

Dental Caries and Risk Factors in Swedish Adolescents about to Start Orthodontic Treatment with Fixed Appliances

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ABSTRACT

Aim: The aim of this study is to investigate the caries situation in a group of Swedish adolescents, who were scheduled for orthodontic treatment with fixed appliances.

Materials and methods: An age- and gender-matched control group was selected from the same city (Malmö, Sweden). Caries and fillings on smooth surfaces and fillings on occlusal surfaces were diagnosed clinically and caries and fillings on approximal surfaces by bitewings. Numbers of mutans streptococci (MS) and lactobacilli (LB) were analyzed in saliva.

Results: There were no significant differences regarding manifest caries lesions and fillings on smooth surfaces. Numbers of occlusal-filled surfaces (FS) and approximal decayed and filled surfaces were around 10%, but did not differ between the groups. However, 53% had approximal enamel caries lesions in the test group and 46% in the control group. The prevalence of approximal decayed surfaces (DS) and FS was low in both groups, 0.57 ± 1.41 in the test group and 0.65 ± 1.38 in the control group ($p > 0.05$), i.e., somewhat more DS in the control group ($p < 0.05$). Most individuals had low/medium counts of cariogenic bacteria in their saliva and less than 10% high counts in both groups.

Conclusion: Most Swedish adolescents who have been scheduled for treatment with fixed appliances appear to have a low-to-medium caries risk nowadays. However, around 10% of all approximal tooth surfaces of premolars/molars had enamel caries and one-third of the individuals had medium/high counts of cariogenic bacteria in their saliva, which may be risk factors for future caries during orthodontic treatment.

Clinical significance: Bitewing radiographs are important before starting orthodontic treatment and approximal caries and many cariogenic bacteria may be risk factors for orthodontic treatment.

Keywords: Cariogenic bacteria, Dental caries, Orthodontics, Teenagers.

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INTRODUCTION

For almost a century, an affordable and easily accessible dental care for all population has been a major political goal in Sweden.¹ In the past 30 years, the Public Dental Service in Sweden has provided regular dental care for all children and teenagers between the ages of 3 and 19.² This service also includes free orthodontic treatment with fixed or removable appliances for those who need it. Today, around 25% of the Swedish adolescents receive this kind of treatment, based on a diagnosis by a specialist using different indices, such as an Index of Orthodontic Treatment Need (IOTN).³

The caries situation in adolescents and young adults has improved during the last few decades in Sweden, as in most industrialized countries, mainly because of the daily use of fluoride toothpaste.⁴ However, orthodontic treatment with fixed appliances may increase the risk of caries and the development of white spot lesions (WSL) in some individuals.^{5,6}

It is important from a cariological point of view first to identify "risk individuals" before starting the orthodontic treatment and, second, to give them a preventive program based on their risk. There has been a long tradition of "caries risk assessment" in Sweden, with Krasse⁷ and Bratthall⁸ as the pioneers. One important "risk factor" during the orthodontic treatment is the number of cariogenic bacteria in saliva, i.e., *mutans streptococci* (MS) and *lactobacilli* (LB).^{9,10} Other risk factors are the plaque amount, decayed and filled tooth surfaces (DFS), and the number of initial caries lesions. The aim of the present investigation is to investigate the caries risk, including two of these indicators (bacteria and caries prevalence), in a group of Swedish adolescents who had been scheduled for orthodontic treatment with fixed appliances.

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METHODS AND MATERIALS

This study was conducted at the Institute of Odontology in Gothenburg, Sweden. The Ethics Committee at the university approved the study (Dnr 562-05). A total of 171 consecutive patients, 70 boys and 101 girls, with a mean age of 14.8 years (range 11.2–17.3), were recruited from the Specialist Clinic of Orthodontics. The selection criteria for this test group were patients who were going

to be treated with fixed appliances in the upper and the lower jaw. They were all referred to the specialist clinic from five public dental clinics in the city of Gothenburg. At the specialist clinic, and before starting the treatment, an orthodontic specialist nurse gave them basic information about the caries risk while being treated with fixed appliances.

