poorly with accepted standardized radiographic criteria. Thus cavitation was observed in only 20% of lesions with radiolucencies involving the dentin, and all cavities were confined to the enamel.

Bille and Thylstrup (1982) concluded that: "assuming a macroscopical cavity into the dentin to be indicative of restorative treatment, the present results indicate that a more individualized treatment decision strategy than hitherto is warranted in populations attending comprehensive dental health care". Although this study was published in 1982, it seems to have had little impact on treatment decision making as taught in undergraduate dental education or as practiced by most general practitioners.

These studies confirm the importance of supplementing radiographic examination of approximal carious lesions with clinical inspection prior to treatment decisions. For ethical reasons, in the study by Pitts and Rimmer (1992) confirming the results from the study by Bille and Thylstrup (1982), visual inspection was achieved by using orthodontic elastometric separators for temporary tooth separation, instead of drilling. An unresolved question is not the detection of approximal caries, but at what stage restorative treatment is

indicated. Some dentists believe that all lesions should be restored, irrespective of extent. In regions where carious activity remains relatively high, operative intervention for an approximal lesion with a radiolucency confined to enamel is not unusual; elsewhere, it is considered unethical to restore such early lesions. To restore lesions that are not active and progressively extending through the enamel is tantamount to malpractice. For example a recent study in Sweden (Mějare et al 2004) showed that the yearly progression rates in adolescents and particularly young adults up to 27 years of age, is very slow. In other words, we have plenty of time to evaluate the outcome of improved preventive measures at risk-surfaces in such a population before invasive decision. That means "prevention before extension".

A majority of dentists consider that an appropriate end point for nonoperative intervention is radiographic evidence that the lesion has extended into the dentin. However, provided that there is no cavitation into the dentin, the dentinal tubules have not been invaded by microorganisms, and the lesion can still be arrested. Invasive intervention for noncavitated lesions of dentin should therefore also be regarded as malpractice. Generally it must be observed that no restorative material can adequately replace enamel and dentin, and their preservation should be paramount in any treatment plan. Thus prevention and hard tissue preservation must be the primary goals.

Close to 100% of fissure caries in molars are initiated during the extremely long period of eruption (12 months for 1st molars and up to 18 months in 2nd molars) compared to premolars (about 3 months). The risk is over if the fissures are maintained caries free up to full eruption and exposed to chewing abrasions. In fissures it has been suggested that sealing of apparently active caries lesions (particularly enamel caries and non-cavitated dentin caries lesions) may be sufficient to arrest progress. However it has been shown that almost 100% of active occlusal caries lesions in erupting first molars were arrested by semi professional mechanical cleaning by the parents, needs-related intervals of PMTC and fluoride painting in a three years RCT studie (Carvalho et al 1992 – Fig 92). The use of fissure sealant in fully erupted caries free molars is a costly over treatment

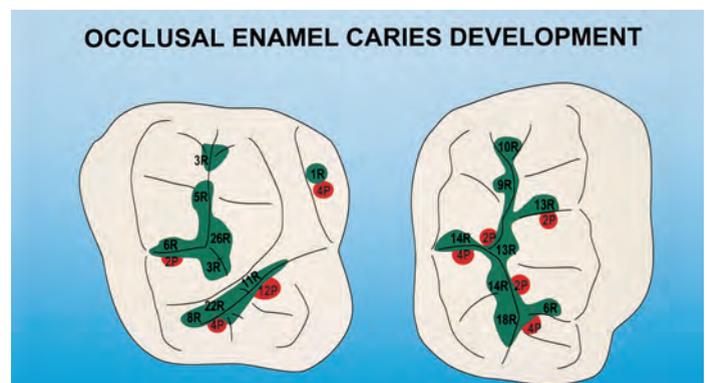


Fig 92, Development of occlusal enamel caries in children in a non-invasive preventive program. (Green [R]). Remineralized or arrested caries; (Red [P]). Enamel caries that has not progressed to cavitation. (Modified from Carvalho et al 1992 with permission.)

Conversely, an approximal lesion may not have adequate access without temporary separation. As shown in Fig 91 cavitation of the enamel surface is likely to occur late in the process of demineralisation, but once the surface does break down it will be no longer possible to prevent further plaque accumulation and invasive intervention will be required when the dentine is cavitated and as a consequence infected. However, regardless of the extent of the cavity, traditional Class 2 preparation should no longer be regarded as mandatory. It is only necessary to gain access to the caries lesion, and remove those areas of enamel and dentine which are infected, degraded and broken down to a point where they are beyond remineralization. Demineralized enamel surrounding the cavity, and demineralized dentin at the base of the cavity, should be regarded as “pre-carious”, because they can be remineralized and therefore retained. Also, as an adhesive restorative material is to be placed, there will be no need to remove undermined enamel, because it may be able to be supported by the restoration. Both the occlusal load and the wear factor should be taken into account for any particular situation, but as much original tooth structure as possible must be retained.

As shown in the earlier discussed study by Bille and Thylstrup (1982 – Fig 91) only 7 out of 58 carious lesions into the outer half of the dentin according bitewing radiographs (score 3) were cavitated into the enamel (clinical score 5) and none into the dentin (clinical score 6). Therefore temporary tooth separation should be supplemented before the decision of invasive therapy is taken, as non-cavitated approximal lesions can and should be remineralized and cavitation into the enamel arrested.

Therefore a new minimal invasive method ad modum P Axelsson (1995, 1999) was proposed for treatment of approximal carious lesions. The following example illustrates recommended procedures for non-cavitated approximal lesions of enamel and dentin and for lesions with limited cavitation: in a new patient, bitewing radiographs reveal one or more posterior approximal lesions in the outer half of the dentin. Meticulous clinical visual examination discloses no cavitation.

At the same or the following appointment, plaque is mechanically removed by Professional Mechanical Tooth Cleaning (PMTC), in which reciprocating EVA tips are used on the affected approximal areas (Fig 93). A slow-release chemical plaque control agent (Cervitec-1% chlorhexidine-thymol varnish) is applied to these surfaces to destroy the remaining cariogenic microorganisms (Fig 94). An orthodontic elastometric separator is then inserted for temporary elective tooth separation to allow clinical visual inspection after 3-5 days (see Figs 95-97).

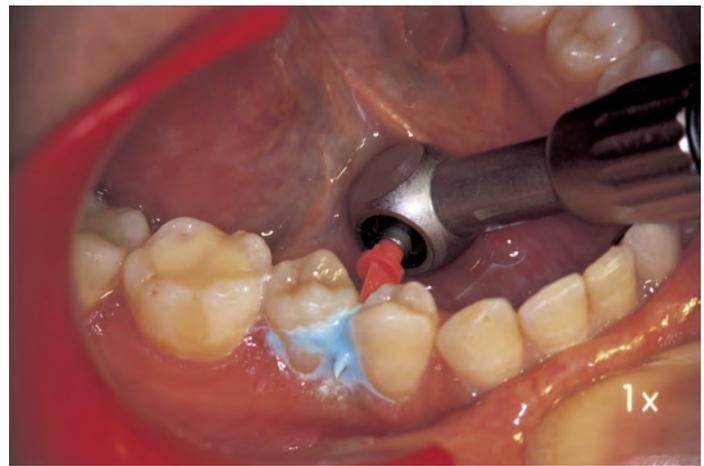


Fig 93, After application of fluoride prophylaxis paste interdentally PMTC is carried out on the approximal surfaces

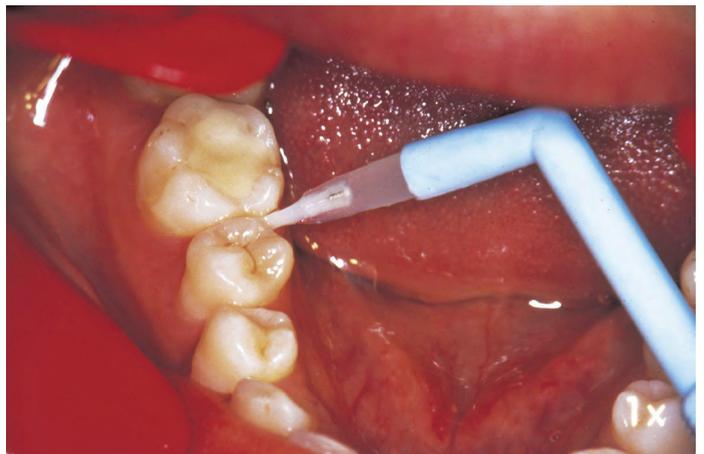


Fig 94, Application of a slow-release chemical plaque control agent (Cervitec® CHX-Thymol varnish) to destroy cariogenic organisms on the decayed approximal surfaces after PMTC.

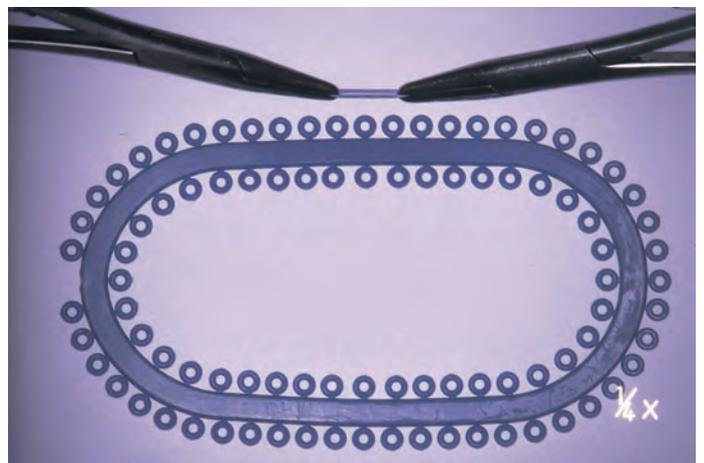


Fig 95, Orthodontic elastomeric separators for temporary tooth separation. Different sizes are available for molars and premolars.

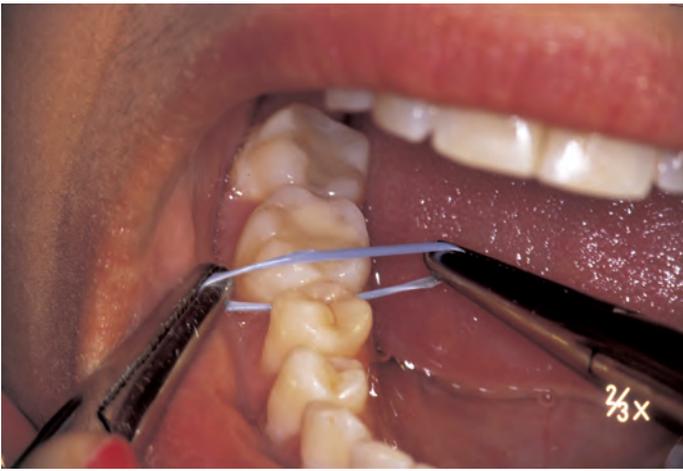


Fig 96, The application is facilitated by stretching the elastomeric separator with two surgical forceps.



Fig 97, The elastomeric separator in situ. (It remains for about 3 days in premolars and 5 days in molars.)

At the second appointment, after PMTC, the approximal surfaces are inspected directly. Elastometric impressions may be taken, to allow replication as records for future reference. Lesions showing no cavitation are coated with chlorhexidine and fluoride varnish (Cervitec + Fluor Protector) to remineralize and seal the outer micropore surface of the lesions (see Fig 98). A second alternative could be etching and use of resin sealant for sealing the surface in similarity to fissure sealants. If limited cavity is diagnosed, it is mechanically cleaned with a small ball-shaped finishing bur and filled with light-cured glass-ionomer cement, placed under pressure from a translucent matrix band. After it is finished with an extra thin tungsten-coated reciprocating tip, these surfaces are coated with chlorhexidine and fluoride varnish to remineralize and “seal” the surface of the surrounding, non-cavitated enamel lesions (see Fig 99).

