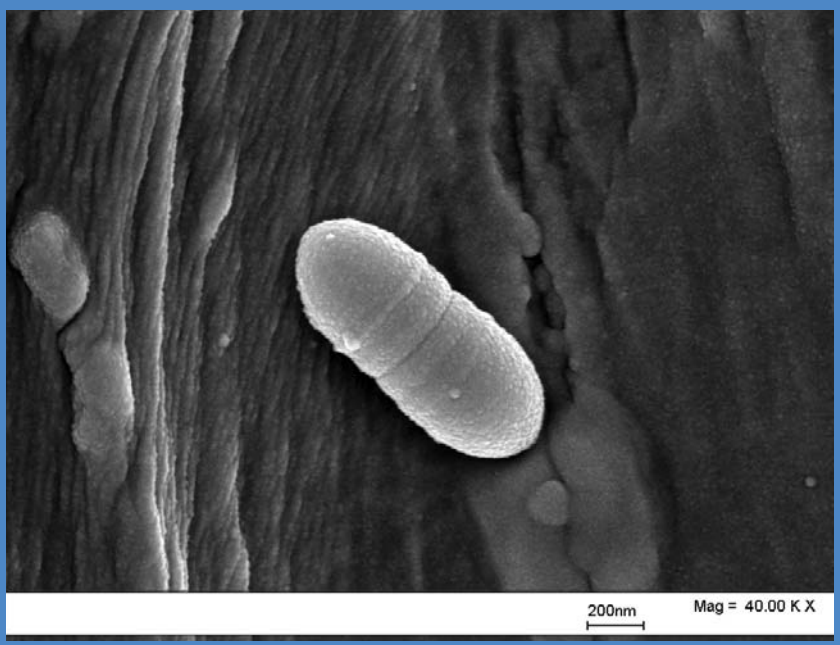
Swedish Dental Journal

Scientific Journal of The Swedish Dental Association



Effect of ozone treatment on different cariogenic microorganisms *in vitro*
page 139

No. 3/08
Vol.32 Pages 105-156

CONTENTS

Periodontitis progession in patients subjected to supportive maintenance care
Jansson, Lagervall
105

What findings do clinicians use to diagnose chronic periodontitis?
Leisnert, Hallström, Knutsson
115

Measuring oral health from a public health peerspective
Johansson, Söderfeldt, Wärnberg Gerdin, Halling, Axtelius, Östberg
125

Effect of ozone treatment on different cariogenic microorganisms *in vitro*
Fagrell, Dietz, Lingström, Steiniger, Norén
139

Work environment factors affecting quality work in Swedish oral and maxillofactial surgery
Pilgård, Söderfeldt, Hjalmers, Rosenquist
149

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Introduction

Swedish Dental Journal, the scientific journal of The Swedish Dental Association and the Swedish Dental Society, is published 4 times a year to promote practice, education and research within odontology. Manuscripts containing original research are accepted for consideration if neither the article nor any part of its essential substance has been or will be published elsewhere. Reviews (after consultations with the editors), Case Reports and Short Communications will also be considered for publication. All manuscript will be exposed to a referee process.

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Periodontitis progession in patients subjected to supportive maintenance care

LEIF JANSSON, MARIA LAGERVALL

Abstract

◎ The maintenance care following the initial active therapy phase plays an essential part in periodontal treatment to prevent disease progression and includes supportive periodontal therapy based on the patient´s individual needs. The purpose of this study was to investigate the longitudinal proximal alveolar bone loss and tooth loss in periodontitis-prone patients during the active treatment and maintenance phase. In addition, the effect on disease progression of potential predictors was investigated.

The investigation was conducted as a retrospective longitudinal study over a period of at least 10 years on a randomly selected population of patients referred for periodontal treatment in a specialist periodontal clinic.

The mean number of teeth lost between baseline and the first re-evaluation was 2.4 and another 2.3 teeth were lost between the first and last re-evaluation. More than 50% of the periodontal pockets ≥6 mm were reduced to ≤5 mm at the re-evaluations. The mean longitudinal bone loss was 9% of the root length, corresponding to a mean annual marginal bone loss of about 0.09 mm. Smoking was significantly correlated to an increased longitudinal tooth loss, while the number of periodontal pockets ≥6 mm at baseline was significantly correlated to an increased longitudinal bone loss.

The magnitudes of marginal bone loss and tooth loss during a maintenance phase of 10-26 years were in accordance with the results from longitudinal studies performed on normal populations in Sweden.

Key words

Maintenance care, marginal bone loss, periodontitis, risk predictor, supportive therapy, tooth loss

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Paradontit progression under aktiv behandlingsfas och stödbehandlingsperiod

LEIF JANSSON, MARIA LAGERVALL

Sammanfattning

◎ En individuellt anpassad stödbehandling efter den aktiva behandlingsfasen utgör en viktig och nödvändig del av behandlingsplanen för att förhindra sjukdomsrecidiv efter parodontal behandling. Syftet med denna studie var att undersöka graden av marginal benförlust och tandförluster under den aktiva behandlingsfasen och stödbehandlingsperioden hos parodontitbenägna individer, som behandlades på specialistklinik i parodontologi. Syftet var dessutom att undersöka effekten av potentiella riskprediktorer på sjukdomsprogressionen.

Studien utgör en retrospektiv longitudinell undersökning över en tidsperiod av minst 10 år på ett slumpmässigt urval från en population bestående av patienter remitterade till specialistklinik i parodontologi.

Det genomsnittliga antalet förlorade tänder mellan baseline och det första utvärderingstillfället var 2,4 tänder och ytterligare 2,3 tänder avlägsnades i genomsnitt mellan den första och sista utvärderingen. Mer än 50% av tandytorna med ficksonderingsdjup ≥6 mm hade reducerats till ≤5 mm vid utvärderingarna. Den genomsnittliga longitudinella benförlusten utgjorde 9 % av rotlängden, vilket motsvarar en årlig benförlust av ca 0.09 mm. Rökare förlorade signifikant fler tänder under den studerade tidsperioden i jämförelse med icke rökare, medan antalet tandytor med ficksonderingsdjup ≥6 mm vid baseline var signifikant korrelerat till en ökad longitudinell benförlust.

Graden av marginal benförlust och antalet förlorade tänder under en stödbehandlingsperiod, som varierade mellan 10 och 26 år, ligger ungefär på samma nivå som rapporterats från longitudinella studier utförda på svenska normalpopulationer.

Introduction

Marginal plaque constitutes a primary etiologic factor for progression of periodontitis (24). The primary risk factors are modified by the the host´s response (16) as well as by local modifying risk factors (24). The progression rate of chronic periodontitis has been studied in several longitudinal studies (5, 7, 19, 20, 26, 29, 31, 32, 36, 41). An annual alveolar bone loss of 0.05 to 0.1 mm has been calculated for an average population in Norway (31), while a mean annual rate of 0.1 to 0.3 mm was found for a similar population in Sri Lanka not receiving dental care (32). A periodontitis-prone subgroup of the latter population lost approximately 1 mm marginal bone per year suffering from aggressive periodontitis (32).

The maintenance care following the initial active therapy phase plays an essential part in periodontal treatment to prevent disease progression and includes supportive periodontal therapy based on the patient´s individual needs (25). Regular prophylactic treatment may prevent further periodontitis progression even for patients without a perfect oral hygiene (42) and frequent recalls minimize the risk of further periodontal attachment loss (1, 2). Several retrospective studies of patients with periodontal disease have demonstrated the importance of maintenance therapy to reduce tooth loss (3, 8, 10, 11, 13, 15, 17, 18, 23, 26, 30, 34, 35, 46, 48, 49). The changes of the longitudinal alveolar bone height during supportive therapy have been found to be clinically insignificant for patients with mild to moderate periodontitis (8, 27) as well as for patients with advanced periodontitis (30, 43). These results are in contrast with the longitudinal attachment loss in periodontitis-prone patients without supportive therapy following periodontal surgery (37), who continued to lose periodontal attachment at an annual rate of about 1 mm.

The purpose of the present investigation was to study the longitudinal proximal alveolar bone loss and tooth loss in periodontitis-prone patients at a specialist clinic of Periodontology during the active treatment and maintenance phase. In addition, the effect on disease progression of potential predictors was investigated.

Material and methods

The investigation was conducted as a retrospective longitudinal study over a period of at least 10 years on a randomly selected population of patients referred for periodontal treatment at the Department of Periodontology, Postgraduate Dental Education Center, Orebro, Sweden, including 60 patients who fulfilled the following inclusion criteria:

- The patients had been diagnosed as having a generalized chronic periodontitis.
- Regular maintenance therapy at least every six months.
- Full-mouth oral radiographic examinations performed at baseline and at the last re-evaluation.