The control group also consisted of 171 patients, 72 boys and 99 girls, with a mean age of 14.8 years (range 11.4–19.1), recruited from the same public dental clinics as the children in the test group. The control group was matched with the test group with regard to the gender, age, and domicile and did not require any orthodontic treatment.

All the children, in both groups, visited their public dental clinic every year for checkups and received preventive dental care, including the application of fluoride varnish once a year. When the children were 6–8 years old, all occlusal fissures of the first permanent molars were treated with fissure sealants.

Clinical Examination

The clinical examination was carried out by one and the same dentist (author HAB) in a dental chair under optimal light conditions. He was trained and calibrated by an experienced researcher at the Department of Cariology. The teeth were cleaned with a handpiece, rubber cup, and pumice and then dried with compressed air. Manifest caries lesions (cavities) and fillings were registered on all smooth surfaces and fillings on all occlusal surfaces. Caries lesions on occlusal surfaces, however, were not registered because they were considered to be difficult to score accurately. WSL on buccal surfaces were diagnosed on clinical photographs (see below).

The test group was examined at the university clinic, shortly before starting the orthodontic treatment, and the children in the control group at the various public dental clinics to which they belonged. For practical reasons, it was not possible to carry out the clinical examination blindly, since the test and control groups were examined at different clinics.

Clinical Photographs

Five standardized intraoral photos of all patients in both groups were taken before the caries registration and before the tooth cleaning. A high-resolution digital camera with a 100-mm macro-lens, a ring flash, a set of mirrors, and two double-ended retractors was used. The five photos were taken with the following projections: (1) frontal, (2) right buccal, (3) left buccal, (4) upper occlusal, and (5) lower occlusal (Figs 1A to E). The images were used for the registration of plaque and WSL on buccal surfaces by one of the authors (HK). The oral hygiene of each patient was scored as either (1) “acceptable” or (2) “not acceptable.” The diagnosis of buccal caries on the digital photos was carried out according to our earlier publication.¹¹

Radiographic Examination

Four bitewing radiographs (Fig. 2) of each subject were taken. At the university clinic (test group), a digital system was used, while at the public dental clinics (control group), conventional dental films were used. All the bitewings were scored by author SR, who was trained and calibrated by an experienced radiologist at the Department of Oral and Maxillofacial Radiology. Approximal caries in enamel (DeS) and dentine (DS) was diagnosed on premolars and molars from the distal surface of the first premolar (4d) to the mesial surface of the second molar (7 m), i.e., a total of 24 surfaces/individual. Filled surfaces (FS) were also registered. There were very few missing

teeth in both groups and the number of missing surfaces (MS) was, therefore, not registered. As different radiographic techniques were used in the test and the control group, it was not possible to read the films blindly. Twenty percent of the films, in both groups, were read twice and the kappa values were between 0.8 and 0.9. No difference was found between digital and analogue bitewing radiographs, which is in agreement with two methodological studies.^{12,13}

Cariogenic Bacteria in Saliva

Paraffin-stimulated whole saliva was collected before the clinical examination and transported to the Department of Cariology, where it was processed within 24 hours. At the laboratory, the samples were shaken on a mechanical mixer for half a minute and plated on mitis salivarius bacitracin (MSB) agar to grow MS. The MSB agar plates were incubated in candle jars (37 °C) for 2 days. To grow LB, the saliva samples were plated in Rogosa SL agar and incubated aerobically at 37 °C for 3 days. The colony-forming units (CFU) of MS were identified by their characteristic colony morphology on the MSB agar. All CFU in the Rogosa SL agar were considered to be LB. Both the MS and the LB counts were divided into three classes, i.e., “high” ($>10^6$ CFU/mL for MS and $>10^5$ CFU/mL for LB), “medium” (10^6 – 10^5 CFU/mL for MS and 10^5 – 10^4 CFU/mL for LB), and “low” ($<10^5$ CFU/mL for SM and $<10^4$ CFU/mL for LB). These thresholds are commonly used in dental research and are known to predict a high or low risk of caries.¹⁴

Statistics

Descriptive statistics were used to define basic characteristics, i.e., the mean and standard deviation for continuous variables and the frequency distribution and percentage for binary variables. The two groups were compared by using an unpaired *t* test for continuous variables and Fisher’s exact test for categorical variables. All tests were two-sided and *p* values less than 0.05 were considered to be significant.