#### PREVENTION INSTEAD OF EXTENSION

ad modum : Axelsson (1995)

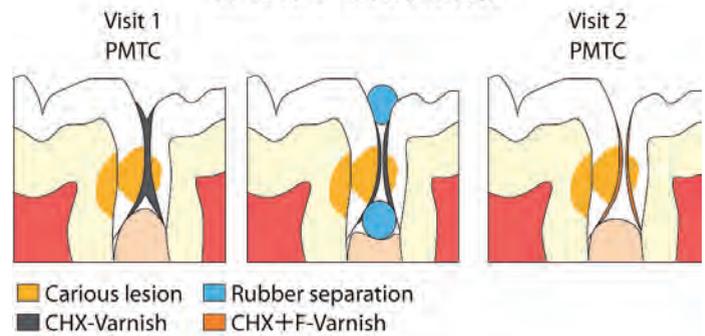


Fig 98, During temporary tooth separation no cavitation of the lesion was discovered. Thus “prevention instead of extension”. (PMTC) Professional Mechanical Toothcleaning; (CHX) chlorhexidine varnish; (F) fluoride varnish. (From Axelsson 1999.)

#### ATRAUMATIC Restorative treatment (ART)

ad modum : Axelsson (1995)

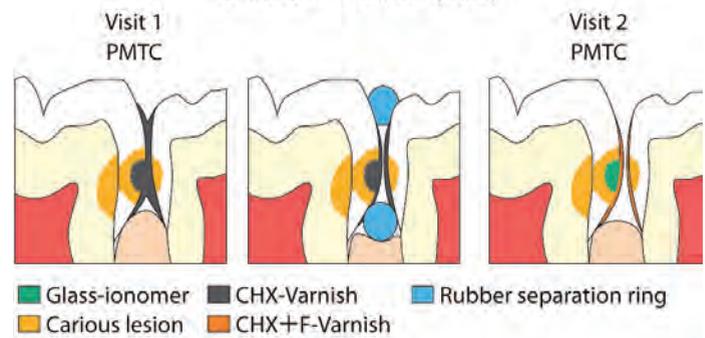


Fig 99, During temporary tooth separation a limited cavity surrounded with incipient caries was discovered. Thus atraumatic restorative treatment with rotating finishing bur and flowable resin modified glassionomer cement. (From Axelsson 1999.)

Later Ekstrand and Martignon (2004) by using temporary tooth separation for accessibility evaluated the effect of sealing with a resin sealer on non-cavitated approximal caries lesions in young adults. Based on bitewing radiographs 77% of the sealed lesions were unaltered after 1½ year compared to only 28% of randomized control lesions. In primary molars they showed that resin infiltration + fluoride varnish was superior to fluoride varnish only on superficial approximal lesions (Ekstrand et al 2010).

For details see Axelsson 1999, 2000, 2004.

## CHAPTER 8

### Minimally invasive treatment of periodontal diseases

#### Minimally invasive alternatives for scaling, root planing and debridement

There is a need for a new approach, based on the concept of “minimally invasive” subgingival instrumentation. For rational elimination of subgingival plaque-retentive factors and microflora by scaling, root planing, and debridement, and to minimize iatrogenic defects, a sharp universal curette hand instrument should be used as a probe for identification of calculus. (Fig 100)

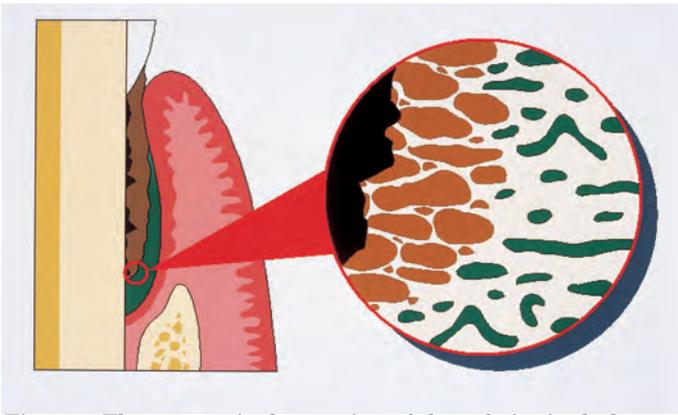


Fig 100, The most apical extension of the subgingival plaque biofilm in the diseased periodontal pocket. The inner dark part of the plaque is mineralized (original magnification x400). (From Listgarten 1976. Reprinted with permission.)

Whenever located, this calculus should be carefully “lifted away” as a first step in new untreated patients. A piezoelectric ultrasonic scaler could also be used for gross scaling, but for final scaling, root planing, and debridement, the instrument of choice should be as minimally invasive as possible. However, it must be observed that for example in Sweden about 80-90% of the adults are maintenance patients with no or limited need for rough scaling, but at the most debridement. Fig 101 illustrates the difference between invasive and non-invasive instruments for scaling, root planing and debridement. Reciprocating PER-IO-TOR instruments (Dentatus, Sweden), designed with plane load-relieving surfaces between essentially right-angled cutting edges, are examples of non-invasive instruments. Once the root cementum is planed and thereby clean, no further root cementum will be removed. Different shapes and sizes facilitate access to concave and convex surfaces as well as to furcation areas (Figs 102 and 103). The reciprocating instruments are used in the EVA-Profin contra-angle handpieces (Fig 104 – Dentatus, Sweden). Also available are rotary instruments based on the same principles (Figs 105a - 105c) (Axelsson 1993).

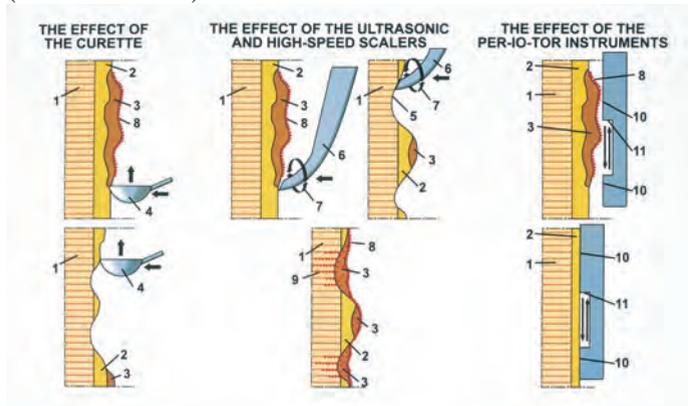


Fig 101, Difference between invasive and non-invasive instruments for scaling, root planing and debridement. 1 = Root dentin with dentinal tubules; 2 = Root cementum; 3 = Calculus; 4 = Curette hand instrument; 5 = Iatrogenic rough, exposed dentin and dentinal tubules; 6, 7 = Ultrasonic or high-speed scaler; 8 = Subgingival plaque biofilm; 9 = Bacterial invasion of the dentinal tubules; 10, 11 = Principal design of reciprocating PER-IO-TOR instruments.

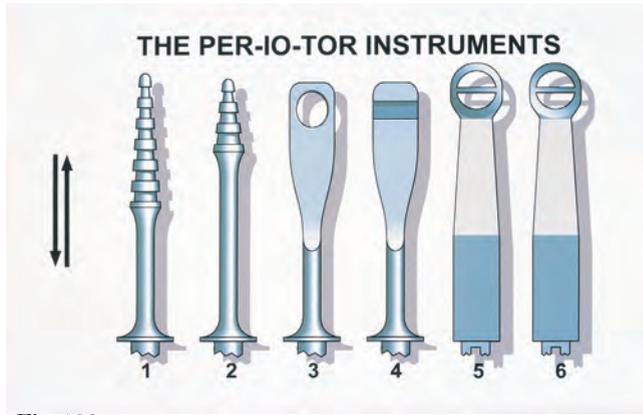


Fig 102



Fig 103



Fig 104

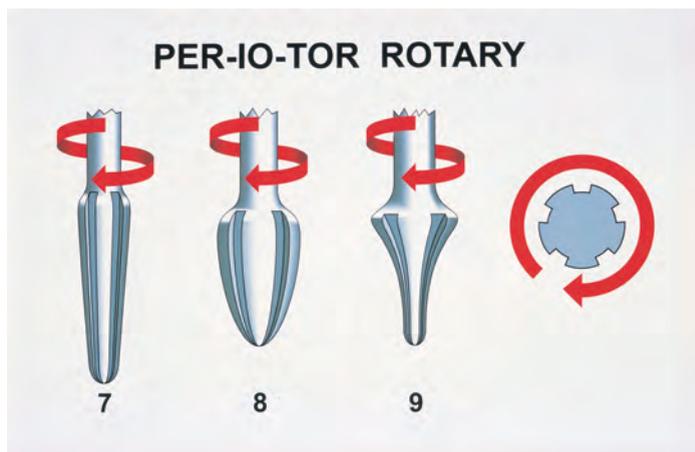


Fig 105a

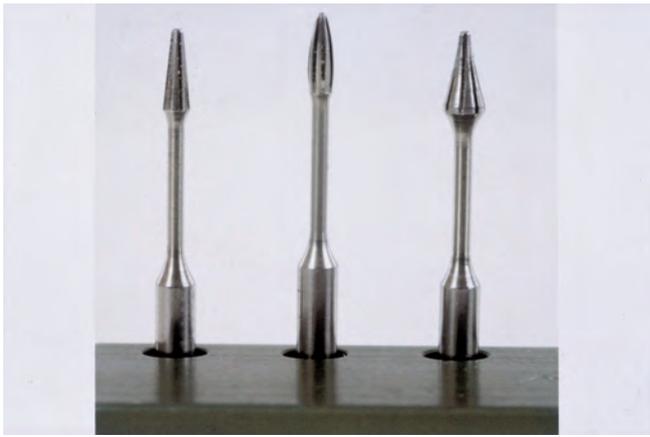


Fig 105b

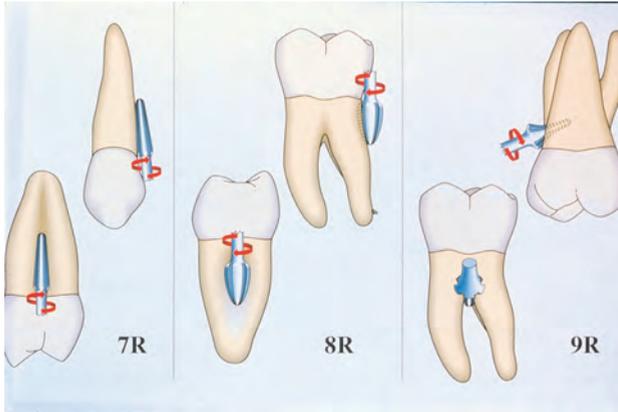


Fig 105c

In an in vitro study, Jotikastihira et al (1992) evaluated root surface roughness and loss of tooth substance after treatment with sonic scalers (Phatelius, Nakanishi Dental, Japan; Sonic Flex, KaVo, Germany; and Titan-S), ultrasonic scalers (Hygienist III, Lysta, Denmark, and Cavitron with TFI-EWPP tip), and PER-IO-TOR reciprocating instrument (PER-IO-TOR 4, spatula shaped). For evaluation, the Roughness Loss of Tooth Substance Index (RLTSI) (Lie and Leknes 1985), was applied, according to the following criteria:

0 = There is a smooth and even root surface, without marks from the instrumentation and with no loss of tooth substance.

1 = There are slightly roughened or corrugated local areas confined to the cementum.

2 = There are definitely corrugated local areas where the cementum may be completely removed, although most is still present.

3 = There is considerably loss of tooth substance, with instrumentation marks into the dentin. Large areas of the root are completely denuded of cementum, or there are a considerable number of lesions from instrumentation.

The PER-IO-TOR 4 spatula-shaped instrument, followed by Cavitron with TFI-EWPP probe-shaped tip, resulted in less roughness and loss of tooth substance than did the other instruments used, and were considerably less invasive than the sonic scalers (Fig 106).

