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Oral health in young adults with long-term, controlled asthma

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Abstract

Objectives. The aim of the present investigation was to study oral health in young adults with
long-term, controlled asthma. ***Material and methods.*** Twenty 18- to 24-year-olds with a mean
duration (SD) of asthma disease of 13.5 (5.4) years and 20 matched healthy controls were
included. A clinical examination was performed and the prevalence of caries, erosions,
gingival inflammation, cervicular fluid, periodontal pockets and plaque formation rate, were
registered. The salivary flow rate, numbers of mutans streptococci and lactobacilli in saliva
were determined. Plaque pH was measured after a sucrose rinse up to 40 min at two
approximal sites. The participants were interviewed regarding dietary and oral hygiene habits.
Results. The mean (SD) DFS, including manifest and initial caries, was 8.6 (10.6) in the
asthma group and 4.0 (5.2) in the control group ($p = 0.09$). Initial caries lesions were more
common in the asthma group than in the control group, 6.0 (8.1) and 1.3 (2.0 ($p = 0.02$). The
asthma group had more gingivitis ($p = 0.01$) and lower stimulated salivary rate than the
controls ($p = 0.01$). The asthmatics had also a somewhat, but not statistically significant,
lower initial pH value in plaque and more pronounced pH drop compared with the controls. In
the asthma group, 65% reported frequent mouthbreathing compared with 10% in the controls
($p = 0.01$). No differences were found in tooth-brushing and dietary habits between the
groups. ***Conclusions.*** Young adults with long-term, controlled asthma had more initial caries,
more gingival inflammation and lower stimulated salivary secretion rate than individuals
without asthma.

Key Words*: asthma, caries, gingival bleeding, mouthbreathing, plaque pH, saliva secretion*

Introduction

Asthma is a chronic inflammatory disorder
of the airways, in which many cells and
cellular elements are involved. Worldwide,
about 300 million people of all ages are
affected by the disease [1]. During the last
few decades, asthma has increased in some
countries but has stabilised in others [2, 3].
In Sweden, for example, about 8% of the
adult population are affected. The asthma
disease in adulthood is more frequent in
females than in males [3]. Today, the most
effective available treatment for asthma is
inhalation with anti-inflammatory
medication (glucocorticosteroids) and,
when necessary, the addition of
bronchodilatory agents (ß$_2$ agonists) [4].

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In recent decades, several studies have investigated oral health in children and adolescents with asthma. The majority of these reports found that both children and adolescents with asthma run a greater risk of dental caries and/or gingival inflammation than healthy controls [5-12]. This impaired oral health may result in a foundation for further caries development and periodontal diseases later in life. However, no study, performed the last 10 years, have focused on adult populations ($\geq$ 18 years of age) with long-term asthma.

The aim of the present investigation was therefore to compare oral health in a group of young adults with long-term asthma with a matched healthy control group and to investigate whether there was any association between asthma and caries.

Material and methods
Study population
The subjects comprised *all* young adults between 18 and 24 years of age with long-term, controlled asthma (n = 33), living and receiving treatment at one of the primary health care centre in the city of Jönköping, Sweden in 2009. Of these, 20 (14 women and 6 men) agreed to participate; the reasons not to take part in the study was in some cases that they were tired out with medical care during several years in life. The control group consisted of a gender- and age-matched friend "social twin" of each asthmatic, without a diagnosis of asthma (n = 20). The mean age (SD) was 21.6 (2.3) years in the asthma group and 21.7 (2.0) in the control group. The inclusion criteria were medical treatment for asthma during a minimum of 4 years and a prescribed combination of inhaled long-acting β_2 agonists and glucocorticosteroids during the last 2 years. The participants in this asthma group represent a group of individuals with moderate, controlled asthma. The study was approved by the ethics committee at Linköping University and informed consent was given by the participants before the examination.

Clinical examination
The dental examination was performed with a mirror and gentle probing under optimal light conditions. Before and during the study, the examiner (author MS) was calibrated with an experienced dentist (author LKW).