All patients had initially followed a treatment plan after a clinical and radiographic examination performed by a periodontist. The initial treatment phase consisted of oral hygiene instructions, tooth extractions, subgingival scaling, root planing, correction of overhangs and polishing. After the completion of the initial active treatment phase, a re-evaluation was performed by the periodontist including oral hygiene status, periodontal pocket depth measurements and bleeding on probing. The next treatment phase, depending on the individual needs, included periodontal surgery, tooth extractions and prosthetic rehabilitation. After the completion of the active periodontal treatment phase, all patients were recalled at least twice every year for supportive periodontal care according to the individual periodontal risk. During the maintenance visits oral hygiene instructions, scaling, root planing and polishing were performed. If there were clinical signs of recurrent periodontitis, periodontal surgery was performed.

From the dental records and the radiographs, the following variables were recorded:

- Age and gender at baseline.
- Number of teeth at baseline, including third molars, at the first and the last re-evaluation.
- The longitudinal tooth loss was defined as the number of teeth lost between baseline and the last re-evaluation.
- Smoking habits at baseline and at the last re-evaluation. Subjects who started or quitted smoking during the study period were excluded.
- Bleeding on probing index (dichotomous variable) at baseline, at the first and the last re-evaluation.
- Plaque index at baseline (45), at the first and the last re-evaluation. The variable was defied as a dichotomous variable and a plaque score of 1, 2 or 3 was registered as 1, while no presence of plaque was registered as 0.
- Periodontal probing pocket depths at baseline and the last re-evaluation. The measurements were performed to the nearest mm at mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual aspect of each tooth.
- The marginal bone level was determined by

assessments on the proximal surfaces of all measurable teeth on the radiographs from baseline and the last re-evaluation, using the Emago system (1997), which was described in earlier study (21). Only teeth that were measurable at both examinations were included in the study. The marginal bone level was defined as the ratio between the distance apex - alveolar crest and the distance apex - cementoenamel junction. The mean of the marginal bone levels of all measured proximal surfaces from the same individual was calculated. If the cementoenamel junction was not visible, the tooth length was measured and the root length was calculated by using a quotient (26). The marginal bone loss was defined as the difference in marginal bone level between baseline and the last re-evaluation. The mean of the marginal bone levels of all proximal surfaces from the same individual was calculated.

- The longitudinal bone loss was defined as the difference in marginal bone level between baseline and the last re-evaluation.

Statistical analysis:

Pearson´s correlation coefficient was calculated in order to examine the correlations between the dependent and the independent variables. Multiple stepwise regression analyses were adopted to calculate the influence of the potential risk predictors on the dependent variables longitudinal marginal bone loss and tooth loss. Results were considered statistically significant at $p<0.05$.

Results

The patients of the sample had a mean age of 40.6 years (range 27-55) at baseline and 83% declared that they were smokers. A majority of the patients were females (77%) and 53% of the patients were followed for more than 15 years (mean 16.2, range 10-24). Means (standard deviations) of the investigated odontological variables are illustrated in Table 1. The bleeding on probing was reduced from 0.76 at baseline to 0.16 at the last re-evaluation. Plaque index was reduced from 0.61 at baseline to 0.23 and 0.19 at the first and last re-evaluations, respectively. The mean number of teeth lost between baseline and the first re-evaluation was 2.4 and another 2.3 teeth were lost between the first and last re-evaluation. The number of periodontal pockets of 4-5 mm was reduced by 30% at the first re-evaluation, while only minor differences were registered between the first and last re-evaluation. More than 50% of the periodontal pockets ≥6 mm were reduced to ≤5 mm at the re-evaluations. The number of periodontal pockets ≥6 mm at baseline was significantly correlated to the number of periodontal pockets ≥6 mm at the first and last re-evaluations.

The intra-examiner correlation of radiographic assessments was calculated based on repeated measurements of 120 teeth in 5 subjects. The Pearson´s correlation coefficient of the distance measurements was 0.97. The marginal bone difference could be estimated at 88.4 % of the sites and the tooth length was used at 15.6 % of these sites. No significant differences according to root length could be found between teeth where the root length was measured and teeth where root length was calculated from the tooth length.

The marginal bone level on the remaining teeth at the last re-evaluation was reduced by 11% during the study period. 87% of the subjects had more than 20 teeth at baseline, while 43% of the subjects had more than 20 teeth at the last re-evaluation (Table 2). The

Table 2. Distribution of number of teeth at individual level at baseline and the last re-evaluation.

Number of teeth	Baseline	The last re-evaluation
6-10	0	2
11-15	2	10
16-20	6	22
21-35	32	18
26-32	20	8

Table 1. Means (standard deviations) of the investigated variables at baseline, the first and the last re-evaluation.

Variable	Baseline	The first re--evaluation	The last re-evaluation
Bleeding Index	0.76 (0.25)	0.48(0.28)	0.16 (0.12)
Plaque Index	0.61 (0.26)	0.23 (0.15)	0.19 (0.13)
Number of teeth	24.5 (3.07)	22.1 (3.31)	19.8 (5.03)
Number of periodontal pockets 4-5 mm	46.5 (23.1)	32.4 (19.1)	27.6 (17.3)
Number of periodontal pockets ≥6 mm	15.2 (16.1)	7.12 (9.23)	6.47 (8.90)
Marginal bone level	0.72 (0.09)	-	0.64 (0.10)

Figure 1. The distribution of the subjects according to longitudinal tooth loss.

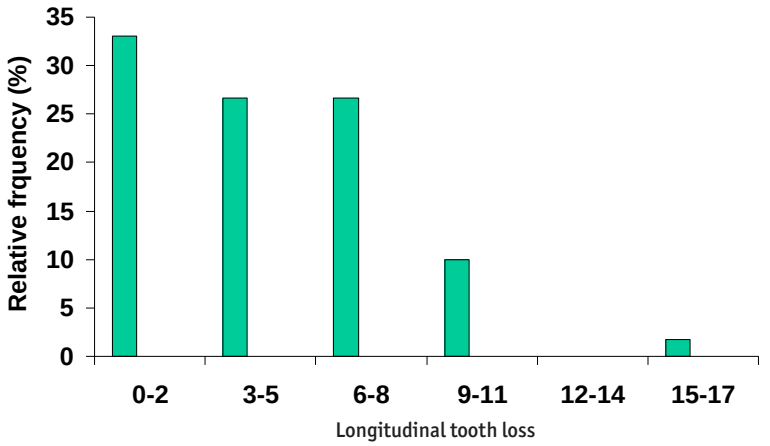
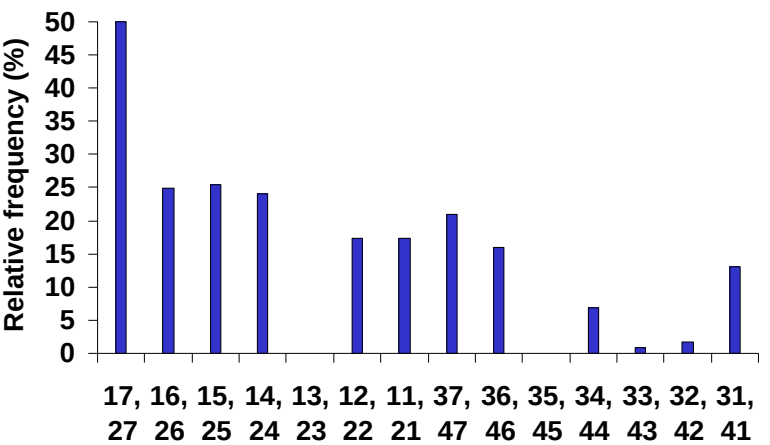


Figure 2. The relative frequencies of longitudinal tooth loss according to tooth number.



mean number of remaining teeth was 24.5 at baseline and 19.8 at the last re-evaluation. The mean annual number of teeth lost during the maintenance phase was 0.14 (s.d. 0.15). 60% of the subjects lost ≤5 teeth between baseline and the last re-evaluation (Figure 1), while 12% lost ≥9 teeth during this time period. The relative frequencies of longitudinal tooth loss according to tooth number is illustrated in Figure 2 50% of the maxillary second molars were lost between baseline and the last re-evaluation, while none of the maxillary canines or mandibular second premolars were lost. The marginal bone level was ≤70% of the root length for 33% of the subjects at baseline (Figure 3), while the corresponding relative frequency was ≤80% for 90% of the subjects. The mean longitudinal bone loss was 9% of the root length, corresponding to a mean annual marginal bone loss of about 0.09 mm. The mean longitudinal bone loss was less than 10% of the root length for 67% of the subjects (Figure 4), while the longitudinal bone loss was ≥20 % for 10% of the sample. The longitudinal tooth loss was increased in the maxillary teeth compared to the mandibular teeth (Figure 2). An increased longitudinal tooth loss was significantly and positively correlated to smoking and plaque index at baseline (Table 3). An increased longitudinal marginal bone loss was significantly and positively correlated to plaque index at baseline and the relative frequency of periodontal pockets ≥6 mm at baseline. In addition, the longitudinal bone loss was significantly increased for males (Table 3). The results of the stepwise regression analyses, using the longitudinal tooth loss as the dependent variable, showed that smoking was significantly correlated to an increased longitudinal tooth loss (Table 4), while the number of periodontal pockets ≥6 mm at baseline was significantly correlated to an increased longitudinal bone loss (Table 5). Age and marginal bone level at baseline were not significantly correlated to longitudinal bone loss.