### ROUGHNESS/LOSS OF TOOTH SUBSTANCE SCORES

Jotikastihira et al JCP 1992

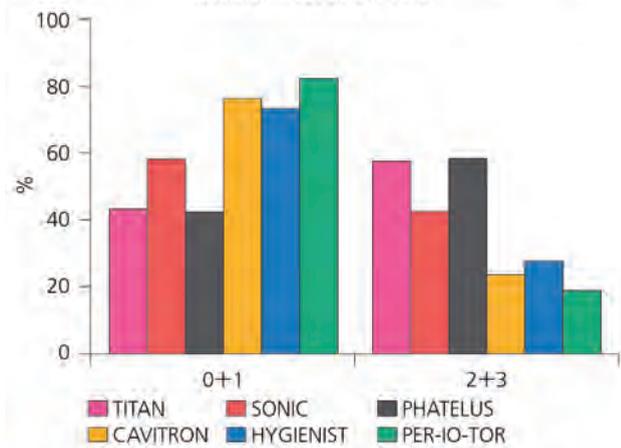


Fig 106, Roughness and loss of tooth substance after instrumentation. 0 or 1 = Smooth or slightly roughened cementum surface; 2 or 3 = Definitely corrugated or completely removed cementum. (From Jotikastihira et al 1992. Reprinted with permission.)

In another in vitro study, Mengel et al (1994) evaluated removal of root substance by PER-IO-TOR instruments used at standardized speeds and application forces. When used non-stop for 2 or 3 minutes, PER-IO-TOR3 removed on average only 4  $\mu$ m, and PER-IO-TOR 1, 2 and 4 less than 7  $\mu$ m of root substance, ie, the approximate amount that has to be removed to plane the rough outer surface of the root cementum (Fig 107). PER-IO-TOR instruments prevent untoward removal of root cementum during root planing and debridement, whereas 10 to 20 strokes with a sharp curette (see Fig 108) or the application of an extra fine, diamond-coated rotary tip for less than 1 second will completely denude the root cementum.

### LOSS OF ROOT CEMENTUM AFTER 2-3 MIN. SCALING AND ROOT PLANING WITH THE PER-IO-TOR INSTRUMENTS.

Menger et al. JCP 1994

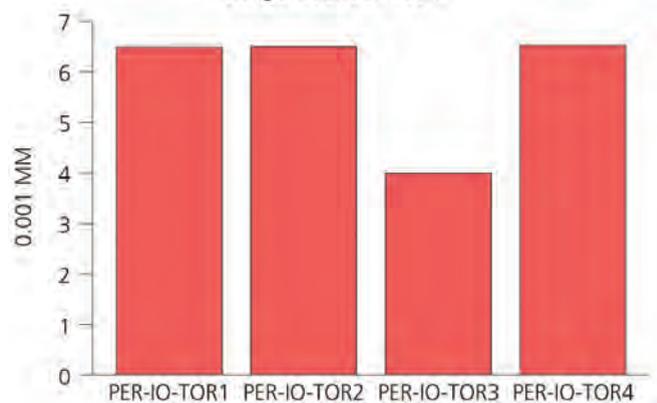


Fig 107, Loss of root cementum after 2 or 3 minutes scaling and root planing with PER-IO-TOR 1-4 instruments. (Modified from Mengel et al 1994. Reprinted with permission.)

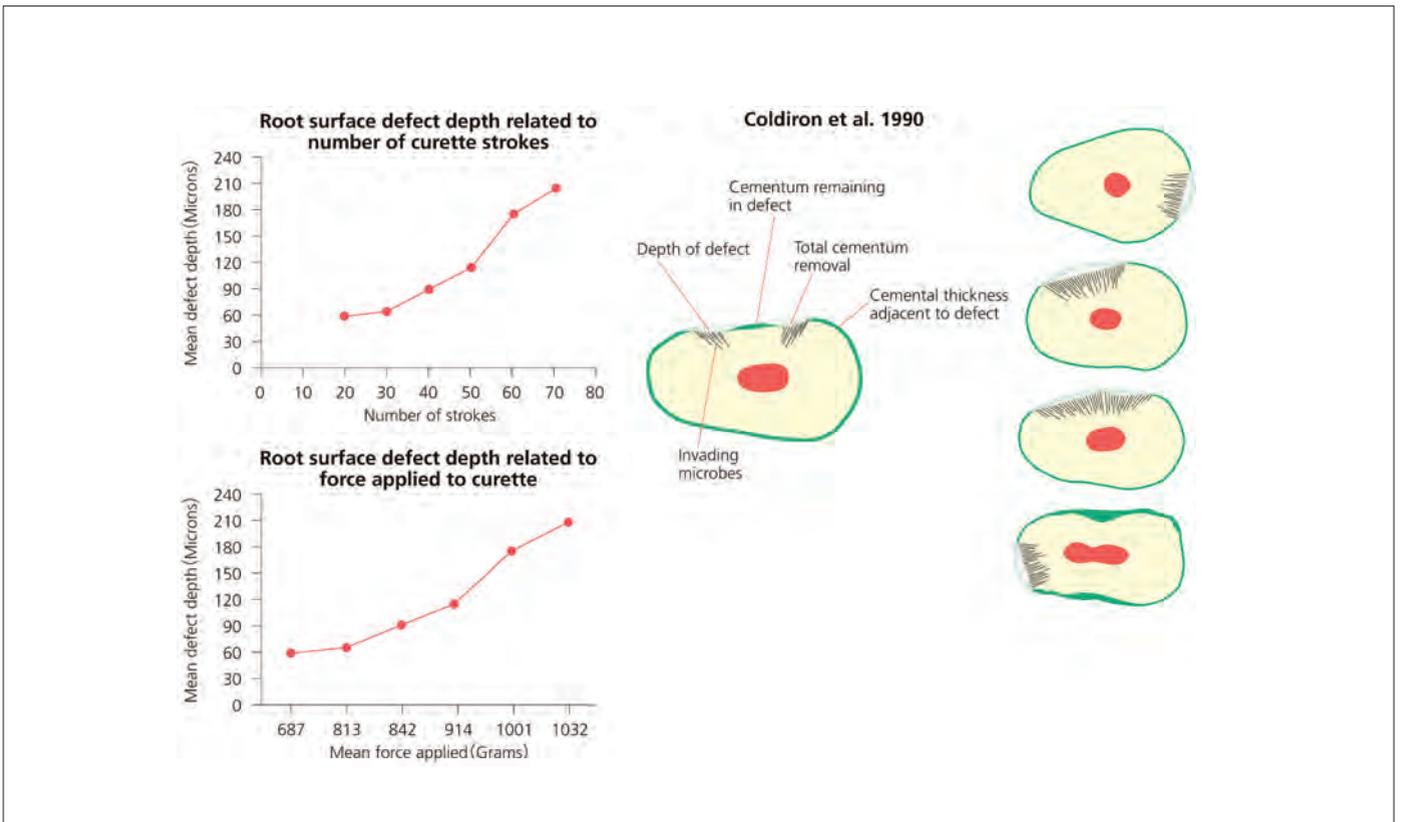


Fig 108, Root surface defect related to the number of curette strokes (a) and force applied to the curette (b). Typical types of root defects formed by the curette during root planing are shown (right). (Modified from Coldiron et al 1990.)



Fig 109a, 109b, The longterm outcome of repeated “aggressive” scaling on the mesial rootsurface of the maxillary right cuspid (13) and the distal rootsurface of the maxillary right lateral (12) (Fig 109a) after 6 years, and 25 years (Fig 109b). Observe the gradually increased size of the interproximal alveolar bone loss, loss of root substance and increased secondary dentin formation in the root canal in order to protect the root pulp. (Courtesy by G Heden.)

Fig 110a, 110b, Radiographs illustrating the total failure of scaling a maxillary left lateral (22) with very advanced loss of alveolar bone (Fig 110a) in spite of two years of repeated extremely invasive non-surgical scaling (Fig 110b). (Courtesy by G Heden.)

Teflon-coated sonic scalers are specially designed for non-invasive subgingival debridement (mainly removal of subgingival biofilms). Because of the extremely low aggressivity these instruments are not suitable for scaling and rootplaning.

In an experimental clinical study Kocher et al (2001b) compared the roughness and topography on approximal root surfaces after subgingival instrumentation with different instruments in severely periodontally diseased teeth, which had to be extracted. One approximal surface of each tooth was instrumented with either 1) Sharp Gracey curette handinstruments (C) (Hu Friedy, Chicago, USA), 2) PER-IO-TOR no 3 reciprocating tip (PT) (Dentatus, Sweden), 3) a sonic scaler (SS) (Soniflax 2000®, KaVo, Biberach, Germany), 4) a piezoelectric ultrasonic scaler on medium power (US) (Perio Sonosoft Lux, KaVo, Biberach, Germany), or 5) a sonic scaler insert coated with a heat-shrunk Teflon tube (tss) (Prototype Kocher et al 2000). After extraction the instrumented approximal surface was also compared with the untreated periodontally diseased approximal surface of the same tooth, which had to be free of calculus and organic material.

The roughness values Ra showed that curettes (C) and the PER-IO-TOR instrument (PT) produced the smoothest surfaces (Ra about 1.5 µm). The other four instruments created a similar roughness of about 3 µm. The untreated root surfaces exhibited an Ra value similar to those treated with conventional sonic and ultrasonic instruments. Only the curettes and the PER-IO-TOR instruments obviously smoothed the surface in comparison to an untreated control surface.

In a supplementary study Kocher et al (2005) evaluated how much of the cementum thickness was removed of the above instruments: curette handinstruments (H), ultrasonic scaler (US) sonic scaler (SS), Teflon coated sonic scaler (tss) and the PER-IO-TOR instrument (PT) compared to the untreated cementum.

The results showed that the Teflon-coated sonic scaler and the PER-IO-TOR instrument followed by ultrasonic scaler with medium power removed less root cementum than the handinstruments and the sonic scaler. While 90 to 95% of the root cementum thickness remained after instrumentation with PER-IO-TOR (PT) and the Teflon coated sonic scaler (tss) only 10% remained after the use of the curette handinstrument (H). The PER-IO-TOR instrument resulted in the smoothest surfaces (Ra µm).

Special plastic curette handinstruments are also available for non-invasive subgingival debridement (removal of biofilms) on natural teeth and particularly implants in maintenance patients (Universal Perio Soft scaler, Hawe-Neos Dental, Switzerland). In a short term clinical study in maintenance patients similar results were achieved after one single debridement with these instruments as standard stainless steel curettes (Burdet et al 1999).

A clean and smooth root cementum is of great importance for good healing of diseased periodontal pockets and for successful non-invasive debridement if subgingival plaque biofilms are reformed. However the thickness of the cementum in the coronal third of the root is originally only 0.03 to maximum 0.1 mm. Therefore only a total of 10-20 strokes with a sharp curette (Calderon et al 1990 – Fig 108) and 5-10 rotations with a 15-micron grit diamond bur (Ritz et al 1991) may result in the complete removal of the root cementum. Figs 109 a, b and 110 a, b show the failure of longterm aggressive repeated invasive scaling, when gingival plaquecontrol was insufficient. This can lead to an infection of the pulp (Adriaens et al 1988 a and b, - see Figs 111 and 112; Hirsch 1989). Additionally, microflora and their toxins in infected root canals may go the other way, which will lead to disturbance in the healing of the periodontitis (Ehnevid et al 1995) – and maybe reduce the success of regenerative therapy. Supragingivally removed root cementum and exposed bacterial invaded dentinal tubulus may increase the risk for root caries development.