Clinical caries examination
Visible initial and manifest caries lesions were registered on all tooth surfaces. Initial caries (D_i) was defined as "a demineralised surface with a chalky appearance" and manifest caries (D_m) as "the minimal level that could be verified as cavities by gentle probing and which, on probing in fissures, caused the probe to get stuck at slight pressure" [13]. The third molars were excluded from all examinations.

Radiographical examination
Four posterior bitewing radiographs were taken. Initial approximal caries ($D_i a$) was defined as "a caries lesion in the enamel that has not reached the enamel-dentine junction or a lesion that has reached or penetrated the enamel-dentine junction but does not appear to extend into the dentine" [14]. Manifest caries ($D_m a$) was defined as "a caries lesion that clearly extends into the dentine". The radiographic alveolar bone loss was recorded, defined as 2 mm or more from the cement-enamel junction to the bone crest [15]. Only surfaces with distinct alveolar bone level were recorded. All the radiographs were analysed by two authors (MS and LKW). One of the examiners was not aware of the group to which the subject belonged. In the event of disagreement, findings were discussed until consensus was reached.

Periodontal conditions
In each individual, the right or left quadrant was randomly selected in upper and lower jaw, with a total of 14 teeth (7 in the upper and 7 in the lower jaw) were

examined. The gingival inflammation , plaque and periodontal pockets (≥ 4 mm) were registered on six tooth surfaces (mesio-lingual, lingual, disto-lingual, mesio-buccal, buccal and disto-buccal) of each tooth.

Gingival inflammation

The index of Löe and Silness [16] was used after drying the teeth with compressed air as follows: 0 = normal gingiva, no inflammation, discoloration or bleeding; 1 = mild inflammation, slight colour change, mild alteration of gingival surface, no bleeding on pressure; 2 = moderate inflammation, erythema and swelling, bleeding on pressure; 3 = severe inflammation.

Plaque formation rate

The plaque index was recorded according to Turesky's modification of the Quigley Hein Index [17] after 3 days without tooth-brushing or proximal cleaning. After disclosing the plaque with Erythrosin® (Rondell Red; Nordenta, Enköping, Sweden), all the tooth surfaces were registered as follows: 1 = no plaque; 2 = separate flecks of plaque at the cervical margin of the tooth; 3 = a band of plaque wider than 1 mm but covering less than 1⁄3 of the tooth; 4 = plaque covering at least 1⁄3 but less than 2⁄3 of the crown; 5 = plaque covering 2⁄3 or more of the crown.

Gingival cervicular fluid

Gingival cervical fluid was collected at the mesio-buccal sites on 16, 24, 33 and 41 using a standard filter paper (Periopaper® Oraflow Inc., NY, USA). The sites were isolated with cotton rolls and air dried. The Periopaper strip was placed gently in the crevice and left in place for 30 s. The amount of fluid absorbed by the paper strip was measured using the Periotron® 8000 model 2 (Oraflow inc., NY, USA) and was calibrated against different volumes of distilled water to obtain a standard curve.

Salivary and microbiological factors

The participants were instructed not to eat or drink for 2 hr preceding the saliva sampling. Unstimulated and paraffin-stimulated whole saliva were collected for 5 min and the secretion rate was expressed as ml/min. One millimetres of the stimulated saliva was transferred into a vial with 1 ml of pre-reduced transport fluid and sent to the Department of Cariology in Gothenborg for further analysis. The sample was dispersed on a Whirlimixer for 30 s and serially diluted in 0.05 M phosphate buffer (pH 7.3). 25-µl portions were plated in duplicate on mitis salivarius with bacitracin (MSB) agar to grow mutans streptococci (MS) and in Rogosa Selective Lactobacillus (SL) agar to grow lactobacilli (LB). The SL agar plates were incubated aerobically at 37°C for 3 days and the MSB agar plates were incubated in candle jars at 37°C for 2 days. The number of colony forming units (CFU) on MSB was counted and identified by their characteristic colony morphology. All CFU in SL agar were considered to be lactobacilli. The number of CFU was transformed to logarithms before the statistical analysis. The buffer capacity of paraffin-stimulated whole saliva was estimated using the Dentobuff® Strip chair-side test (Orion Diagnostica, Espoo, Finland).