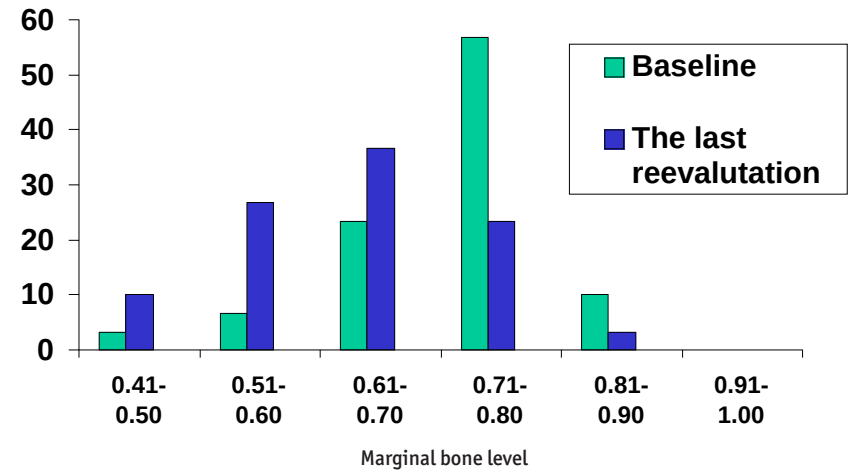


Figure 3. The distribution of the subjects according to marginal bone level at baseline and at the last reevaluation.

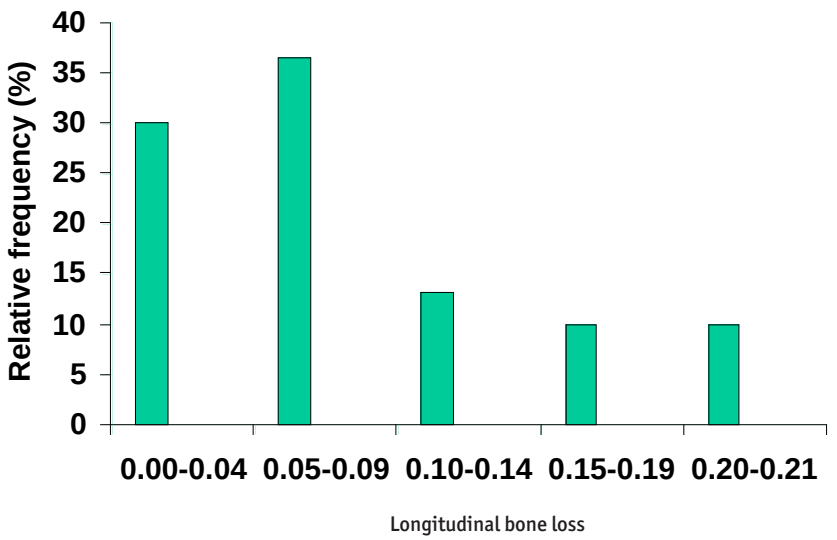


Figure 4. The distribution of the subjects according to the longitudinal marginal bone loss.

Table 3. Correlations of the independent variables with longitudinal tooth loss and marginal bone loss.

Independent variable	Longitudinal tooth loss	Longitudinal bone loss
Age	NS	NS
Gender (0=female, 1=male)	NS	0.35 (p = 0.016)
Number of years between baseline and the last re-evaluation	0.37 (p = 0.002)	NS
Smoking	0.43 (p < 0.001)	NS
Bleeding index at baseline	NS	NS
Bleeding index at the last re-evaluation	NS	NS
Plaque index at baseline	0.49 (p < 0.001)	0.43 (p < 0.001)
Plaque index at the last re-evaluation	NS	NS
Relative frequency of periodontal pockets ≥4 mm at baseline	NS	NS
Relative frequency of periodontal pockets ≥6 mm at baseline	NS	0.39 (p = 0.002)
Relative frequency of periodontal pockets ≥4 mm at the last re-evaluation	NS	NS
Relative frequency of periodontal pockets ≥6 mm at the last re-evaluation	NS	NS
Number of teeth at baseline	NS	NS
Marginal bone level at baseline	NS	NS

Table 4. Results of stepwise multiple regression analysis using the number of lost teeth between baseline and the last re-evaluation as the dependent variable. R^2=0.44.

Independent variable	Regression coefficient	Standard deviation	*p*
Number of years between baseline and the last re-evaluation	0.435	0.100	<0.001
Smoking	2.95	1.12	0.012
Constant	-4.37	1.82	0.021

Table 5. Results of stepwise multiple regression analysis using the longitudinal marginal bone loss between baseline and the last re-evaluation as the dependent variable. R^2=0.11.

Independent variable	Regression coefficient	Standard deviation	*P*
Number of periodontal pockets ≥6 mm at baseline	0.0007	0.0003	0.016
Constant	0.05	0.02	0.006

Discussion

This retrospective study was performed on a population of patients with regular supportive therapy at least every six months in a specialist clinic of periodontology. The purpose was to study the longitudinal tooth and bone loss during the maintenance phase and to identify potential predictors. The patient material consisted of periodontitis susceptible individuals and a great majority (83 %) were smokers. At the last re-evaluation, a majority of the subjects had a marginal bone loss > 1/3 of the root length indicating advanced periodontitis. An earlier study (43) has demonstrated that individuals with high susceptibility to periodontal disease experienced significantly more tooth and alveolar bone loss compared to a "normal" population during 12 years of maintenance. In addition, several longitudinal studies have shown a significant association between smoking and periodontitis progression or tooth loss, indicating that smoking is most likely a risk factor of periodontal disease (39). Consequently, two risk predictors for tooth and bone loss were present in a majority of the sample of the present study.

The radiographic assessments were performed on intra-oral full-mouth radiographs using a technique which magnifies the radiographs 5 times on a computer screen. The distances were indicated using a cursor. In order to estimate the degree of marginal alveolar bone loss, well-defined measuring points were selected. A projection-related measurement technique was used to improve the precision of the assessments by calculating the alveolar bone level in per cent of the tooth length or the root length. This kind of measurement technique has been adopted in several earlier studies (14, 19, 20, 26, 44) and has shown a high reproducibility of measurements.

In periodontal patients, a majority of teeth is lost due to periodontal disease (38). In a retrospective study on 335 individuals with chronic periodontitis receiving periodontal treatment in a dental school, 20.6% of the teeth were lost (33), and of teeth lost, 62% were extracted due to periodontal disease. In another study from North America (49), 63 patients with moderate periodontitis, maintained for 10 years or longer in dental school clinics, lost 7.1% of the teeth during the maintenance period and 76% of these teeth were lost due to periodontal reasons. These frequencies are approximately in agreement with the results of the present study with 9.8% teeth lost from baseline until the last re-evaluation and 10.4% teeth lost during the supportive care. This corresponds to an annual mean loss of 0.14 teeth during the maintenance period. A study population in North Carolina consisting of patients with periodontal disease maintained for 15 years or longer was found to have an annual mean loss of 0.14 teeth with 87% of the teeth lost due to periodontal disease (34) and a Swedish study on a group of patients with high susceptibility to periodontitis showed similar results with an annual tooth loss of 0.16 (43), while other studies (8, 9, 10, 11, 15, 22, 23, 30), have reported significantly lower annual tooth loss rates varying between 0.02 (30) and 0.10 (22).