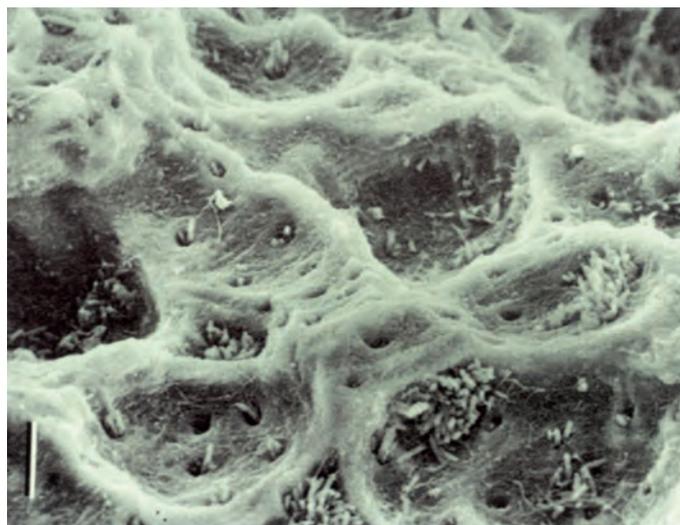


Fig 111, Invasion of bacteria in dentinal tubules via apertures denuded of cementum during invasive scaling and root planing (Fig 111) bar = 10 µm; (Fig 112) bar = 1 µm. (From Adriaens et al 1988b. Reprinted with permission.)



Fig 112, Invasion of bacteria in dentinal tubules via apertures denuded of cementum during aggressive scaling and root planing (Fig 111) bar = 10 µm; (Fig 112) bar = 1 µm. (From Adriaens et al 1988b. Reprinted with permission.)

Significantly more subgingival plaque biofilms will reaccumulate subgingivally on root surfaces with heavy iatrogenic grooves after invasive instrumentation (rotating diamond burs) compared to less invasive instrumented root surfaces (Curette handinstrument) (Leknes et al 1994 – see Figs 113 – 115 ). Even supragingivally the plaque reaccumulation is significantly correlated to the surface roughness (Quirynen et al 1990, Quirynen and Bollen 1995).

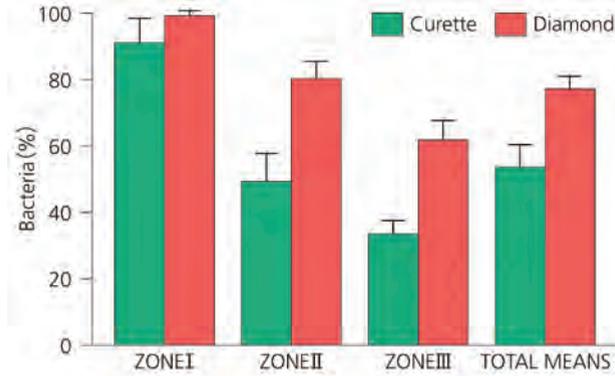


Fig 113, Graph showing the amount of reaccumulated subgingival plaque biofilm after instrumentation with curette compared to rotating diamond on the most coronal 1/3 of the subgingival rootsurface (zone I), the middle 1/3 (zone II) and the most apical 1/3 (zone III). (From Leknes et al 1994. Reprinted with permission)

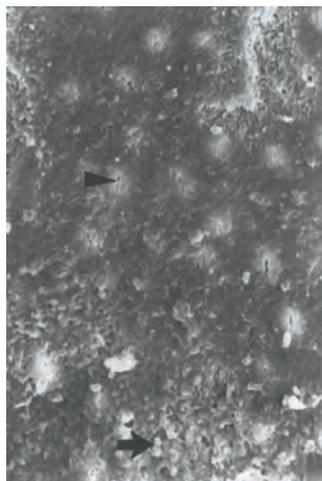


Fig 114, Curretted specimen from zone III. Some isolated cocci are visible (arrow), but considerable parts of the surface are devoid of organisms. Smear apertures of dentinal tubules are also visible (original magnification x 1 500). (From Leknes et al 1994. Reprinted with permission.)

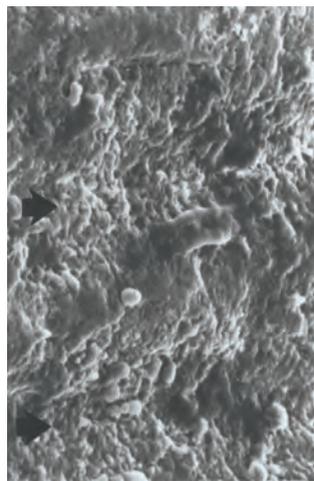


Fig 115, Diamond-treated specimen from zone III. Multilayered aggregates of bacteria are located in horizontal instrumentation grooves (arrows) (original magnification x 1 500). (From Leknes et al 1994. Reprinted with permission.)

It must be observed that "horizontal" iatrogenic roughness may result in irregular lateral migration of unaccasable plaque biofilms and loss of periodontal support (fig 116a, b)



Fig 116a

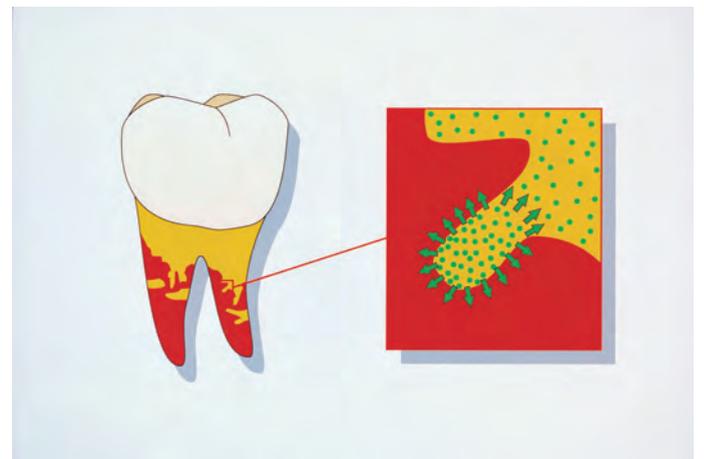


Fig 116b, Iatrogenic grooves and other roughness on the root surface may result in irregular lateral as well as apical migration of inaccessible subgingival plaque biofilms resulting in irregular loss of periodontal support.

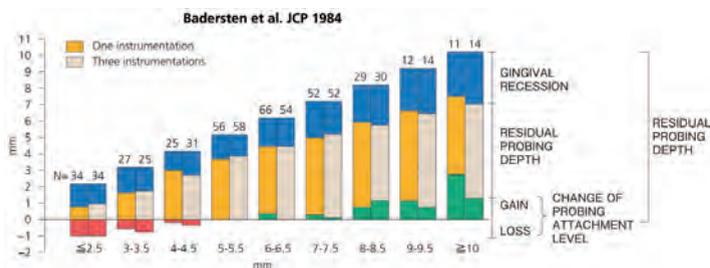


Fig 117, Mean amounts of gingival recession, residual probing depth and gain/loss of probing attachment level at 24 months in relation to initial probing depth. (Modified from Badersten et al 1984b with permission.)

Invasive scaling and root planing should only have to be performed initially in patients with untreated periodontitis. Repeated invasive scaling and root-planing must be regarded as a failure. The study by Badersten et al (1994) showed that the longterm effect on periodontal attachment and pocket depth in patients with advanced periodontal disease of one initial scaling, root planing and debridement was at least as successful as three initial repeated instrumentations with one month intervals, particularly in the deepest pockets, when excellent gingival plaque control was established by selfcare and needs related intervals of Professional Mechanical Plaque Control (PMTc) for two years (see Fig 117). Thus it may be concluded that the need of scaling and root planing should be very limited in practices with a majority of maintenance patients. In maintenance patients at the most “non-invasive” subgingival debridement (removal of reformed subgingival biofilms) should be necessary in a few sites, where gingival plaque control by self care and PMTC has been failing and scaling restricted to supragingival calculus lingually in mandibular anterior teeth and buccal surfaces of maxillary molars in fast “salivary-calculus” formers. From this point of view it may be observed that for example about 90% of the adult patients in Sweden should be regarded as maintenance patients and a majority receive needs-related supportive care by dental hygienists. The earlier mentioned PER-IO-TOR instruments (see Figs 102-105c – Dentatus, Sweden) have been designed in order to supplement and solve some of the problems related to instrumentation with hand instruments,

sonic and ultrasonic scalers, rotating diamond burs etc. The basic concept is illustrated in Fig 101. The instruments are mechanically driven with reciprocating strokes of 1-1.5 mm length. The instrument inserted into the periodontal pocket against the subgingival plaque biofilms and calculus on the rough root cementum, is designed so that when the working side faces the root surface, plaque biofilms and calculus can then be scraped off and the rough root cementum planed when reciprocating the instrument in the direction of the arrows along the root. But further removal of root cementum is prevented as soon as the root cementum is cleaned and planed because of the special design. The working parts are the essentially right-angled cutting edges formed between the opposed side walls of a recessed groove and the smooth aligned areas and of the working side of the instrument. When plaque biofilm and the calculus have been removed and the root cementum is planed, the surface parts will contact and rest against the flat faces of the root cementum surface and will form load-relieving surfaces taking up the pressure of the tool and keeping back the cutting edges. In the continued use of the instrument, these parts of the instrument will slide along the tooth surface and the cutting edges will not perform any further scraping action, thus preventing removal of root cementum of any significant degree and exposure of the dentine, in contrast to more invasive instruments such as handinstruments, ultrasonic scalers etc, which remove mineralized tooth substance, cementum as well as root dentin, continuously when they are used as earlier illustrated in Fig 101.

The specific characteristic of the PER-IO-TOR® reciprocating instruments (Figs 102 - 104) are:

- Specially designed reciprocating instruments which will optimize cleaning and planing of the rough root cementum and prevent further removal of root cementum once the surface is clean and smooth. Therefore, there are grooves with right-angled cutting wedges between smooth plane surfaces.
- Special size, shape and assortment of instruments, allowing access to any area of the diseased and rough root surfaces.
- Mechanically driven instruments with 1-1.5 mm reciprocating strokes which are easy to use and do not cause ergonomic problems (Axelsson 1993).

### The use of the PER-IO-TOR instruments

The PER-IO-TOR® precision surgical stainless steel instruments are designed for use in the new PROFIN® contra-angle handpiece (Fig 104) – modification of the EVA contra-angle handpiece – or the original EVA® contra-angle handpiece. In the latter, the instruments are self-steering because they can freely rotate 360° during the reciprocating movement and automatically follow the shape of the tooth surfaces. The PROFIN® contra-angle handpiece is similar to the EVA® contra-angle hand-piece, but in addition, the instruments can even be locked in six secured angles or positions during the reciprocating movement. Both the handpieces will result in 1-1.5 mm reciprocating strokes of the instruments.

The speed of the instrument should be adjusted to what is comfortable for both the patient and the operator. However, the recommended speed should be between 10.000 – 15.000 rpm, equalling also 20 000 – 30 000 single strokes per minute. The new handpiece is equipped with waterspray and some versions also with fiber light. However heat is not a problem with low speed reciprocating instrument in the wet environment subgingivally in contrast to rotating instruments and ultrasonic scalers.

Initially it is recommended that the operator should practise the use of the different PER-IO-TOR® instruments with a water spray on wet teeth without old, heavy amounts of calculus directly after extraction and disinfection, but without dehydration of the root surface – ie under conditions which resemble the in vivo clinical setting: the root surface contaminated by saliva, exudates, blood etc.

**Note:** The speed must not be too low, as vibration could cause patient discomfort. Higher pressure is necessary than for the other tips and instruments of the PROFIN® Directional – and EVA® systems. (Dentatus, Sweden). In contrast to sonic scalers and particularly the ultrasonic scalers, the tactile feeling is superior during the use of the PER-IO-TOR instruments.

**Note:** Gross scaling, using hand – or ultrasonic instruments could be the first rational step in scaling for new patients with heavy deposits of calculus (Figs 118a-118b). Then the final detailed scaling, root-planing and debridement procedures are carried out with the PER-IO-TOR® instruments. In maintenance patients (90% of the Swedish adult population) initial, gross scaling should not be necessary, if initial treatment and the needs-related maintenance program have been effective. The demanding, time-consuming conventional subgingival scaling and root-planing procedure should be necessary only once, (Badersten et al 1984). Only a few risk surfaces with recurrent periodontal disease may need an extra light non-invasive subgingival scaling and root-planing but mostly only removal of reformed subgingival biofilms by debridement using the PER-IO-TOR® instruments is necessary.