Plaque pH in vivo

The participants were instructed not to clean their teeth for 3 days and not to eat or drink anything 1 hr before the test. Ten millilitres of a 10% sucrose solution was used as a mouth rinse for 1 min. pH was measured with the microtouch method [18] in two approximal spaces in the upper jaw, one between the cuspid and second incisor (13/12) and one in the premolar and molar region (16/15). Measurements were made at baseline (0 min) and at seven time points (1, 3, 5, 10, 20, 30 and 40 min) after the rinse. An iridium touch microelectrode, with a diameter of 0.1 mm and a tip with a 2-mm long loop (Beetrode® Model

MEPH3L, W.P. Instruments Inc., New Haven, Conn., USA), was used. The electrode was connected to an Orion SA 720 pH/ISE meter (Orion Research Inc., Boston, Mass, USA). A reference electrode (MERE1, W.P. Instruments Inc.) was used. A salt bridge was created in 3 M KCl between the reference electrode and a finger of the subject. The electrodes were calibrated prior to the reading of each value according to Scheie et al. [19].

Dental erosions
Erosions were diagnosed on all buccal, lingual and occlusal tooth surfaces, according to Johansson et al. [20]. 1 = smoothed enamel, developmental structures have totally or partially vanished. Enamel surface is shiny, matt, irregular, "melted", rounded or flat, macro-morphology generally intact; 2 = enamel surface as described in Grade 1 but with macro-morphology clearly changed, facetting or concavity formation within the enamel, no dentinal exposure; 3 = enamel surface as described for Grades 1 and 2 but with macro-morphology greatly changed (close to dentinal exposure of large surfaces) or dentine surface exposed by ≤ 1/3; 4 = enamel surface as described for Grades 1, 2 and 3 and with dentine surface exposed by > 1/3 or pulp visible through the dentine.

Questionnaire
In connection with the clinical examination, a semi-structured interview was performed by MS. All the subjects were interviewed about tooth-brushing habits, use of fluorides, mouthbreathing, allergy, dietary and smoking habits. The frequency of intake of dietary risk products was registered according to Wendt and Birkhed [21]. The subjects with asthma were interviewed about factors connected to their disease, such as prior and current asthma medication and duration of asthma medication.

Statistical analysis
The results for continuous variables are presented as the mean and SD. The data were analysed using SPSS version 17.0 (SPSS Inc., Chicago, IL, USA)and SAS version 8.2 (SAS Institute Inc., Cary, NC, USA). Fisher's exact test was used to test the association between caries as an independent variable with categorical dependent variables and Mann-Whitney *U*-test was used for continuous dependent variables. The level of significance was defined as $p < 0.05$.

Results
The asthma group and medication
All the participants had controlled asthma, with regular check-ups at their health care centre. Only one asthmatic individual had been hospitalised during the last year. Fifteen subjects in the asthma group reported allergy. The mean exposure time (SD) for asthma drugs was 13.5 (5.4) years. The participants in the asthma group were all using a dry powder inhaler, while 8 were using a combination of salmeterol and fluticasone (Seretide® Diskus®, GlaxoSmithKline, Middlesex, UK) and 12 a combination of formoterol and budenoside (Symbicort® Turbuhaler®, AstraZeneca, London, UK). The mean dose (SD) of steroids (µg/day) at the time of the dental examinations was for fluticasone 240 (77.1) and for budenoside 320 (71.5) µg/day. The majority of the asthmatic individuals (n = 16) inhaled their asthma medication twice a day in all seasons, while three inhaled them only periodically. One participant used the medication more than twice a day. One individual smoked every day.

Dental caries
The results are presented in Table 1. The prevalence of initial approximal caries lesions was higher in the asthma group (*p* = 0.01). In the asthma group, 35% (n = 7) had ≥ 9 caries lesions compared with 15% (n = 3) in the control group (NS). There was no statistically significant difference in

mean DFS in asthmatics who experienced a debut of the disease before 5 years of age (n = 13) compared with those with a debut at the age of 5 years or older (n = 7). Asthmatics with a duration of asthma disease of < 9 years (n = 4) compared with asthmatics with a duration of > 9 years (n = 16) had a mean DFS of 4.2 (5.8) and 9.7 (11.4) respectively (NS). No differences in mean DFS were found between the two different asthma medication subgroups. Individuals with both asthma and allergy had a mean DFS of 9.0 (11.1) compared with 7.8 (10.5) in asthmatics without allergy (NS).