RESULTS

Clinical Registrations

The study revealed only a few caries lesions and fillings on the smooth surfaces; 20 DFS in a total of 10 patients in the test group and 7 DFS in a total of 7 individuals in the control group ($p > 0.05$). A total of 218 occlusal fillings were found in the test group and 142 in the control group. This difference was almost statistically significant ($p = 0.069$). A majority of these 360 fillings were located on the first permanent molars. Table 1 shows the frequency distribution of individuals with various numbers of occlusal fillings. If scores 0 and 1 are combined, 71% in the test group (121/171) and 78% in the control group (133/171) had no or just one filled occlusal filled surface ($p > 0.05$).

Clinical Photographs

The plaque scoring using the intraoral photos showed that a majority (>two-thirds) of the individuals both in the test and the control group had “acceptable” oral hygiene. Since a crude plaque index was used, no statistical comparison was carried out.

Most of the WSL on the photos were found on the buccal surfaces of the first molars and very few on the premolars and second molars (Fig. 3). About 49% in the test group and 51% in the control group had no (0) detectable WSL ($p > 0.05$). For those with WSL, 14% had >5, 26% had 2 to 5, and 11% had 1 WSL in the test



Figs 1A to E: Intraoral clinical photographs: (A) Frontal view; (B) Right buccal view; (C) Left buccal view; (D) Upper occlusal view; and (E) Lower occlusal view

group; the corresponding values in the control group were 13, 29, and 7%, respectively ($p > 0.05$).

Approximal Caries and Fillings

The mean values (\pm SD) for caries and fillings, diagnosed on bitewing radiographs, are presented in Table 2. Both dentine caries (D) and

enamel caries (DeS) are shown. The prevalence of DS and FS was low in both groups: 0.57 ± 1.41 in the test group and 0.65 ± 1.38 in the control group ($p > 0.05$), i.e., somewhat more DS in the control group ($p < 0.05$).

The number of approximal caries lesions in enamel (DeS) was high in both groups: 2.10 ± 2.80 in the test group and 3.00 ± 3.70 in the control group, i.e., somewhat more in the control group

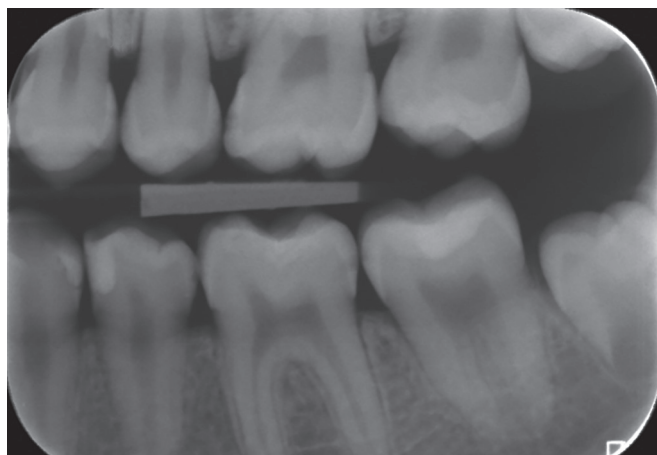


Fig. 2: Bitewing radiographs on premolars and molars

Table 1: Frequency distribution of individuals in the test and the control group (171 individuals/group) into various numbers (N) of FS in premolars and molars. Both the number of individuals and percentages are given

No.	Test group		Control group	
	FS (occlusal)		FS (occlusal)	
	n	%	N	%
0	97	57	111	65
1	24	14	22	13
2-3	23	13	27	16
4-5	18	11	9	5
>5	9	5	2	1
Total	171	100	171	100