Fig 118a, Clinical demonstration of the turning technique during instrumentation of mandibular teeth.



Fig 118b, Clinical demonstration using two hands grip for a well-controlled instrumentation of maxillary teeth.

PER-IO-TOR no 1 and no 2 are circular, tapered instruments with circumferential ridges and specially designed for access to root grooves and furcation areas (Fig 119). PER-IO-TOR no 1 is thinner than PER-IO-TOR no 2. The instrument is specially designed for access and treatment of root surfaces with root grooves, in narrow bone pockets and furcation areas. For example, the instrument gives good access for treatment of the mesial root surfaces of the first maxillary premolars and the distal root surfaces of the second maxillary molars, which are normally difficult to reach for subgingival scaling and root-planing.

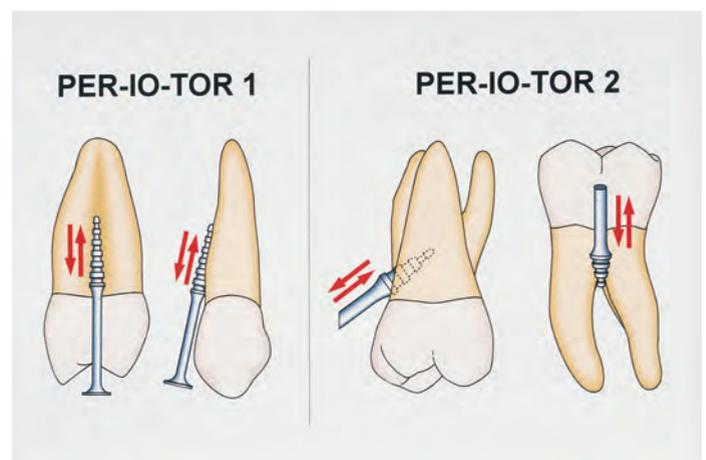


Fig 119, Illustration of how PER-IO-TOR 1 and 2 can be used.

Fig 120 show the spatula-shaped PER-IO-TOR no 3 and no 4. PER-IO-TOR no 3 is an extra-thin eyelet spatula-shaped instrument to be used horizontally or diagonally on flat or slightly convex approximal surfaces, in very narrow interproximal spaces where the thicker spatula-shaped PER-io-TOR no 4 has no access, for example, in the mandibular incisors.

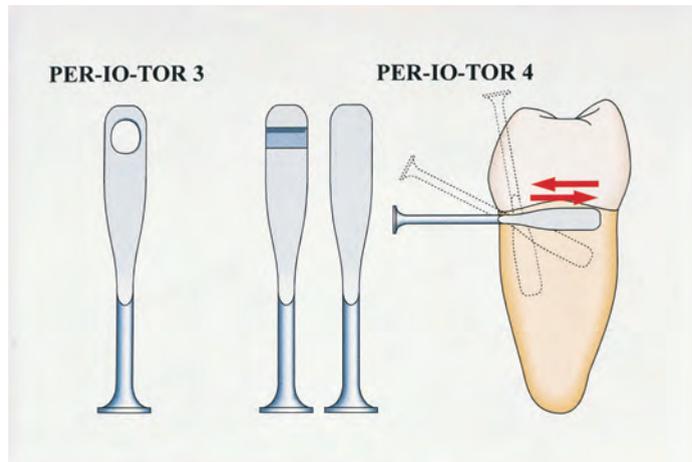


Fig 120, Illustration of how PER-IO-TOR 3 and 4 can be used.

PER-IO-TOR no 4 is a spatula-shaped instrument with a groove on the working side. It is thicker, but more efficient than PER-IO-TOR no 3. Therefore, this instrument is the first choice for every accessible flat or convex approximal surface. It can be used horizontally, as well as diagonally. Even vertical instrumentation can be carried out on root surfaces, where the crown of the tooth does not block the correct direction parallel to the root surface (Fig 121).



Fig 121, PER-IO-TOR no 4 used vertically on the distal surface of a maxillary central incisor.

**Note:** It is very important to control that the working side with the notch is pressed against the root surface before starting treatment.

PER-IO-TOR no 5 (Fig 122) has a concave working surface for vertical use on convex buccal and lingual surfaces as well as on the line angles.

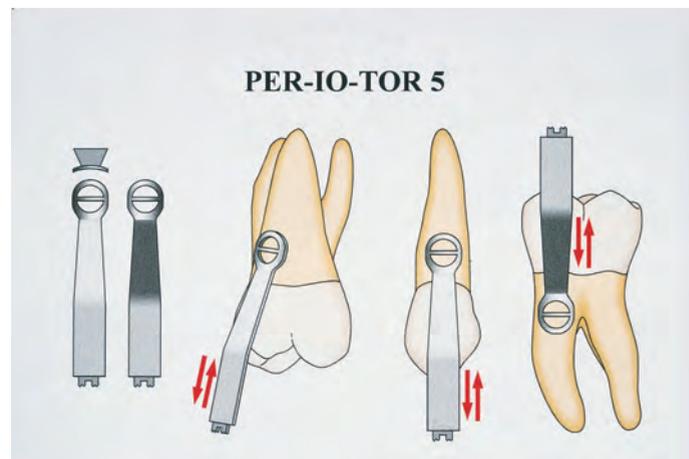


Fig 122, Illustration of how and where PER-IO-TOR no 5 can be used.

PER-IO-TOR no 6 (Fig 123) has a convex working surface for vertical or diagonal use on concave approximal surfaces.

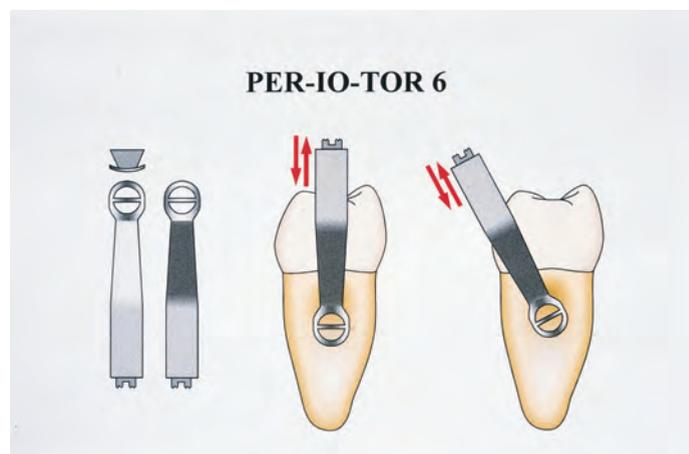


Fig 123

The use of the different PER-IO-TOR instruments are demonstrated on extracted teeth with apical marginal communication and heavy amounts of calculus from patients with advanced untreated periodontitis. However it must be pointed out that from a rational and efficient point of view, the first step in vivo should have been to use a sharp curette hand instrument as a probe in coronal direction from the base of the pocket and whenever calculus was localized, it should simultaneously be "lifted away" without invasive removal of root cementum. An alternative initially could have been a piezoelectric ultrasonic scaler with extra long and thin tip as earlier discussed. That is because the PER-IO-TOR instruments are "non-invasive". Therefore they should only be used for the final "non-invasive" scaling, root planing and debridement. However in spite the PER-IO-TOR instruments are much less efficient in removal of calculus than handinstruments and ultrasonic scalers it can be removed as are demonstrated in the following serie of illustrations.

Fig 124 shows an extracted untreatable maxillary molar with gross amount of calculus up to the apical region and in the furcation area. However it must be observed that most frequently scaling, root planing and debridement is performed on the coronal 1/3 of the root. Again it also is stressed that initial scaling should start with the use of a sharp curette handinstrument, which also offer excellent facility for localization of calculus and other surface roughness. However in this case PER-IO-TOR no 2 was used already from the beginning in the furcation area between the mesiobuccal and palatinal roots (Fig 125), which resulted not only in a clean but also extremely smooth surface almost similar to glass, which hardly could have been achieved after instrumentation with fine grit diamond burs, curette handinstruments, sonic and ultrasonic scalers. PER-IO-TOR no 4 was used for instrumentation of the remaining part of the mesial surface (Fig 126).



Fig 124, An extracted maxillary molar with heavy amounts of calculus on apical 2/3 of the roots



Fig 125, PER-IO-TOR no 2 was used in the furcation area. Observe the extremely smooth and shiny root surface in the furcation area after the instrumentation.



Fig 126, Then the spatula-shaped PER-IO-TOR no 4 was used on the remaining approximal surface



Fig 127

PER-IO-TOR no 5 and no 6 are specially designed for convex (PER-IO-TOR no 5 – Figs 122) and concave root surfaces (PER-IO-TOR no 6 – Fig 123) respectively. Fig 127 shows how PER-IO-TOR no 5 is used on the mesio-buccal convex part of a mandibular left third molar and the result on this particular part of the root is shown in Fig 128.



Fig 128

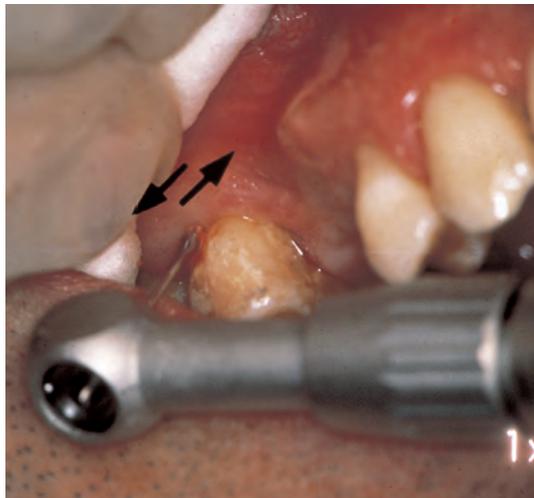


Fig 129

Clinical use of the PER-IO-TOR instruments is exemplified with some cases. Fig 129 shows PER-IO-TOR no 2 in function on the buccal surface of a maxillary first molar with furcation involvement degree 1. If the furcation area is very narrow and deep, for example on the distal surface of the second maxillary molars or the mesial surface of the first maxillary premolars PER-IO-TOR no 1 is used. PER-IO-TOR no 1 and no 2 will be used in the furcation areas in a similar manner to the rotating diamond tips for recountering the furcation areas, ie, initially, the bottom of the furcation area is reached tactically before the instrument is used. It is then gradually used coronally as well as mesially and distally strictly following the shape of the furcation area during the instrumentation procedure. In contrast to the use of the diamond tip, the furcation area is only cleaned and planed and not recountered.

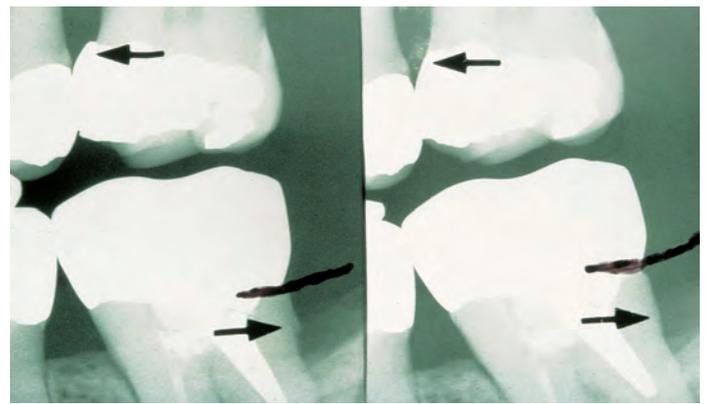


Fig 130, 131

When using PER-IO-TOR no 4, the working side with the groove initially has to be positioned properly, firmly against the root surface. In very narrow interproximal spaces such as mandibular incisors, PER-IO-TOR no 4 may be replaced with the eyelet PER-IO-TOR no 3 (Fig 120). On the flat or slightly convex approximal surfaces of the molars, PER-IO-TOR no 4 is especially efficient in a horizontal or slightly diagonal direction. The radiographs in Figs 130 and 131 show the results on subgingival located calculus on approximal surfaces in molars before and after treatment with PER-IO-TOR no 4. Fig 130 shows subgingival calculus on the distal root surface of a mandibular molar and filling overhang on the mesial surface of the maxillary molar. The result after scaling and rootplaning with PER-IO-TOR no 4 and recountering of the filling with Profin Laminear diamond-coated (50 µm grit) and tungsten-coated reciprocating double knife-shaped tips (Fig 52) is shown to the right (Fig 131). In Fig 132 (left) subgingival calculus is located on the mesial, as well as the distal root surface of a second mandibular molar, a bridge abutment. The result after subgingival scaling and root-planing by using PER-IO-TOR no 4 is shown to the right.