The longitudinal tooth loss and bone loss varied significantly within the dentition. The highest frequency of tooth loss was found for the maxillar second molar, while none of the maxillary canines or mandibular second premolars were lost. This distribution of tooth loss was in agreement with earlier

reports (10, 11, 15, 23, 28, 34, 48, 49). In the present study, the pattern of tooth loss was similar to the pattern of longitudinal bone loss within the dentition. Consequently, the highest bone loss was found in maxillary molars, while mandibular canines and second premolars had the lowest periodontitis progression rate. The high tooth mortality and longitudinal bone loss for maxillary molars may be explained by several contributing factors such as furcation involvements and difficulty to remove plaque.

Several studies have focused on tooth loss in periodontitis-prone individuals during the maintenance phase, while limited knowledge is available regarding the rate of longitudinal bone loss in periodontitis susceptible patients. A Swedish study (43) found that the annual mean overall longitudinal bone loss over 12 years during supportive care was 0.06 mm for a group of patients with high susceptibility to periodontal disease versus 0.02 mm for individuals with "normal" susceptibility. The longitudinal bone loss was found to be ≥0.17 mm a year for 16% of the patients in the high susceptibility group (43) compared 20 % in the present study, in which the mean annual longitudinal bone loss for the whole sample was 0.09 mm. Thus, a high resemblance according to longitudinal bone loss was found for these two Swedish studies. These data are in agreement also with a study on 52 patients with mild to moderate periodontitis who reported an annual mean bone loss of 0.06 mm (8). The magnitudes of marginal bone loss during the maintenance phase were in accordance with the results from longitudinal studies performed on normal populations in Sweden (19, 20, 26, 41). These longitudinal bone loss rates are in contrast to the amount of disease progression reported by *Lindhe & Nyman* (30), who found unchanged bone scores in patients with advanced periodontitis during a maintenance period over 14 years with a well-supervised care program, and in another study on 155 compliant patients an annual bone gain of 0.02 mm was found after a maintenance phase of 7 years (22). An American study (27) reported an annual bone loss of 0.04 mm for periodontitis patients maintained for 10 years in a dental school in North Carolina. These magnitudes of longitudinal bone loss were in agreement with the results from studies on "normal" populations with regular dental care habits reporting mean annual marginal bone losses of 0.02-0.04 mm (39, 47).

The results of the stepwise regression analyses, using the longitudinal tooth loss as the dependent variable, showed that smoking was the only variable significantly correlated to an increased longitudinal tooth loss. Several earlier studies have adopted linear multiple regression analyses or logistic regression analyses in order to investigate potential predictors of longitudinal tooth loss during maintenance care 10, 15, 28). In these studies smoking was found to be one of the most important risk predictors of tooth loss in agreement with the results of the present study. However, smoking was not found to be a risk factor of longitudinal bone loss in accordance with another study on patients during maintenance phase (40) but in contrast to several cohort or follow-up studies (6, 7, 21, 36), which have included smoking as an independent variable in regression analyses investigating the periodontitis progression and these studies showed a strongly significant association between smoking and longitudinal bone loss. The limited size of the sample in the present study as well as few individuals who were non-smokers could explain the non-significant influence of smoking on bone loss. In addition, it cannot be excluded that teeth lost at the re-evaluation had a more diseased state compared to remaining teeth which may underestimate the longitudinal bone loss in smokers who lost significantly more teeth than non-smokers (6).

The number of periodontal pockets ≥6 mm at baseline was significantly correlated to the number of periodontal pockets ≥6 mm at the first and last re-evaluations and the regression analysis showed a significant correlation to an increased longitudinal bone loss. A high prevalence of residual pockets has been associated with an increased risk for periodontitis progression (4, 12). In a longitudinal epidemiological study over 15-18 years using a logistic regression model (36), deepened pockets ≥6 mm at baseline were found to be significantly correlated to severe periodontitis progression. Consequently, several studies support the hypothesis that deepened periodontal pockets constitute a risk predictor of further longitudinal bone loss even if deep pocket may be stable over several years during a maintenance phase (25).

In conclusion, for a group of periodontitis-prone subjects with a great majority of smokers, the magnitudes of marginal bone loss and tooth loss during a maintenance phase of 10-26 years were in accordance with the results from longitudinal studies performed on normal populations in Sweden. This emphasizes the importance of compliance and regular supportive care with an adequate plaque control in order to prevent periodontitis progression.

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What findings do clinicians use to diagnose chronic periodontitis?

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Abstract

◉ The prevalence of chronic periodontitis is around 40% in the adult population and most patients visiting a dental clinic experience an intervention related to this disease, either as prophylaxis, e.g. disease information, oral hygiene instruction and polishing, or as treatment of the disease, *per se*. Hence, chronic periodontitis is a diagnosis that initiates time and costs consuming interventions. The findings clinicians use to diagnose chronic periodontitis are probably also the base for their choice of treatment. The aim of this study was to examine:

• What findings dental students, dental hygienist students, dental teachers, and supervisors in Public Dental Health use to diagnose patients with chronic periodontitis.

• If different categories of clinicians use different findings to diagnose chronic periodontitis.

A questionnaire was distributed. Seventy-six clinicians representing the four categories answered the question: "What findings, or combinations of findings, do you use when you diagnose chronic periodontitis?"

Twenty-five different findings were identified as findings the clinicians use when they diagnosed chronic periodontitis. The most frequently reported findings were bleeding, deepened pockets and loss of marginal bone tissue. Variations between different categories of clinicians were identified. For example, dental hygienist students used more findings ($P<0.05$), and were also more inclined to use irrelevant findings like calculus, plaque, smoking, compared to the other categories of clinicians ($P<0.05$). The majority of clinicians used only one finding at a time to diagnose chronic periodontitis, and more seldom combined findings. Only 12 out of 76 clinicians used a finding that provided soft tissue inflammation, e.g. bleeding, in combination with a finding that provided loss of supporting tissue, e.g. marginal bone loss. Few clinicians commented that there should be a progressive loss of supporting tissue over time. Further research is needed to investigate if these variations in findings used to diagnose chronic periodontitis indicate variations in treatment of these patients.

Key words

Periodontitis, diagnosis, chronic disease, decision-making

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Vilka fynd använder kliniker vid diagnostik av kronisk parodontit?

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Sammanfattning

◎ Kronisk sjukdom har ett eller flera av följande karakteristika: sjukdomen är varaktig, lämnar kvarvarande invaliditet, orsakar irreversibla patologiska förändringar och fordrar återkommande stöd i form av någon slags intervention eller instruktion. Detta innebär att diagnosen kronisk parodontit med stor sannolikhet medför personella och ekonomiska insatser från patient och tandvård. Majoriteten av alla patienter med parodontit har kronisk parodontit. Vilka fynd som används för att diagnostisera sjukdomen kan vara av central betydelse för val av behandling. Tidigare forskningsresultat visar att det finns stora variationer inom hälso- och sjukvård avseende vilka fynd som används för att ställa diagnos och hur man omhändertar patienter med likartade diagnoser/symptom.

Målet med studien var att undersöka vilka fynd olika kategorier av kliniker använder för att ställa diagnosen kronisk parodontit och om det finns skillnader mellan de olika kategorierna.

En enkät distribuerades som innehöll frågan: ”Vilka fynd eller kombinationer av fynd använder du för att ställa diagnosen kronisk parodontit?”. De undersökta kategorierna av kliniker utgjordes av sista terminens tandläkarstuderande och tandhygieniststuderande, kliniska lärare på Tandvårdshögskolan i Malmö och VFU (verksamhetsförlagd utbildning) -handledare i folktandvården dvs. tandläkare som är ansvariga för tandläkarstuderande när de fullgör sin obligatoriska tjänstgöring i folktandvården. Sjuttiosex kliniker, som representerade de olika kategorierna, angav tjugofem olika fynd för att ställa diagnosen kronisk parodontit. De fynd som angavs mest frekvent av samtliga kategorier var blödning, fördjupad tandköttsficka och förlust av marginal benvävnad. Tandhygieniststuderande angav signifikant fler fynd ($P<0.05$) än övriga kategorier och var mer benägna att använda irrelevanta fynd, dvs. fynd som inte per definition beskriver själva sjukdomen, t.ex. tandsten, plack och rökning, jämfört med övriga kategorier ($P<0.05$). Stor variation inom en och samma kategori av kliniker sågs också avseende vilka fynd som användes för att ställa diagnosen kronisk parodontit, dvs. om man angav fynd som påvisar inflammation i tandens stödjevävnad, förlust av tandens stödjevävnad eller om fynden var irrelevanta. Anmärkningsvärt var att de flesta deltagarna använde fynden solitärt, dvs. de angav antingen ett fynd som påvisade inflammation i tandens stödjevävnad eller ett fynd som påvisade förlust av tandens stödjevävnad eller ett fynd som var irrelevant. Endast 12 av de 76 deltagarna angav att de kombinerade fynden för att ställa diagnosen, dvs. en kombination av fynd som beskrev både förlust *och* inflammation av tandens stödjevävnad. Variationerna i vilka fynd man använde för att ställa diagnosen kronisk parodontit medför kanske att patienter med samma diagnos och sjukdomsbild får olika behandling av olika kliniker, om fyndet som användes för att ställa diagnos också ligger till grund för behandlingen. Detta kan i sin tur leda till icke kostnadseffektiv behandling. Vi avser att belysa detta i framtida studier.