Table 1. Caries status in young adults with asthma and without asthma. Both total and approximal initial caries (Di) and manifest caries (Dm) are shown, mean and SD. NS = not statistically significant.

Table 1

	Asthma (n = 20)	Control (n = 20)	p-value
Initial caries (D$_i$)	6.0 (8.1)	1.3 (2.0)	0.02
Initial approximal caries (D$_i$a)	4.1 (5.3)	0.7 (1.2)	0.01
Manifest caries + filled surfaces (D$_m$FS)	2.7 (3.7)	2.8 (5.1)	0.94
Manifest approximal caries + filled surfaces (D$_m$FSa)	0.9 (1.4)	1.3 (1.9)	0.65
Total (D$_{i+m}$FSa)	8.6 (10.6)	4.0 (5.2)	0.09

Periodontal conditions
No statistically significant differences were found between the two groups in terms of the number of periodontal pockets and alveolar bone loss. The mean gingival index (SD) in the asthma group was 1.8 (0.4), while it was 1.3 (0.8) in the control group ($p = 0.03$). Gingival bleeding was more common in the upper incisors and canine region in the asthma group, 35% (38%) compared with 26% (37%) in the control group. The mean gingival index in the same region was 1.7 (0.6) and 1.5 (0.6), but the difference was not statistically significant. There were no differences between the asthma and control group when it came to the plaque formation rate, 2.2 (0.4) vs 2.0 (0.8). The mean volume of gingival cervicular fluid was 0.61 (0.2) in the asthma group and 0.76 (0.16) µl in the control group ($p = 0.07$). No statistically significant difference in gingival cervicular fluid between individuals with allergy in the asthma and control group was found. In individuals with asthma and allergy (n = 15); the mean volume of the gingival cervicular fluid was higher compared with asthmatics without allergy (n = 5). However, the difference was not statistically significant.

Salivary and microbiological factors
The data are presented in Table 2. A lower stimulated salivary flow rate was found in the asthma group compared with the control group ($p = 0.01$). No statically significant difference was found in unstimulated salivary flow or buffer capacity or in LB and MS.

Table 2. Caries-related factors in young adults with asthma and without asthma. Mean and SD, NS = not statistically significant.

Table 2

	Asthma (n = 20)	Control (n = 20)	p-value
Un-stimulated saliva (ml/min)	0.2 (0.2)	0.3 (0.2)	NS
Stimulated saliva (ml/min)	2.0 (0.6)	2.8 (1.1)	0.01
Lactobacillus class (log)			
< 10^4 (low)	15	9	NS
> 10^4-10^5 (medium)	4	9	NS
> 10^5 (high)	1	2	NS
Mutans streptococcus class (log)			
< 10^5 (low)	14	12	NS
>10^5-10^6 (medium)	5	4	NS
> 10^6 (high)	1	4	NS

Mouthbreathing
More individuals reported frequent mouthbreathing in the asthma group (n = 13) than in the control group (n = 2) ($p = 0.01$). Asthmatics who reported frequent mouthbreathing had a mean (SD) DFS of 9.1 (11.3) compared with 7.5 (10.0) in asthmatics without mouthbreathing (NS).

Plaque pH

The results are presented in Table 3 and Figure 1.The pH values in 3 individuals, 2 in the control group and 1 in the asthma group, were excluded for technical reasons. No statistically significant difference in plaque pH was found between the two groups . However, the plaque pH at baseline (0 min) was somewhat lower in the asthma group and the control group displayed a faster pH recovery back to resting pH compared with the asthma group (NS).

Table 3. Initial pH, final pH, minimum pH and area under the pH response curve below pH pH 6.2 (AUC6.2) after a mouth rinse with 10 ml of a 10% sucrose solution for 1 min in young adults with asthma and without asthma (control). Mean value and SD for two approximal tooth sites (13/12 and 16/15) are shown. NS = not statistically significant.