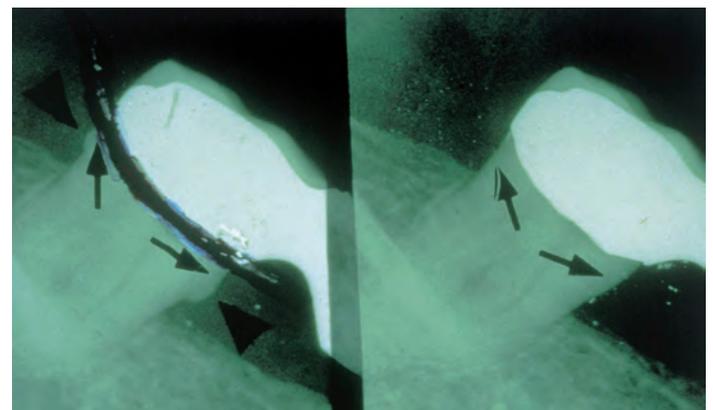


Fig 132, Fig 133

Even rotary instruments according to the PER-IO-TOR concept are designed as earlier shown (see Figs 105a-105c). The straight and conical PER-IO-TOR 7R should be used for scaling, root planing and debridement vertically along the root surfaces and especially in root grooves. The convex and pointed PER-IO-TOR 8R is designed for the same purpose on root concavities. PER-IO-TOR 9R is a concave and pointed tip designed specially for scaling, root planing and debridement in furcation areas. For details on Minimally Invasive Scaling, Rootplaning and Debridement, see Axelsson 2009a.

## References

- Adriaens PA, Edwards CA, De Boever JA, Loesche WJ (1988). Ultrastructural observations on bacterial invasion in cementum and radicular dentin of periodontally diseased human teeth. *J Periodontol* 59:493-503.
- Adriaens PA, Adriaens LM (2004). Effects of non-surgical periodontal therapy on hard and soft tissues. *Periodontology* 2000 vol 36:121-145.
- Agerbaek N, Polsen S, Melsen B, Glavind L (1977). Effect of professional toothcleaning every third week on gingivitis and dental caries in children. *Comm Dent Oral Epidemiol* 6:40-41.
- Albandar JM, Buischi YAP, Axelsson P (1995). Caries lesions and dental restorations as predisposing factors in the progression of periodontal diseases in adolescents. A 3-year longitudinal study. *J Periodontol* 66:249-254.
- Arneberg P, Silness J, Nordbo H (1980). Marginal fit and cervical extent of class II amalgam restorations related to periodontal condition. A clinical and roentgenological study of overhang elimination. *J of Periodontal Res* 15:669-677.
- Ashley FP, Sainsbury RH (1981). The effect of a school-based plaque control programme on caries and gingivitis. *Br Dent J* 150:41-45.
- Axelsson P (1969). The EVA-system. *Sver Tandläkarförb Tidn* 61:1086-1104.
- Axelsson P, Lindhe J (1974). The effect of a preventive programme on dental plaque, gingivitis and caries in schoolchildren. Results after one and two years. *J Clin Periodontol* 1:126-138.
- Axelsson P, Lindhe J, Wäseby J (1976). The effect of various plaque control measures on gingivitis and caries in schoolchildren. *Community Dent Oral Epidemiol* 4:232-239.
- Axelsson P, Lindhe J (1977). The effect of a plaque control programme on gingivitis and dental caries in schoolchildren. *J Dent Res* 56 (spec issue): 142-148.
- Axelsson P & Lindhe J (1978). Effect of controlled oral hygiene procedures on caries and periodontal disease in adults. *Journal of Clinical Periodontology* 5:133-151.
- Axelsson P (1981). Concept and practice of plaque control. *Pediatr Dent* 3:101-113.
- Axelsson P & Lindhe J (1981a). Effect of controlled oral hygiene procedures on caries and periodontal disease in adults. Results after 6 years. *Journal of Clinical Periodontology* 8:239-248.
- Axelsson P & Lindhe J (1981b). The significance of maintenance care in the treatment of periodontal disease. *Journal of Clinical Periodontology* 8:281-294.
- Axelsson P, Lindhe J J (1981c). Effect of oral hygiene and professional tooth-cleaning on gingivitis and dental caries. *Community Dent Oral Epidemiol* 6:251-255.
- Axelsson P, Kristoffersson K, Karlsson R, Bratthall D (1987b). A 30-month longitudinal study of the effects of some oral hygiene measures on *Streptococcus mutans* and approximal dental caries. *J Dent Res* 66:761-765.
- Axelsson P (1987). Placknybildningsindex PFRI-Indikator för karies- och parodontitprevention, munhygien-frekvens och ytrelaterad munhygien. *Tandläkartidningen* 79:387-391
- Axelsson P, Lindhe J (1987) Efficacy of mouthrinses in inhibiting dental plaque and gingivitis in man. *J Clin Periodontol* 14:205-212
- Axelsson P, Paulander J, Nordqvist K, Karlsson R (1987a). The effect of fluoride containing dentifrice, rinsing and varnish on interproximal dental caries. A 3-year clinical trial. *Community Dent Oral Epidemiol* 15:177-180
- Axelsson P (1988a). The Community Caries Index of Treatment Needs (CCITN). Presented at the 1st International Conference on Preventive Dentistry and Epidemiology, Karlstad Sweden.
- Axelsson P, Paulander J, Tollskog G (1988). A new computer-based oral epidemiology system. Presented at the 1st International Conference on Preventive Dentistry and Epidemiology, Karlstad, Sweden.
- Axelsson P (1991). A four-point scale for selection of caries risk patients, based on salivary S mutans levels and plaque formation rate index. In: Johnson NW (ed). *Risk Markers for Oral Diseases Caries*, vol 1. Cambridge, NY: Cambridge UP: 158-170.
- Axelsson P, Lindhe J & Nyström B (1991). On the prevention of caries and periodontal disease. Results of a 15-year longitudinal study in adults. *Journal of Clinical Periodontology* 13:182-189.
- Axelsson P (1993). New ideas and advancing technology in prevention and non-surgical treatment of periodontal disease. *In Dent J* 43: 223-238.
- Axelsson P, Paulander J, Svärdröm G, Tollskog G, Nordensten S (1993a). Integrated caries prevention: The effect of a needs-related preventive program on dental caries in children – County of Värmland, Sweden – results after 12 years. *Caries Res* 27 (suppl 1):83-84.
- Axelsson P (1994). Mechanical plaque control. In: Lang N, Karring T (eds). *Proceedings of the 1st European Workshop on Periodontics, 1993*. London: Quintessence:219-243.
- Axelsson P, Buischi YAP, Barbosa MFZ, Karlsson R, Pradi MCB (1994a). The effect of a new oral hygiene training program on approximal caries in 12-15-year-old Brazilian children: Results after 3 years. *Adv Dent Res* 8:278-284.
- Axelsson P (1998). Needs-related plaque control measures based on risk prediction. In: Lang NP, Attström R, Löe H (eds). *Proceedings of the European Workshop on Mechanical Plaque Control*. Berlin: Quintessence: 190-247.
- Axelsson P, Paulander J, Lindhe J (1998) Relationship between smoking and dental status in 35-, 50-, 65-, and 75-years old individuals. *J Clin Periodontol* 25:207-305
- Axelsson P (1999) *An Introduction to Risk Prediction and Preventive Dentistry a clinical textbook*. Quintessence Publ Co.
- Axelsson P (2000). *A Clinical textbook on Diagnosis and Risk Prediction of Dental Caries*. Quintessence Publ Co.

- Axelsson P, Paulander J, Svärdström G, Kaijser H (2000). Effects of population based preventive programs on oral health conditions. *J Parodontol Implantol Orale* 19:255-269.
- Axelsson P, Paulander J, Nordström L, Jonsson AS, Appel B (2001). The role of genetic interleukin-1 polymorphism on tooth loss and periodontal support loss in 50-60-year-old smokers and non-smokers (abstract). Gothenburg, Sweden: Scientific Congress, Dept of Periodontology, Univ of Gothenburg.
- Axelsson P (2002). *A Clinical Textbook on Diagnosis and Risk Prediction of Periodontal Diseases*. Quintessence Publ Co.
- Axelsson P, Nyström B & Lindhe J (2004). The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults. Results after 30 years of maintenance. *Journal of Clinical Periodontology* 31:749-757.
- Axelsson P (2004). *A Clinical Textbook on Preventive Materials, Methods and Programs*. Quintessence Publ Co.
- Axelsson P (2009a). *Minimally Invasive Treatment, Arrest and Control of Periodontal Diseases – a clinical textbook*, Quintessence Publ Co.
- Axelsson P. (2009b) *Professional Mechanical Tooth Cleaning (PMTTC) - a Clinical Textbook Oral Care*, Tokyo
- Axelsson P (2012). *Minimally Invasive Treatment, Arrest and Control of Caries and Erosions – a clinical textbook in press*.
- Bellini HT, Arneberg P, von der Fehr F (1981). Oral hygiene and caries. A review. *Acta Odontol Scand* 39:257-265.
- Bille J, Thylstrup A (1982). Radiographic diagnosis and clinical tissue changes in relation to treatment of approximal carious lesions. *Caries Res* 16:1
- Björn A-L, Björn H, Grkovic B (1969a). Marginal fit of restorations and its relation to periodontal bone level. Part I: Metal fillings. *Odontol Revy* 20:311-322.
- Björn A-L, Björn H, Grkovic B (1970b). Marginal fit of restorations and its relation to periodontal bone level. Part II: Crowns *21:337-346*.
- Bosman CW & Powell RN (1977). The reversal of localized experimental gingivitis. *Journal of Clinical Periodontology* 4:161-172.
- Boyde A (1984). Airpolishing effects on enamel, dentine, cement and bone. *Br Dent J* 156:287-291.
- Broadbent JM, Williams KB, Thomson WM; Williams SM (2006). Dental restorations: a risk factor for periodontal attachment loss? *J Clin Peirodontol* 33:803-810.
- Brunsvold MA, Lane JJ (1990). The prevalence of overhanging dental restorations and their relationship to periodontal disease. *J Clin Periodontol* 17:67-72.
- Carvalho JC, Ekstrand KR, Thylstrup A (1989). Dental plaque and caries on occlusal surfaces of first permanent molar in relation to stage of eruption. *J Dent Res* 68:773-779.
- Carvalho JC, Ekstrand KR, Thylstrup A (1991). Results of 1 year of non-operative caries treatment of erupting permanent first molars. *Community Dent Oral Epidemiol* 19:23-28.
- Carvalho JC, Thylstrup A, Ekstrand KR (1992). Results after 3 years of non-operative occlusal caries treatment of erupting first permanent molars. *Community Dent Oral Epidemiol* 20:187-192.
- Coldiron NB, Yukna RA, Weir J, Caudill RF (1990). A quantitative study of cementum removal with hand curettes. *J Periodontol* 61(5):293-299.
- Dahlén G, Lindhe J, Sato K, Hanamura H & Okamoto H (1992). The effect of supragingival plaque control on the subgingival microbiota in subjects with periodontal disease. *Journal of Clinical Periodontology* 19:802-809.
- Ehnevid H, Jansson L, Lindskog S, Blomlöf L (1993b). Periodontal healing in relation to radiographic attachment and endodontic infection. *J Periodontol* 64:1199-1204.
- Ehnevid H (1995). *Local factors modifying marginal periodontal healing (thesis)*. Stockholm, Sweden: Karolinska Institute.
- Ehnevid H, Jansson L, Lindskog S, Weintraub A, Blomlöf L (1995). Endodontic pathogens: propagation if infection through patent dential tubules in traumatized monkey teeth. *Endod Dent Traumatol* 11:229-234.
- Firestone AR, Imfeld T, Schiffer S, Lutz F (1978). Measurements of interdental plaque, pH in humans with an indwelling glass pH electrode following a sucrose rinse. A long-term retractive study. *Caries Res* 21:555-558
- Fure S (2003). 10-year incidence of tooth loss and dental caries in elderly Swedish individuals. *Journal of Caries Research* 37:462-469.
- Furuichi Y, Lindhe J, Ramberg P, Volpe AR (1992). Patterns of de novo plaque formation in the human dentition. *J Clin Periodontol* 19:423-433.
- Garmyn P, van Steenberghe D, Quirynen M (1998). *Efficacy of plaque control in the maintenance of gingival health: Plaque control in primary and secondary prevention*. Chicago: Quintessence:107-120.
- Gilmore N, Scheiham A (1971). Overhanging dental restorations and periodontal disease. *J Periodontol* 42:8-12.
- Gisselsson H, Björn AL, Birkhed D (1983). Immediate and prolonged effect of individual preventive measures in caries and gingivitis susceptible children. *Swed Dent J* 7:13-21.
- Gjerme P (1986). *Promotion of self care in oral health*. Oslo: Dental Faculty, Scandinavian Working Group for Preventive Dentistry.
- Glantz P (1969). On wettability and adhesiveness. A study of enamel, dentine, some restorative materials and dental plaque. *Odont Revy* 20: suppl 17.
- Glavind L (1977). Effect of monthly professional mechanical tooth cleaning on periodontal health in adults. *Journal of Clinical Periodontology* 4:100-106.
- Gorzo I, Newman HN, Strahan JD (1979). Amalgam restorations, plaque removal and periodontal health. *J of Clin Periodontol* 6:98-105.
- Graf H, Mühlemann H (1966). Telemetry of plaque pH from interdental area. *Helv Odont Acta* 19:94-101.