Introduction

Within health care there are wide variations in how clinicians' diagnose and manage patients with the same symptoms (14-17, 19). These variations are seen within different disciplines among both experts and novices (5). In spite of this, clinicians generally believe that the treatment decisions made by their colleagues would be similar to their own. Hence, they assume that there is a broad consensus in medical practice (17, 26). Considering the increasing flow of information and new technologies that are developed or improved it is also reasonable to assume that the diversity in diagnoses and management will increase.

Periodontitis is an infectious disease characterized by inflammation and loss of supportive tissues around teeth. Based on the character and etiology of the disease it is classified into eight groups where the group chronic periodontitis represents the absolute majority of subjects with periodontitis (1, 2). The prevalence of chronic periodontitis is up to 40% in the adult population while severe attachment loss occurs in 7-20%, but the reported prevalence varies depending on the selected population and definition of the disease (1, 2, 11, 23, 29). Chronic periodontitis is mainly treated by general dentists and dental hygienists.

The method used to prevent and treat chronic periodontitis is to reduce the dental biofilm accumulation and its ability to induce tissue destruction, and thus, the goal is to prevent tooth loss. The Swedish Council on Technology Assessment in Health Care (SBU) has in a theoretical model, based on five original studies on economic analyses of preventive diagnostic and treatment methods (8, 9, 13, 22, 25), calculated the annual costs for examination and treatment of chronic periodontitis in 55-59 years old individuals in Sweden to 175 million SEK. The theoretical model included both direct costs, such as salaries for dentists and nurses, material, x-rays, localities, equipment, and indirect costs such as loss of production and salary due to absence from work (27).

Diagnosis is an essential fundament for making treatment decisions. In medical decision-making, several findings are used to diagnose chronic periodontitis, e.g. bleeding on probing providing soft tissue inflammation, deepened pocket, and bone loss measured in radiographs providing loss of supporting tissue over time (30). In the classic paradigm, "the sequential processing view", on decision-making strategies, the clinician, e.g. the dentist, first use findings pertinent to diagnosis to make a diagnostic judgment, and subsequently, based on that diagnostic judgement and another information relevant for treatment, he or she chooses a treatment option, i.e. the clinician judges the probability of a particular diagnosis and then chooses an action, e.g. further testing, treatment, wait-and-see (24). Contrary to "the sequential processing view" we believe that clinicians use the "independent processing view". In this model the dentist makes the diagnostic judgement and the treatment choice by means of a largely independent, often simultaneous processing of both the diagnostic findings and treatment information, when diagnosing and treating patients. In this model the same information and findings that constitute the base for the diagnosis also constitute the base for the treatment option and the diagnosis itself has no direct impact on the treatment option (28).

To study the decision-making strategies in patients with periodontitis several research questions have been raised. This is the first study on this issue and our aim was to examine:

- What findings dental students, dental hygienist students, dental teachers, and supervisors in Public Dental Health use to diagnose patients with chronic periodontitis.
- If different categories of clinicians use different findings to diagnose chronic periodontitis.

Material and methods

Study design

In a questionnaire on findings clinicians use when diagnosing chronic periodontitis one question was: "What findings, or combination of findings, do you use when you diagnose chronic periodontitis?" The questionnaires with included information were distributed to dental teachers at the faculty by one of the authors (LL) in a personal meeting. Supervisors in the Public Dental Health were informed via e-mail and after a general meeting at the faculty the questionnaires were distributed and answered directly after the meeting. The students filled in the questionnaire at the school in connection to their clinical work. The participation of the dentists were voluntarily and anonymous while it was regarded as a part of the education for the students. The licensed dentists stated their age, sex, years of experience as dentist, and specialists noted type of speciality. Teachers in the dental hygienist education did not participate because they were too few to form a group that could be statistically analysed, and thus, compared with the other categories of clinicians.

Clinicians

Dental students (DS):
Thirty-seven dental students, in their final month of a 5 year-education, at the Faculty of Odontology, Malmö University were asked to participate. Twenty-two of the students answered the questionnaires. Thirteen were females and nine were males. The mean age was 27 years (range 24-36) for the females and 26 years (range 24-30) for the males. Fifteen students could not participate due to other commitments; these students were therefore not obliged to participate.

Dental hygienists students (DHS):
Sixteen dental hygienist students in their final month of a 2 year-education at the Faculty of Odontology, Malmö University were asked to participate. Fourteen females and one male of a total of 16 students participated. The mean age was 31 years (range 21-45 years). One student did not participate due to illness.

Dental teachers (DT)*:*
Eighteen dental teachers in the Comprehensive Care Clinic (CCC) at the Faculty of Odontology, Malmö University, were asked to participate. The teachers worked at the CCC four to sixteen hours per week. Twelve teachers participated, four of these were specialists in prosthodontic, two in periodontology and six were general dental practitioners. Six teachers were females and 6 were males. The mean age was 47 years (range 34-67); for the males 53 years and for the females 41 years. The mean age of the 18 teachers that worked at the CCC were 45 years (range 34-67). The questionnaires were returned anonymously in such a way that no drop-out analyses could be performed without unmasking the anonymity. The drop-outs could easily have been identified since they were all known by the authors according to age, gender and speciality.

Supervisors in the Public Dental Health Service (S):
Thirty dentists in the Public Dental Health service, who also have a role as supervisors for dental students in their period of outreach training (18), were asked via e-mail if they would participate. Twenty-seven supervisors, 15 females and 12 males, participated in the study. The mean age was 52 years (range 36-45) for the females and 49 years (range 30-64) for the males. Three of the 30 dentists did not participate due to other commitments.

Analysis
If differences existed between the numbers of findings each category used was analysed with one way analysis of variance (ANOVA). If differences existed, Turkey's test was used to analyse between which categories these differences existed. Differences between different categories use of respectively findings were analysed using chi-square test (P=0.05).

Results

Analysis of the answers
After the data had been collected the questionnaires were read by all the authors. Analyses of the answers were performed stepwise. In a first step, the questionnaires were scrutinised to find content-word or concepts that could be coded as a finding. Twenty-five different findings were identified as findings the clinicians used to diagnose chronic periodontitis. In a second step different content-words or concepts that could be interpreted as the same finding were brought together. For example bleeding on probing and bleeding index were registered as bleeding. Further, subgingival and supragingival calculus was registered as calculus, and plaque and plaque index were registered as plaque. In a third step, findings registered by less than three participants, were excluded. Such findings were age, halitosis, genetics, and diabetes. After these steps, 13 findings remained and were further analysed.

Table 1. The most frequently used findings (N=13) by four different categories of clinicians when they diagnose chronic periodontitis. The findings are divided into three subgroups.

Soft tissue inflammation findings	Loss of supporting tissue findings	Irrelevant findings
-bleeding	-marginal bone loss	-plaque
-pus	-marginal bone loss changed over time	-calculus
	-marginal bone loss on >1/3 of root length	-smoking
	-vertical bone pocket	-mobility
	-attachment loss	
	-furcation involvement	
	-deepened pocket	

Figure 1. Dental students, dental hygienist students, supervisors, and dental teachers use of 13 findings when they diagnose chronic periodontitis. The bars represent the percentage of clinicians within each category that used respectively finding.