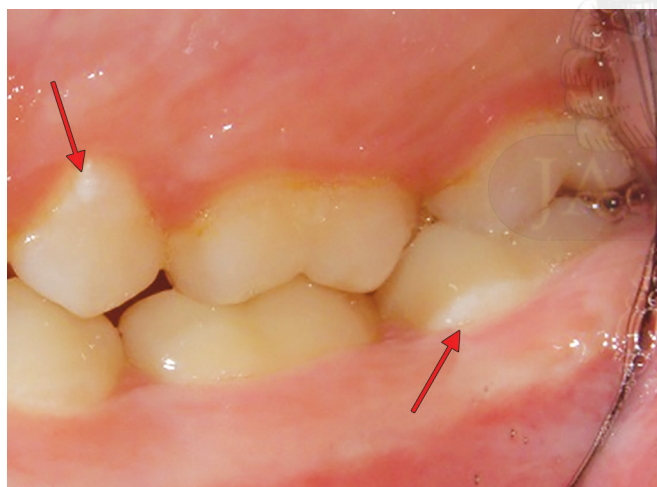


Fig. 3: WSL (arrows) noted on the second premolar and the second molar

($p < 0.05$) (Table 2). The number of individuals who had no enamel lesions (DeS = 0) was 47% (81/171) in the test group and 32% (54/171) in the control group ($p > 0.05$) (Table 3). A total of 350 + 517 enamel caries lesions were scored in the two groups ($n = 171 + 171 = 342$), which means that $\approx 10\%$ (867/8208) of the approximal surfaces of the premolars and molars were affected by early caries lesions and 90% were caries free.

Table 3 shows the frequency distribution of individuals in the test group and the control group with various numbers of both

Table 2: Approximal caries diagnosed on bitewing radiographs on premolars and molars in the test and the control group (data are presented as mean \pm SD)

	Mean (\pm SD)		p value
	Test (n = 171)	Control (n = 171)	
DS	0.25 (± 0.77)	0.46 (± 1.16)	0.0494*
FS	0.32 (± 0.92)	0.19 (± 0.67)	0.1362
DS + FS	0.57 (± 1.41)	0.65 (± 1.38)	0.5963
DeS	2.10 (± 2.80)	3.00 (± 3.70)	0.0116*
DS + FS + DeS	2.67 (± 3.68)	3.65 (± 4.51)	0.0284*

* $p < 0.05$ (unpaired t test)

DS, decayed surface (dentine); DeS, decayed surface (enamel)

Table 3: Frequency distribution of individuals in the test and the control group (171 individuals/group) into various numbers (N) of approximal DFS and DeS in premolars and molars. Both the number of individuals and percentages are given

No.	Test group				Control group			
	DFS		DeS		DFS		DeS	
	n	%	n	%	n	%	n	%
0	124	73	81	47	123	72	54	32
1	31	18	22	13	23	14	25	15
2-3	10	6	25	15	14	8	45	26
4-5	4	2	20	12	7	4	14	8
>5	2	1	23	13	4	2	33	19
Total	171	100	171	100	171	100	171	100

DFS, decayed and FS including only manifest caries; DeS, decayed surfaces including only enamel caries

approximal DFS (including only manifest caries) and approximal DeS (enamel caries). There was a skewed distribution and most individuals had 0 or just 1 surface affected.

The number of individuals who had no decayed and filled approximal surfaces (DFS = 0) was 73% in the test group and 73% in the control group (Table 3). If all the approximal fillings and all the dentine caries lesions are combined (97 in the test group and 112 in the control group) on all bitewings (24 surfaces \times 342 individuals = 8208), only 2.5% (209/8208) of the approximal surfaces of the premolars and molars had dentine caries or were filled.

Cariogenic Bacteria

Two of the 342 saliva samples had to be discarded. The three classes (high, medium, and low) of MS and LB are presented in Table 4 (observe that percentage values for individuals in each class are given). Most individuals (58–76%) had “low counts” and only 5 to 9% had “high counts.” If high and medium are combined into one class, 31 to 42% in the test group and 24 to 31% in the control group fall into this “high-to-medium class;” there were no significant differences between the two groups.