- Gröndah HG, Hollender L, Malmcrona E, Sundquist B (1977). Dental caries and restorations in teenagers. I. Index and score system for radiographic studies of proximal surfaces. *Swed Dent J* 1:45-50.
- Gwinnett AJ, Golub LM, Kleinberg I (1975). Effect of a repeated prophylaxis on plaque accumulation and gingival crevicular fluid flow. *Journal of Dental Research Special Iss*, abstract no 609.
- Hamp SE, Lindhe J, Fornell J, Johansson LÅ, Karlsson R (1978). Effect of a field program based on systematic plaque control on caries and gingivitis in schoolchildren after 3 years. *Comm Dent Oral Epidemiol* 6:17-23.
- Hirsh RS, Clarke NG, Shrikandi W (1989). Pulpal pathosis and severe alveolar lesions: A clinical study. *Endod Dent Traumatol* 5:48-54
- Håkansson R (1991). Dental care habits and dental status in 1974-1985 among adults in Sweden. Comparative cross-sectional and longitudinal investigations. Thesis, Lund University, Sweden.
- Hellström M, Ramberg P, Krok L, Lindhe J (1996). Effect of supragingival plaque control on the subgingival microflora in human periodontitis. *Journal of Clinical Periodontology* 23:934-940.
- Horning GM, Cobb CM, Killoy WJ (1987). Effect of an air-powder abrasive system on root surfaces in periodontal surgery. *J Clin Periodontol* 14:213-220.
- Hotz P (1998). Role of dental plaque control in the prevention of caries. In: *Proceedings of the European Workshop on Mechanical Plaque Control*, ed Lang NP, Attström R & Loe H. Quintessence, pp 35-49.
- Hugoson A & Laurell L (2000). A prospective study on periodontal bone height changes in a Swedish population. *Journal of Clinical Periodontology* 27:665-674.
- Igarashi K, Lee I, Schachtele C (1989). Comparison of in vivo human dental plaque pH changes within artificial fissures and at interproximal sites. *Caries Res* 23:417-422.
- Imfeld T (1978). In vivo assessment of plaque acid production. A long-term retrospective study. In: Guggenheim (ed). *Proceedings of ERGOB Conference on Health and Sugar Substitutes*. Basel: Karger.
- Jansson L, Ehnevid H, Lindskog S, Blomlöf L (1994). Proximal restorations and periodontal status. *J Clin Periodontol* 21:577-582.
- Jansson L, Blomster S, Forsgårdh Å, Bergman E, Berglund E, Foss L, Reinhardt E-L, Sjöberg B (1997). Interfactory effect between marginal plaque and subgingival proximal restorations on periodontal pocket depth. *Swed Dent J* 21:77-83.
- Jansson L, Lavstedt S & Zimmerman M (2002). Marginal bone loss and tooth loss in a sample from the county of Stockholm – a longitudinal study over 20 years. *Swedish Dental Journal* 26:21-29.
- Jotikasthira NE, Lie T, Leknes KN (1992). Comparative in vitro studies of sonic, ultrasonic and reciprocating scaling instruments. *J Clin Periodontol* 19(8):560-569.
- Karlsson B-S, Larsson Y (1976). Den kariesförebyggande effekten av mekanisk plackkontroll bland 13-16-åriga skolbarn. *Tandläkartidningen* 68:1085-1086.
- Katsanoulas T, Reneé I, Attström R (1992). The effect of supragingival plaque control on the composition of the subgingival flora in periodontal pockets. *Journal of Clinical Periodontology* 19:760-765.
- Kjaerheim V, von der Fehr F, Poulsen S (1980). 2-year study on the effect of professional toothcleaning on schoolchildren in Oppedgård, Norway. *Community Dent Oral Epidemiol* 8:401-406.
- Klimek J, Prinz M, Mellwig E, Arends J (1985). Effect of a preventive program based on professional toothcleaning and fluoride application on caries and gingivitis. *Comm Dent Oral Epidemiol* 13:295-298.
- Klock B, Krasse B (1978). Effect of caries-preventive measures in children with high numbers of S mutans and lactobacilli. *Scand J Dent Res* 86:221-230.
- Klock B (1984). Long-term effect of intensive caries prophylaxis. *Comm Dent Oral Epidemiol* 12:69-71.
- Kocher T, Langenbeck M, Rühling A, Plagmann HC (2000b). Vigorous versus gentle subgingival debridement as assessed on extracted teeth (I). Residual deposits. *J of Clin Periodontol* 27:243-249.
- Kocher T, Fanghanel J, Sawaf H, Litz R (2001a). Substance loss caused by scaling with different sonic scaler inserts – an in vitro study. *J Clin Periodontol* 28(1):9-15.
- Kocher T, Rosin M, Langenbeck N, Bernhardt O (2001b). Subgingival polishing with a teflon-coated sonic scaler insert in comparison to conventional instruments as assessed on extracted teeth (II). Subgingival roughness. *J Clin Periodontol* 28(8):723-729.
- Kocher T, Bernhardt O, Rosin M, Rühling A (2005). Subgingival polishing with a teflon-coated sonic scaler insert in comparison to conventional instruments as assessed on extracted teeth. Part III: substance removal. (In press.)
- Kois JC (1996). The restorative-periodontal interface: Biological parameters. *Periodontol* 2000 11:29-38.
- Kornman KS, di Giovine F (1998). Genetic variations in cytokine expressions: a risk factor for severity of adult periodontitis. *Ann Periodontol* 3:327-338.
- Kristoffersson K, Bratthall D (1982). Transient reduction of *Streptococcus mutans* interdentally by chlorhexidine gel. *Scand J Dent Res* 90:417-22.
- Kristoffersson K, Axelsson P, Bratthall D (1984). The effect of a professional tooth-cleaning program on interdentally localized *Streptococcus mutans*. *Caries Res* 18:385-390.
- Kuusela S, Honkala E, Kannas L, Tynjala J, Wold B (1997). Oral hygiene habits of 11-year-olds in 22 European countries and Canada in 1993-94. *J Dent Res* 76:1602-1609.
- Lang NP, Cumming BR & Loe H (1973). Toothbrushing frequency as it relates to plaque development and gingival health. *Journal of Periodontology* 44:396-405.

- Lang NP & Karring T (1994). Proceedings of the 1st European Workshop on Periodontology. Chicago: Quintessence Publishing 1994.
- Lang NP, Mombelli A, Attström R (1997a). Dental plaque and calculus. In: Lindhe J, Karring T, Lang N (eds). *Clinical Periodontology and Implant Dentistry*. Copenhagen: Munksgaard:102-137.
- Leknes KN, Lie T, Wikesjö UME, Bogle GC, Selvig KA (1994). Influence of tooth instrumentation roughness on subgingival microbial colonization. *J Periodontol* 65:303-308.
- Lervik T, Riordan PJ, Haugejorden O (1984) Periodontal disease and approximal overhangs on amalgam restorations in Norwegian 21-year. *Comm Dent Oral Epidemiol* 12:264-268.
- Lie T, Leknes KN (1985). Evaluation of the effect on root surfaces of air rubine scalers and ultrasonic instrumentation. *J Periodontol* 56:522-531.
- Lindhe J, Hamp SE, Løe H (1973). Experimental periodontitis in the Beagle dog. *Journal of Periodontal Research* 8:1-10.
- Lindhe J, Hamp SE, Løe H (1975). Plaque-induced periodontal disease in beagle dogs. *J Periodontal Res* 10:243-255
- Lindhe J, Westfelt E, Nyman S, Socransky SS & Haffajee AD (1984). Long-term effect of surgical/non-surgical treatment of periodontal disease. *Journal of Clinical Periodontology* 1:448-458.
- Listgarten M, Mayo H, Tremblay R (1975). Development of dental plaque on epoxy resin crowns in man. A light and electron microscopic study. *J Periodontol* 46:10-26.
- Listgarten M (1976). Structure of the microbial flora associated with periodontal health and disease in man. A light and electron microscopic study. *J Periodontol* 47:1-18.
- Listgarten M (1994). The structure of dental plaque. *Periodontol* 2000 5:52-65.
- Løe H, Theilade E, Jensen SB (1965). Experimental gingivitis in man. *Journal of Periodontology* 36:177-187.
- Løe H (1967). The Gingival Index, the Plaque Index and the Retention Index Systems. *J of Periodontol* 38:610-616.
- Løe H, von der Fehr F, Schiött C (1972). Inhibition of experimental caries by plaque prevention. The effect of chlorhexidine mouthrinses. *Scand J Dent* 80:1-9.
- Løe H, Anerud A, Boysen H, Smith M (1978) The natural history of periodontal disease in man. The rate of periodontal destruction before 40 years of age. *J Periodontol* 49:607-620
- Lövdal A, Arno A, Schei O & Werhaug J (1961). Combined effect of subgingival scaling and controlled oral hygiene on the incidence of gingivitis. *Acta Odontologica Scandinavica* 19:537-555.
- Magnusson I, Lindhe J, Yoneyama T & Liljenberg B (1984). Recolonization of subgingival microbiota following scaling in deep pockets. *Journal of Clinical Periodontology* 11:193-207.
- McNabb H, Mombelli A, Lang N (1992). Supragingival cleaning 3 times a week. The microbiological effect in moderately deep pockets. *Journal of Clinical Periodontology* 19:348-356.
- Mejäre I, Mjör IA (1990). Glass ionomer and resin-based fissure sealants: A clinical study. *Scand J Dent Res* 98:345-350
- Mejäre I, Källestål C, Stenlund H, Johansson H (1998). Caries development from 11 to 22 years of age: a prospective radiographic study. Prevalence and distribution. *Caries Res* 32:10-16
- Mengel R, Buns C, Steizel M, Flores-de-Jacoby L (1994). An in vitro study of oscillating instruments for root planing. *J Clin Periodontol* 21:513-518.
- Meyer K, Lie T (1977). Root surface roughness in response to periodontal instrumentation studied by combined use of microroughness measurements and scanning electron microscopy. *J Clin Periodontol* 4:77-91.
- Mombelli A, Nicopoulou-Karayianni K, Lang NP (1990) Local differences in the newly formed crevicular microbiota. *Schweiz Monatsschr Zahnmed* 100:154-158
- Mousqués T, Listgarten MA & Phillips RW (1980). Effect of scaling and root-planing on the composition of the human subgingival microbial flora. *Journal Periodontal Research* 15:144-151.
- Möller IJ, Poulsen S (1973). A standardized system for diagnosing recording and analyzing dental caries data. *Scand J Dent Res* 81:1-11
- Nyman S, Rosling B & Lindhe J (1975). Effect of professional tooth cleaning on healing after periodontal surgery. *Journal of Clinical Periodontology* 2:80-86.
- Nyman S, Lindhe J & Rosling B (1977). Periodontal surgery in plaque-infected dentitions. *Journal of Clinical Periodontology* 4:240-249.
- Nyman S, Westfelt E, Sarhed G, Karring T (1988). Role of "diseased" root cementum in healing following treatment of periodontal disease. A clinical study. *J of Clin Periodontol* 15:464-468.
- Orland F, Blayney J, Wendell-Harrison R (1954). Use of the germ-free animal technique in the study of experimental dental caries. *J Dent Res* 33:147-174.
- Pack ARC, Coxhead LJ, McDonald BW (1990). The prevalence of overhanging margins in posterior amalgam restorations and periodontal consequences. *J Clin Periodontol* 17:145-152.
- Page RC, Kornman K (1997). The pathogenesis of human periodontitis: an introduction. *Periodontol* 2000 14:9-11.
- Paulander J, Wennström J, Axelsson P, Lindhe J (2004). Some characteristics of 50-55-year-old individuals with various experience of destructive periodontal disease – a cross-sectional study. *Acta Odontologica Scandinavica* in press.
- Paulander J, Axelsson P, Lindhe J (2004). Intra-oral pattern of tooth and periodontal bone loss between the age of 50 and 60 years. A longitudinal prospective study. *Acta Odontologica Scandinavica* 62:214-222.
- Pitts NB, Rimmer PA, (1992). An in vivo comparison of radiographic and directly assessed clinical caries status of posterior approximal surfaces in primary and permanent teeth. *Caries Res* 26:146-152