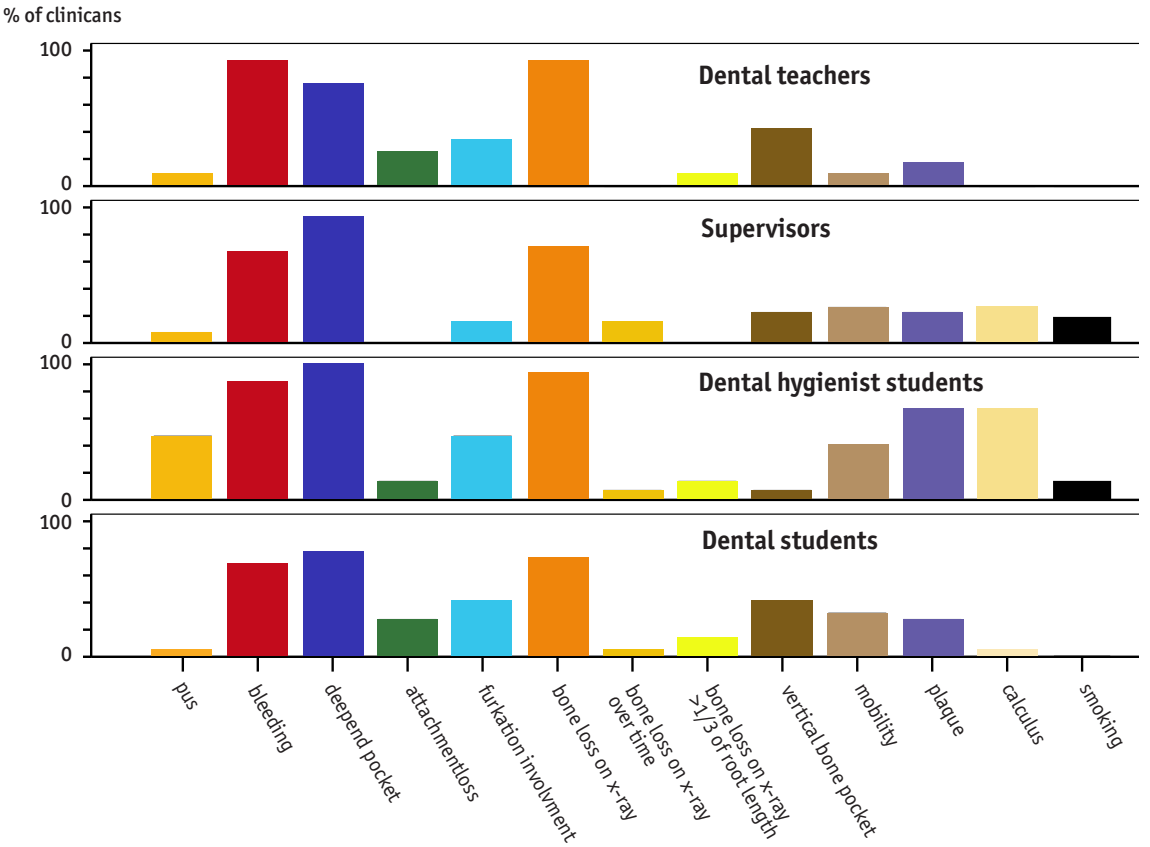

Figure 2. Mean number of findings (N=13) used by four different categories of clinicians to diagnose chronic periodontitis in patients. The bar within each column represents the 95% confidence interval. Dental hygienists students used more findings compared to the other categories (P<0.05).

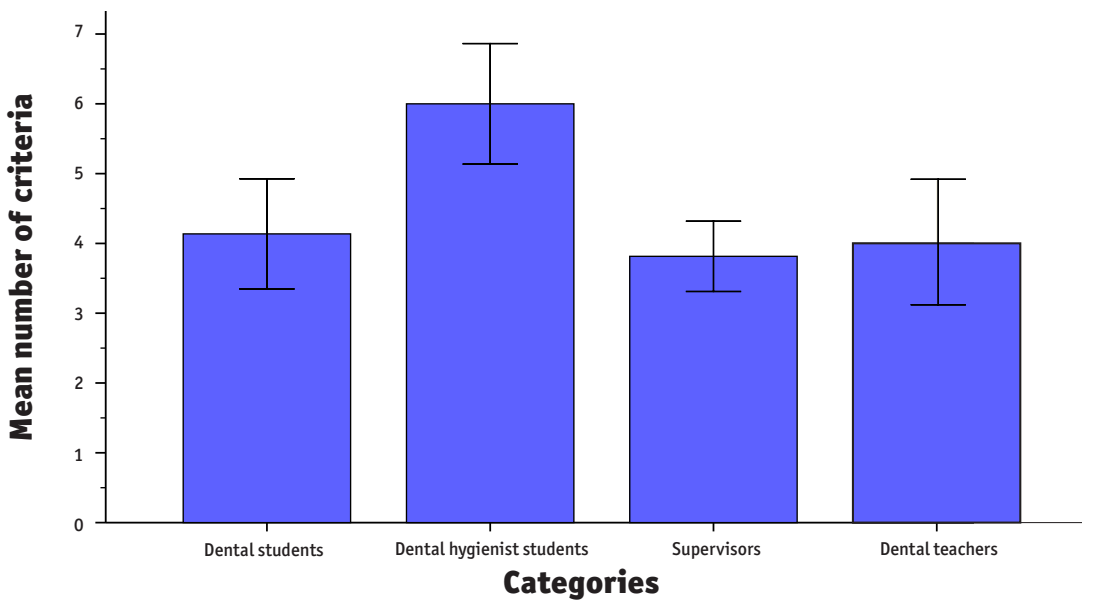

Table 2. Distribution of number of clinicians within each category that used findings that provide soft tissue inflammation (1), loss of supporting tissue (2). The majority used the findings solitarily to diagnose chronic periodontitis. Only 12 of 76 used findings in subgroups 1 and 2 as combinations.

Category of clinicians	Findings 1 and 2		Findings 1 or 2	
	n	%	n	%
Dental students, N=22	15	68	7	32
Dental hygienist students, N=15	15	100	0	0
Supervisors, N=27	18	67	9	33
Dental teachers, N=12	11	92	1	8

Table 3. Number of clinicians within each category that used irrelevant findings to diagnose chronic periodontitis.

Irrelevant findings	Dental students N=22		Dental hygienist students N=15		Supervisors N=27		Dental teachers N=12	
	n	%	n	%	n	%	n	%
Calculus	1	5	10	67	7	26	0	0
Plaque	6	27	10	67	6	22	2	16
Smoking	0	0	2	13	5	19	0	0
Mobility	7	32	6	40	7	26	1	8
TOTAL	**13**	**59**	**13**	**87**	**17**	**63**	**3**	**25**

Findings

The 13 findings were divided into three subgroups showing: soft tissue inflammation, loss of supporting tissue, and irrelevant findings, i.e. findings that were considered not being relevant to diagnose the disease, *per se*. Table 1 presents the subgroups of these findings.

Figure 1 presents the number of clinicians that used each of the 13 findings to diagnose chronic periodontitis. Within all categories the majority of the clinicians used deepened pocket, bone loss on x-rays, and bleeding. Differences between the categories use of findings existed. None of the supervisors used attachment loss as a finding, while 13% to 27% of the other categories of clinicians used this finding ($P<0.05$). A higher frequency of dental hygienist students used plaque, calculus, and pus compared to the other categories ($P<0.05$).

Dental hygienist students used more findings as compared to the other categories ($P<0.05$) (Figure 2). They registered 6 findings as a mean that provided soft tissue inflammation or loss of supporting tissue. All the other categories used as a mean 4 findings. The different categories use of the 13 findings are presented in Table 2 and 3. There was a difference in the number of findings that each category of the clinicians used, as presented in Table 2. Fifty-eight of the 76 clinicians used each finding solitarily, i.e. one at a time, and not in combination to diagnose chronic periodontitis. However, about a third of the dental students and the supervisors only used findings either from the soft tissue inflammation subgroup or the loss of supporting tissue subgroup. The distribution of clinicians that used irrelevant findings is presented in Table 3. With the exception of the dental teachers, the majority of clinicians within each category used irrelevant findings.

Eighteen clinicians, 4 dental students, 2 dental hygienist students, 7 dental teachers and 5 supervisors, of totally 76 participants, reported that they combined two findings to reach the diagnosis. However, of these 18 clinicians only 12 combined one finding that provided soft tissue inflammation with a finding that provided loss of supporting tissue. The other 4 only combined findings that all provided loss of supporting tissue.

Discussion

Chronic periodontitis is a common disease that affects about 40% of the adult population depending on how the disease is defined and selection of age group (7, 10). Most patients visiting a dental clinic experience an intervention related to the disease chronic periodontitis, either as prophylaxis, e.g. disease information, oral hygiene instruction and polishing, or as treatment of the disease, *per se*. The latter group is treated with scaling and root planning, often performed by a dental hygienist. In more severe cases

the treatment includes surgery and in some cases antibiotics even though evidence is lacking for any long-time effects of this treatment (12). Chronic periodontitis is a diagnosis that probably initiates time consuming interventions. The findings used to diagnose this condition could be the base for choice of treatment option. This is why we intended to examine what findings different clinicians use when they diagnose the disease *per se*.