Table 3

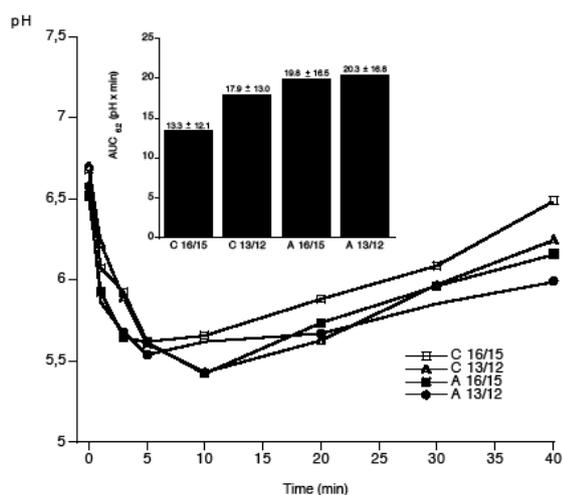| pH value	Asthma (n = 19)	Control (n = 18)	p-value
Site 13/12			
Initial pH (0 min)	6.6 (0.5)	6.7 (0.3)	0.59
Final pH (40 min)	6.0 (0.7)	6.2 (0.5)	0.29
Minimum pH	5.2 (0.4)	5.6 (0.4)	0.90
Maximum decrease	1.4 (0.4)	1.1 (0.4)	0.65
$AUC_{6.2}$	20.3 (16.8)	17.7 (13.2)	0.61
Site 16/15			
Initial pH (0 min)	6.5 (0.5)	6.6 (0.4)	0.56
Final pH	6.2 (0.6)	6.5 (0.5)	0.27
Minimum pH	5.3 (0.6)	5.5 (0.9)	0.76
Maximum decrease	1.2 (0.5)	1.1 (0.3)	0.85
$AUC_{6.2}$	19.7 (16.4)	13.3 (12.1)	0.18

Figure 1. Changes in plaque pH in two approximal tooth areas (16/15 and 13/12) after a mouth rinse with 10 ml of a 10% sucrose solution for 1 min in adolescents with asthma (A) and without asthma (control; C). The corresponding data for the area under the curve below pH 6.2 (AUC6.2) for the two groups and two sites are also shown (n = 18/19 per group, mean and SD).

Dental erosions

Generally, the grade of erosions was mild in most cases (Grade 1) in the two groups. Individuals with erosions on the occlusal tooth surfaces, cuspal cuppings were more frequent in the asthma group (n = 15) compared with the control group (n = 8, NS). In 9 individuals in the asthma group, ≥4 surfaces with dental erosions in the palatal anterior tooth surfaces in the maxillary jaw was found compared to 4 individuals in the control group (NS).

Questionnaire

The asthma group had a more frequent intake of both sugary drinks and sweet meals than the controls, however the differences were not statistical significant. Neither no statistically significant differences were found in the frequency of tooth-brushing between the two groups and all the participants used a fluoridated dentifrice every day. In the asthma group, 6 participants used some kind of fluoride supplement (tablets or rinsing solution) compared with 2 in the control group (NS). In the asthma group 15 individuals medicated periodically for allergy, compared to 8 in the control group. One participant belonging to the asthma group and 2 in the control group were smoking cigarettes daily.

Discussion

Published studies on oral health in adults with asthma are relatively few and present large variations in ages of the participants, asthma severity, duration, medication and sample size [10, 11, 22-24]. One explanation for this may be the difficulty involved in recruiting well-controlled, homogeneous groups with long-term disease. This sometimes limit the possibility to draw reliable conclusions. In the present study, the number of participants was relatively low, but, on the other hand, the group was well balanced with respect to both duration of the disease and medication. The group consisted of *all* young adults in ages between 18 and 24