DISCUSSION

There were only minor differences between the test and the control group and the caries risk for most individuals was considered to be low. The majority of the individuals, thus, had no caries or fillings and had low counts of cariogenic microorganisms in their saliva. On the contrary, $\approx 10\%$ of all approximal tooth surfaces on the premolars and molars had enamel caries, diagnosed on bitewings, $\approx 50\%$ WSL diagnosed on clinical photos and around one-third of the individuals had medium-to-high counts of cariogenic bacteria

Table 4: Frequency distribution of cariogenic bacteria in saliva, divided into three classes (high, medium, and low) in the test and the control group

Class	Test group (%), n = 171		Control group (%), n = 171	
	MS	LB	MS	LB
High	9	6	5	6
Medium	33	25	29	18
High + medium	42	31	34	24
Low	58	69	66	76
High + medium + low (%)	100	100	100	100

Observe that percentage values for individuals in each class are given. High: $>10^6$ CFU/mL for MS and $>10^5$ CFU/mL for LB. Medium: 10^6 – 10^5 CFU/mL for MS and 10^5 – 10^4 CFU/mL for LB. Low: $<10^5$ CFU/mL for SM and $<10^4$ CFU/mL for LB

in their saliva, which may be risk factors for future caries if treated with fixed appliances.

There was a tendency ($p < 0.05$) for the orthodontic group to have somewhat lower caries indices on the approximal surfaces (DS, DeS, and DS + FS + DeS) than the control group (Table 2). The reason for this is not known, but it is possible to speculate that the dentists working at the five public dental clinics avoided referring patients with a high caries prevalence or high caries risk for orthodontic treatment.

The mean age of the population in the present study was around 15 years, with a span between 11 years and 19 years. There are several epidemiological, cross-sectional studies of caries in 15-year-olds in Sweden.^{15–17} In one of these studies, by Alm and co-workers,¹⁵ the mean number of approximal tooth surfaces with initial caries lesions, manifest caries lesions and fillings, and total caries experience and fillings, recorded on bitewing radiographs at 15 years of age, was 2.78, 0.45, and 3.23, respectively. These figures are very close to those found in the present investigation (Table 2), which indicates that our population is representative of Swedish teenagers today.

Only a crude plaque index was used in the present investigation, but the impression was that most of the participants ($>2/3$) had good oral hygiene. The reason may be that all the children in Sweden regularly meet dental nurses or hygienists, mostly once a year, who give them instructions on how to brush their teeth. The good oral hygiene found in the present investigation is in agreement with a recent Swedish study, showing that there has been a major reduction in the mean plaque score in 10- to 30-year-olds from about 30% in 1973 to 15% in 2003.¹⁸

There are deviating opinions whether malocclusions would increase the caries risk.¹⁹ Some, but not all, of the articles indicate an association between increased caries risk and malocclusion. The correlation, however, seems to be weak or uncertain as many other confounding factors might influence the results. Socioeconomic factors, selection of patients' eligibility for orthodontic treatment, oral hygiene, fluoride distribution, etc., are some of these factors, many of them are interrelated. Another factor to take into consideration in this context is the dental aesthetic index (DAI).²⁰

The purpose of this study was to study the frequency of risk factors in patients to be treated with fixed orthodontic appliance. Even if the results are based on cross-sectional data, we believe that they may be of help in customizing prophylactic measures that are needed to avoid new caries lesions during the orthodontic treatment.

CONCLUSION

The main conclusion from the present investigation of Swedish adolescents about to be treated with fixed appliances—and based on two main parameters: (1) caries prevalence and (2) cariogenic bacteria in saliva—is that most teenagers in Sweden nowadays can be considered to have a low caries risk. However, the presence of enamel caries of approximal surfaces and of WSL on buccal surfaces and the fact that one-third of the individuals had medium-to-high counts of cariogenic bacteria in their saliva may be risk factors for future caries during orthodontic treatment.

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