Methodological considerations

Our overall aim, of which this study is a part, is to examine how different categories of clinicians reach their treatment plans for patients with chronic periodontitis. One question was "What findings, or combination of findings, do you use when you diagnose chronic periodontitis?". The aim was to have the clinicians to report in their own words all the findings they used, and whether they used these findings solitarily or in combinations to diagnose chronic periodontitis. This open structure of the question might be the reason that very few, only 18 of the 76 participants, stressed that they used the findings in combinations. In studies where the participants are asked to describe their judgement strategies it is vital that they are not steered (5). If we had given alternatives the answers would probably have been limited to these. Further, the situation in which the clinicians were presented to the questionnaire was almost identical for the different categories. The dentists were informed and had a choice whether or not to participate, in opposite to the students, who were obliged to participate. The dental teachers returned the questionnaires by post or handed it back on a later occasion. They might have obtained information that the other categories were unable to get, since they answered the questionnaire and returned it back on that same occasion.The clinicians in this study are neither a randomised selection nor a representative group of dental clinicians in Sweden. They could rather be regarded as a highly knowledgeable group. Dental teachers are supposed to be informed about the evidence base for the clinical methods used at the CCC, and thus expected to have the knowledge on which findings should be used to diagnose patients with chronic periodontits. Supervisors in the Public Dental Health continuously participate in postgraduate education and are recruited from dentists with experience and interest in clinical questions, educational matters and supporting the students' professional development (18).

The dental and hygienist students were almost licensed: they had finished their work in their tutorial groups and their clinical work and must therefore be seen as highly knowledgeable theoretically in the different subjects included in the dental curriculum. Overall, one would expect the variation in findings they use when they diagnose chronic periodontitis to be smaller than amongst a randomised selection of clinicians (17).

Except for the dental teachers the response frequencies were satisfying. Even after receiving a reminder only 12 out of 18 dental teachers responded. The responding teachers were representative for the whole group of dental teachers according to age, sex, and kind of speciality. However, the author that was present, LL, when the dental teachers answered the questionnaire received negative feed-back from some of the colleagues. They felt as if it was a test and as if they were controlled. This might be one explanation for the relatively low response frequency.

Reflection on the answers

The MESH-term "Chronic Disease", in Pub Med, is defined as "Diseases which have one or more of the following characteristics: they are permanent, leave residual disability, are caused by irreversible pathological alteration, require special training of the patient for rehabilitation, or may be expected to require a long period of supervision, monitoring, or care". Translated to a health care perspective this, in our opinion means, that when patients receive the diagnosis chronic periodontitis, personal and economic resources are consumed and the patients often become lifelong dependents on dental care. The diagnosis and probably the findings that constitute the diagnosis are therefore crucial.

In concordance with other studies in decision making our results underpin existing evidence that variations in medical practice exist (6, 17, 26). In this study, we recorded all 25 different findings used by the clinicians to diagnose chronic periodontitis. The most frequently used findings were deepened pockets, bleeding on probing, and loss of bone level on x-ray. This is in concordance with other studies on how to define the disease chronic periodontitis (4).

The listed findings correspond well to findings that are in concordance with soft tissue inflammation and loss of supporting tissue. However, it was surprising that only 12 out of 76 clinicians combined the findings belonging to these two subgroups. To be in concordance with the definitions of chronic periodontitis "An infectious disease resulting in inflammation within the supporting tissues of the te-

eth and progressive attachment and bone loss"(21), at least one finding providing soft tissue inflammation, and one providing loss of supporting tissue should be used, for example bleeding and bone loss. Furthermore to be chronic there should be a loss of supporting tissue over time (20). Until date, no exact definition exists and very few of the clinicians in this study comments that there should be a loss of supporting tissue over time.

In all categories there were clinicians that used irrelevant findings, i.e. findings not mentioned in any study or classification to be a finding used to diagnose chronic periodontitis. Such findings were for example plaque and calculus. These findings are considered to be irrelevant since they do not, *per se*, describe the disease. Plaque and calculus are findings that could be present both in patients with and without periodontitis (3). Even though the dental hygienist students were in the majority when it comes to the use of irrelevant findings, both dental students and supervisors used such findings. The teachers used few irrelevant findings and were found to be more evidence-based but the students were not in compliance with their teachers. Only one dental teacher used tooth mobility as an irrelevant finding. None of the supervisors in the Dental Public Health used attachment loss as a finding when they diagnosed chronic periodontitis. This was expected since attachment loss as a measurement of loss of supporting tissue is hard to perform in daily praxis and is also time-consuming, and hence, more often used in research projects. The supervisors in contrast to the dental teachers have sparse experience of performing research.

The reasons why dental hygienist students differed could, according to our experience, depend on their educational training and the traditional image of their future work, which mainly consists of prophylactic treatment, supporting treatment and treatment of the disease *per se*, including removal of the biofilm with bacteria and calculus. The clinical experience and knowledge of the teachers could also be an explanation as to why there are differences between students. The majority of the teachers at the dental hygienist education are dental hygienists while they are all dentists at the dentist education.

Conclusions from this study are:

- Variations were found between what findings different categories of clinicians used when they diagnose chronic periodontitis.
- Dental hygienists students used a significantly higher number of findings ($P<0.05$), and were also more inclined to use irrelevant findings like calculus, plaque, and smoking compared to the other categories ($P<0.05$).
- Within each category of clinicians wide variations were found in which findings they used to diagnose chronic periodontitis. The majority only used the findings solitarily and they did not combine one finding that provided soft tissue inflammation with a finding that provided loss of supporting tissue. Only 12 of 76 clinicians used two relevant findings in combination.
- The wide variations when clinicians diagnose chronic periodontitis might indicate variations in treatment plans and treatment options. Further research is planned to investigate the extent to which the used findings influence the treatment options.

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Measuring oral health from a public health perspective

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Abstract

◉ The paper aims to analyse measures of oral health-related quality of life (OHQOL) from a Public Health perspective. Twenty-two measures were analysed conceptually as to their mirroring of the Public Health principles: empowerment, participation, holism and equity. Elements of empowerment were found in connection with application of the measures. Participation was found in using lay opinions during development in 12 measures. All measures analysed had elements of a holistic approach so far that they were not wholly biological. Two measures captured positive health effects. Measures were available for all ages, various languages and populations, an element of equity. No measure was wholly compatible with Public Health. They were based on a utilitarian theory not in full accordance with modern health promotion. There is a need to develop measures that more obviously capture the positive aspects of health and health as a process, as well as the personal perspective of oral health.

Key words

Measures, oral health, oral health-related quality of life, public health

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Mätning av oral hälsa ur ett folkhälsoperspektiv

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Sammanfattning

◎ Syftet med studien var att analysera mätinstrument för självrapporterad munhälsorelaterad livskvalitet ur ett folkhälsoperspektiv. Hälsorelaterad livskvalitet har kommit i fokus under senare år och innefattar en helhetssyn på människan. Detta synsätt på hälsa ligger till grund för modernt folkhälsoarbete. Tjugotvå mätinstrument analyserades med utgångspunkt från de teorier de baserats på och på vilket sätt de speglade några av de principer som praktiskt folkhälsoarbete bygger på: empowerment, ”klientdeltagande”, holism och jämlikhet.

Resultatet visade att empowerment i viss utsträckning kunde identifieras vid användning av mätinstrumenten. Klientdeltagande förekom i 12 av mätinstrumenten då utformningen av frågeställningarna i mätinstrumenten baserades på intervjuer med målgruppen. Samtliga analyserade mätinstrument hade en holistisk ansats i bemärkelsen att de inkluderade psykologiska och sociala aspekter av välbefinnande. Endast två mätinstrument innehöll frågeställningar om positiva effekter av munhälsa. Jämlikhetsaspekten tillgodosågs genom att mätinstrumenten var anpassade för individer i alla åldrar, till olika språk och till olika populationer.

Inga mätinstrument var helt utformade i enlighet med principerna för folkhälsoarbete då de baseras på en utilitaristisk teori som beskriver nedsatt förmåga som oacceptabel och som därmed inte är i överensstämmelse med modernt folkhälsoarbete. Det finns behov av att utveckla mätinstrument som tydligare omfattar positiva aspekter av munhälsa och beskriver hälsa som en process, och som i större omfattning innefattar individens syn på munhälsa.