years of age with long-term, controlled asthma, with the same kind of medical treatment and with a mean exposure time of asthma medication for about 14 years, living and receiving treatment at one of the primary health care centre in the city of Jönköping, Sweden in 2009. They were all considered to be well controlled. In childhood, asthma is more common in boys than girls, but in adult age, the gender distribution changes, the disease become more frequent in females [3]. This is supported in this study were 28 of 40 participants were female. No differences were found concerning the caries prevalence between females and males in this study. Since the gender distribution were the same in both asthma and control group, we believe that this gender distribution may not affect the outcome of the caries prevalence in asthma and control group respectively. In our study the group of young adults with asthma had a higher prevalence of caries than the healthy controls. This is in agreement with other studies investigating caries in adult asthmatics, where the asthma groups had higher, but not always statistically significant different DFS scores compared with the control groups [10, 25]. However, the differences found in the present study were most pronounced when it came to the prevalence of initial caries lesions. The number of manifest caries lesions and fillings were almost the same in the two groups. One explanation for higher prevalence of initial caries and no difference in manifest caries between the two groups in the present study may be that the caries lesions due to extensive preventive activity progress slowly. Nowadays, it is much more common with initial caries than manifest caries in young adults [26]. If a group of individuals have several initial caries lesions, as found in this study, this group may be classified as a risk group for developing manifest caries lesions later in life. No statistically significant difference in caries prevalence was found in asthmatics who experienced a

debut of the disease before 5 years of age compared with those with a debut at the age of 5 years or older.

We also found that the asthmatics had more gingival inflammation than the control group. This is in agreement with Metha et al. [11], who reported more severe gingivitis in asthmatics compared with healthy controls. Surfaces with gingival bleeding in the our study were mainly located in the front region of the upper jaw. This may be explained by the higher frequency of mouthbreathing among asthmatics, which may lead to more plaque and less saliva. Another way of investigating gingival inflammation, other than by using an index, is to measure the volume of gingival cervicular fluid. However, no difference was found in the volume of fluid between the two groups. One limitation was that we did not measure the fluid in the front teeth of the upper jaw. Since the gingival bleeding was more frequent in this region fluid measurements in this area could have influenced on the result.

No difference was observed in plaque formation rate between the groups. This is in contrast with other studies of adult asthmatics, where higher plaque scores were found [11, 27]. This might be explained by the generally high oral hygiene status in the two groups in our study. Even if no difference was found in 3-day plaque accumulation between the two groups, more gingival inflammation was found in the asthmatics compared to the control group, which indicates that the asthma disease and the combination of medication and mouthbreathing might make the gingival tissues in asthmatic individuals more vulnerable to developing gingival inflammation.

The lower salivary secretion rate in asthmatics in the present study is in agreement with earlier studies [24, 28] but differs from a study by Hyyppä et al. [29],

who found no difference in the salivary flow between asthmatics and healthy controls. This lower salivary secretion may be caused by the medication and may influence the plaque pH in these individuals. The somewhat lower plaque pH in the asthma group is in agreement with Kargul et al. [30], who found a reduced pH among asthmatic adolescents who used asthma inhalers. A low pH in the oral cavity may also be a risk factor for the development of dental erosions. Sivasithamparam et al. [23] found a higher incidence of erosions on occlusal surfaces in asthmatics compared with healthy controls. One explanation for erosion may be that dry powder inhalers have a low pH and sometimes contains lactose monohydrate as a carrier vehicle in proportions of 12–25 mg per dose. This lactose monohydrate makes the inhalator its self acidic [30]. This correlation could not be confirmed in the present study.

It appears that the oral health of asthmatics is affected in different age groups, from early childhood to young adulthood. In recent studies by our research group, investigating the oral health of younger asthmatics, it was concluded that it was not the disease *per se* that caused a higher caries prevalence but rather caries-related factors, such as a lower salivary secretion rate, frequent mouthbreathing and a higher consumption of sugary drinks [8, 9]. This is in line with the present study, including the same caries-related factors. Ryberg et al, concluded that impaired salivary gland function in asthmatics is caused by the asthma medication not the asthma disease itself [24]. We have not investigated salivary gland function and could not confirm this. However, the lower salivary flow rate in our study may be caused by the medication and represents a potential factor for caries development in asthmatics. To further analyze factors determining oral health in asthmatics, more well-controlled studies with large samples size are urgent.

To summarise, the present study found that young adults with long-term, controlled asthma had a higher caries prevalence, a higher level of gingivitis and lower salivary secretion compared with healthy controls. Special attention is therefore needed to maintain good oral health in individuals with asthma.

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