- Poulsen S, Agerbaek N, Melsen B, Korts DC, Glavind L, Rölla G (1976). The effect of professional tooth cleaning on gingivitis and dental caries in children after 1 year. *Community Dent Oral Epidemiol* 4:195-199.
- Quirynen M, Marechial M, Busscher HJ, Weerkamp AH, Darius PL, van Steenberghe D (1990a). The influence of surface-free energy and surface roughness on early plaque formation. An in vivo study in man. *J of Clin Periodontol* 17:138-144
- Quirynen M, Dekeyser C, van Steenberghe D (1991). The influence of gingival inflammation, tooth type, and timing on the rate of plaque formation. *J Periodontol* 62:219-222.
- Quirynen M, Bollen C (1995). The influence of surface roughness and surface-free energy on supra- and subgingival plaque formation in man. A review of the literature. *J of Clin Periodontol* 22:1-14.
- Ramberg P, Axelsson P & Lindhe J (1995a). Plaque formation at healthy and inflamed gingival sites in young individuals. *Journal of Clinical Periodontology* 22:85-88.
- Ritz L, Hefti AF, Rateitschak KH (1991). An in vitro investigation on the loss of root substance in scaling with various instruments. *J Clin Periodontol* 18(9):643-647.
- Rodriguez-Ferrer J, Strahan J, Newman H (1980). Effect on gingival health of removing overhanging margins of interproximal subgingival amalgam restorations. *J of Clin Periodontol* 7:457-462.
- Rosling B, Nyman S, Lindhe J & Jern B (1976). The healing potential of the periodontal tissues following different techniques of periodontal surgery in plaque-free dentitions. A 2-year clinical study. *Journal of Clinical Periodontology* 3:233-250.
- Saxe SR, Greene JC, Bohannon HM, Vermillion JR (1967). Oral debris, calculus and periodontal disease in the beagle dog. *Periodontics* 5:217.
- Saxton CA (1973). Scanning electron microscope study of the formation of dental plaque. *Caries Res* 7:102-119.
- Saxton CA (1975). The formation of human dental plaque: a study by scanning electron microscopy. Thesis, University of London.
- Sbordone L, Ramaglia L, Gulletta E & Iacono V (1990). Recolonization of the subgingival microflora after scaling and root planing in human periodontitis. *Journal of Periodontology* 61:579-584.
- Siegrist B, Kornman KS (1982). The effect of supragingival plaque control on the composition of the subgingival microbial flora in ligature-induced periodontitis in the monkey. *J Dent Res* 7:936-941.
- Silness J, Loe H (1964). Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. *Acta Odontol Scand* 22:121-135.
- Silness J (1970). Periodontal conditions in patients treated with dental bridges. III. The relationship between the location of the crown margin and the periodontal condition. *J Periodontol Res* 5:225-229.
- Smulow JB, Turesky SS, Hill RG (1983). The effect of supragingival plaque removal on anaerobic bacteria in deep periodontal pockets. *J Am Dent Assoc* 107:737-742.
- Socransky SS, Haffajee AD, Cugini M, Smith C, Kent R Jr (1998). Microbial complexes in subgingival plaque. *J Clin Periodontol* 25:134-144
- Spinks G, Carson R, Hancock E, Pellen G (1986). An SEM study of overhang removal methods. *J of Periodontol* 57:632-636.
- Straub A, Salvi G, Lang N (1998). Supragingival plaque formation in the human dentition. In: Lang NP, Attström R, Loe H (eds). *Proceedings of the European Workshop on Mechanical Plaque Control*. Berlin: Quintessence: 72-84.
- Talbott K, Mandel ID, Chilton NW (1977). Reduction of baseline gingivitis scores with repeated prophylaxes. *J Prev Dent* 4(6):28-29.
- Than A, Duguid, McKendrick W (1982). Relationship between restorations and the level of the periodontal attachment. *J of Clin Periodontol* 9:193-202.
- Vale JD, Caffesse RG (1979). Removal of amalgam overhangs. A profilometric and scanning electron microscopic evaluation. *J Periodontol* 50:245-249.
- Van der Fehr, Loe J, Theilade E (1970). Experimental caries in man. *Caries Res* 4:131.
- Waerhaug J (1960). Histologic considerations which govern where the margins of restorations should be located in relation to the gingiva. *Dent Clin North Am* 4:161-176.
- Waerhaug J (1975). Presence or absence of plaque on subgingival restorations. *Scand J Dent Res* 83:193-201.
- Weeks LM, Leschner NB, Barnes CM, Holroyd SV (1984). Clinical evaluation of the Prophy-jet as an instrument for routine removal of tooth stain and plaque. *J Periodontol* 55:486-488.
- Wennström A, Wennström J & Lindhe J (1986). Healing following surgical and non-surgical treatment of juvenile periodontitis. A 5-year longitudinal study. *Journal of Clinical Periodontology* 13:869-882.
- Westergaard J, Frandsen A, Slots J (1978). Ultra-structure of the subgingival flora in juvenile periodontitis. *Scand J Dent Res* 86:421-429
- Westfelt E, Nyman S, Socransky SS & Lindhe J (1983b). Significance of frequency of professional tooth cleaning for healing following periodontal surgery. *Journal of Clinical Periodontology* 10:148-156.
- Ximénez-Fyvie LA, Haffajee AD, Som S, Thompson M, Torresyap M & Socransky SS (2000). The effect of repeated professional supragingival plaque removal on the composition of the supra- and subgingival microbiota. *Journal of Clinical Periodontology* 27:637-647.
- Zappa U, Smith B, Simona C, Graf H, Case D, Kim W (1991). Root substance removal by scaling and root planing. *J Periodontol* 62(12):750-754.

**About Per Axelsson**, DDS, Odont Dr, Professor of Preventive Dentistry, Axelsson Oral Health Promotion, Stockholm, Sweden

1960, Graduated from the Royal Dental School, Karolinska, Stockholm, Sweden

1960–1961 Public Dental Health Service, Lidköping, Sweden

1961–1970 Private Practice (fulltime) in Karlstad, Sweden (Mainly Preventive Dentistry and Periodontology). 1970–2004 10-25 hours per week (Ratio: 6 Dental hygienists per Dentist)

1970–1975 Postgraduate studies at Department of Periodontology, University of Göteborg, Sweden (Chairman Professor Jan Lindhe)

1975–1999 Chairman Department of Preventive Dentistry, Public Dental Health Service, County of Värmland, Sweden

1976–2004 Started the Dental Hygiene School, University of Karlstad, Sweden

(Teaching Periodontology, Cariology and Preventive Dentistry)

1978 Thesis (Ph.D) "The Effect of Plaque Control Procedures on Gingivitis, Periodontitis and Dental Caries" at Department of Periodontology, University of Göteborg, Sweden

1978 Visiting Scientist at The Institute of Oral Biology and Department of Community Dentistry, University of Washington, USA

1979 Awarded the Research Prize by The Swedish Dental Association for the best Ph.D. during the last three years

1983 Associate Professor in Preventive Dentistry at The University of Göteborg, Sweden

1992 Visiting Professor at The Universities of Pretoria, Cape Town and Johannesburg, South Africa

1993–1998 Professor in Preventive Dentistry at The University of Göteborg, Sweden

From 1999 Promotor of "The Per Axelsson Oral Health Promotion Center" in Sao Paulo, Brazil

2006 Awarded the GABA International Research Prize for the most important scientific paper on Preventive Dentistry published during 2004–2005

Since 1976 International Research Projects in Switzerland, Germany, Poland, Brazil, Egypt and South Africa.

More than 100 published scientific papers.

Single author of eight international textbooks: "Preventive Dental Materials, Methods and Programs" (1992) Eiko Co, Tokyo, "An Introduction to Risk Prediction and Preventive Dentistry" (1999), Quintessence Publ.Co, "Diagnosis and Risk Prediction of Dental Caries" (2000), Quintessence Publ.Co, "Diagnosis and Risk Prediction of Periodontal Diseases" (2002), Quintessence Publ.Co, "Preventive Materials, Methods and Programs" (2004) Quintessence Publ. Co, "Professional Mechanical Tooth/cleaning/PMTc" (2009) Oral Care Co, Tokyo. "Minimally Invasive Treatment, Arrest and Control of Periodontal Diseases" (2009), Quintessence Publ.Co, "Minimally Invasive Treatment, Arrest and Control of Caries and Erosions" (2012) in press, Co-author of five international textbooks on Preventive Dentistry and Periodontology. 4 DVDs on "Prevention, Arrest and Minimally Invasive Therapy of Periodontal Diseases, Caries and Erosion" (2011) Oral Care Co, Tokyo. More than ten international patents and innovations in preventive and diagnostic materials and instruments. For example the EVA-Profin system (Prophy-contra angle and supplementary reciprocation instruments) and the PER-IO-TOR system for minimally invasive scaling, rootplaning and debridement.

Hundreds of international courses and lectures on Cariology, Periodontology and Preventive Dentistry.

1998 Honorary Member of The Swedish Society of Preventive Dentistry.

1998 Honorary Member of The Swedish Society of Cariology.

2006 Honorary Member of The European Society of Preventive Dentistry.

2008 Honorary Doctor at the University of Karlstad



Questions and lecture or course requests may be directed to the author by email: [p.axelsson@comhem.se](mailto:p.axelsson@comhem.se) or by mail Professor Per Axelsson, Oral Health Promotion AB, Rålabshovsleden 44, 11219 Stockholm, Sweden.