Introduction

The general the health concept, as well as the idea of public health, have both developed gradually. Since the WHO definition in 1948, health is no longer considered as something that a person simply has got, but it is created over time as a process, without any starting or final point (82). Public health has been described as *"a social and political concept aimed at improving health, prolonging life and improving the quality of life among whole populations through health promotion, disease prevention and other forms of health intervention"* (80, p 3). Public health covers a multitude of ways of working for the best of the public. A widening of the concept of public health has been made though health promotion – sometimes called "the new public health" (58). Health promotion is defined as *the process of enabling people to increase control over, and to improve their health* (82, p.1). Health promotion is also described as a social and political process that aims to strengthen the individual's skills and capabilities but also to change social, environmental and economic circumstances on a community level for improving health (82). *Schou & Locker* (60, p.182) consider health promotion as *the modern equivalent of the public health movement of the 19th century.*

A part of both health and health promotion concerns the oral cavity. Oral health like general health has traditionally been defined as the absence of disease. However, the view of oral health has also gradually changed, especially during the last decades. Focus has shifted from a biologically defined disease view to a holistic multidimensional perspective, and oral health is now considered necessary for obtaining an essential part of general health in terms of well-being and quality of life (34). This can be illustrated by the definition of dental (oral) public health as *"the science and art of preventing oral disease, promoting oral health and improving the quality of life through the organised efforts of society"* (18, p. 9). The widening concept of oral health emphasises the importance of connecting the mouth with the rest of the body and with the person to whom the body belongs (72). *Sheiham* (63) suggests that *oral health promotion* should be integrated with health promotion in general, since oral health is also influenced by socio-political factors. The promoting factors as well as the risk factors are to a large extent the same. There is consensus nowadays on this multidimensional and dynamic perspective on health as well as on oral health. There has been an intense theoretical development opening new conceptual dimensions. Still, theory is not enough – for creation of empirical knowledge, measurement is essential. There is however, no non-theoretical measurement. All measuring presupposes a theoretical and conceptual understanding of what should be measured (9). This is, indeed the gist of measurement validity, the measuring of what is intended to be measured.

Running parallel to the described development, several new indices have been developed. They were initially designated as socio-dental indicators or subjective oral health indicators but are nowadays more usually referred to as measures of oral health-related quality of life, in this paper called OHRQOL. The shift of term is based on the assumption that the functional and psychosocial impacts they document must, of necessity, affect the quality of life. This assumption has not been subject to any critical scrutiny in dentistry, which, according to *Locker & Allen* (37) makes it somewhat unclear what exactly is being measured by indexes of OHQOL. This terminological change could be seen as a consequence of the growing concern among members of the health care system, as well as among the public, that the ultimate goal of medicine and health care must be quality of life and not simply the cure of disease and the forestalling of death (51). In the light of this it would be relevant to study if, in the field of oral health promotion, the theoretical development of the concepts also can be traced in other ways in the measures that have been used. More specifically, the question becomes: do the available measures for OHRQOL, reflect any of the principles of health promotion, though they were not developed for this specific purpose?

Based upon the WHO Working Group's development of basic principles for health promotion, *Rootman* (58) presented seven principles for practical health promoting work, according to Public Health ideas. Four of these principles; *empowerment, participation, holism and equity* may be possible to connect with the measures for OHRQOL found in this study. Health Promotion initiatives should also, related to *Roothman* be: *intersectorial, multi-strategic and sustainable* (58). These aspects of health promotion are not part of this study because they refer more to application strategies of health promotion projects. The four principles empowerment, participation, holism and equity were chosen, because they were considered as more appropriate on an individual level than the three more comprehensive ones (intersectorial, multistrategic and sustainable). The measures were analysed with a theoretical and conceptual approach in the meaning that the content

of the measures has been interpreted considering their theoretical starting-points for oral health and OHRQOL, and in accordance with the Public Health ideas.

Thus, health promotion initiatives should be *empowering*, meaning that they should enable individuals and communities to assume more power over the personal, socio-economic and environmental factors that affect their health (58). Empowerment is rare to find as a fully operational principle, but it has been described in a more practical manner as including factors like control, competence and self-esteem (55).

Practical work in health promotion should also be *participatory,* a consequence of achieved empowerment. Participation in health promotion implies that those who have a direct interest should also have the opportunity to participate in all stages of planning and evaluation of a health promotion initiative (58). The operational question then may be if such participation can be found in the construction of the measure.

The third principle, *holism*, means that physical, mental, social and even spiritual aspects of health and not only disease and disability, should be considered (58). Traditionally, mainly negative aspects like disease and illness have been connected with the health concept and the broader more positive aspects have been neglected. A pathogenetic, not a salutogenetic perspective, has been dominant. *Positive health* has been described as psychological well-being, physical health and the ability to cope with stressful situations (7). *Antonovsky* (4) considered the dynamics of well-being as a complement to the medical perspective, oriented towards treating a special disease.

The fourth principle of health promotion addressed is *equity.* It can be achieved through a fair distribution of power and resources and by removing unfair inequalities that are avoidable (58). One way to reach equity is to enable people to take action in health promotion actions like planning, intervention and evaluation of health promotion (48). Equity also involves asking how accessible to public health different interventions are and an identification of the socio-economic composition of the population reached (57).

Operationally, measures should be available and applicable for all, irrespective of nationality, race, sex, age or socio-economic level.

The aim was to describe measures of OHRQOL, their definition of the concept, dimensions and applications in accordance with the health promotion principles and thereby with the Public Health approach. Operationally the following questions emerge:

- Do the measures focus conditions for empowerment and own activity?
- Can participation be found in construction and application of the measures?
- Do the measures contain physical, psychological, social, or spiritual aspects and do they focus positive health or do they just address degrees of symptoms and problems?
- Are the measures available and applicable for all?

Material and methods

Study selection

Papers concerning OHRQOL measures were identified by a search of the literature covering January 1st 1990 to December 31st, 2006. This search period was selected because it was primarily during the last decade of the twentieth century that the development of OHRQOL measures emerged (67). The search was done by applying the Medline database (EntrezPubMed www.nebi.nlm.nih.gov/entrez/query.fcgi) and the MeSH terms used were *dental health* and *oral health* in combination with *self-rated, self-assessed, subjective, measures* and *quality of life.* The search terms were broad to capture both the measures which headings contained the formerly used terms self-rated oral health with its synonyms and the more recently used concept OHRQOL. Moreover, a second search was performed by scrutinising the obtained articles' reference lists for additional studies, also searching for the measures and authors that evolved from the articles. Papers that contained multidimensional measures of self-rated oral health or OHRQOL, were written in English, and presented with an abstract, were included in the study. Exclusion criteria were papers not containing OHRQOL measures, papers written in languages other than English and papers without abstracts.

Search results

The initial literature search produced 3009 papers reporting 22 measures for self-rated oral health and OHRQOL. The hits in the search are shown in Table 1. After removing duplicates and applying the exclusion criteria, the number of the papers was reduced. The main reason for not including some of the remaining papers was that the initial search was very broad, yielding hits that, for example, captured purely clinical variables, risk factors of disease, single

symptoms and functions, dental fear, dry mouth, dental attendance, dental health behaviour and oral hygiene. Data from the conference in Chapel Hill 1996 (63) were also used to get information beyond that presented in the available papers.

Table 1. The results of search in PubMed database.

Search-terms and combinations	Number of hits
Oral health and self-rated	24
Oral health and self-assessed	21
Oral health and subjective	98
Oral health and measures	437
QOL and oral health	16

Basis for classification

Twenty-two of the identified OHRQOL measures were analysed as to their reflection of the four principles of health promotion as described above: *empowerment, participation, holism and equity*.

There are four issues in the aim for operationalization in the classification of the measures. First, the judgement if a measure contained an element of empowerment was determined by how the reading comprehension level was reported during the development of the particular measure. This is only one, although necessary, of the aspects that create empowerment. The reason to choose it was that it was possible to assess in terms of health literacy levels reported when the measures were used. Other aspects of empowerment refer more to the context where the measure is used.

Second, the participation was estimated through lay people's participation in the development of an OHRQOL measure, as an element of capturing the client's perspective on OHRQOL. The lay perspective can be considered as an aspect of public health, enabling individuals and groups to state how their health is to be promoted and recognising the value of their perspective (46). The degree of lay perspective during the development of the OHRQOL measures was therefore one of the questions in the present study.

Third, the *holistic* perspective was judged in terms of whether the measures favour a generic approach of oral health and therefore also incorporate aspects related to the environment, like physical, mental, social and spiritual factors. The holistic aspects of the analysed measures were judged in relation to the domains of each measure. Another aspect that was considered was whether the measures captured possible salutogenic aspects of oral health. The holistic character of the measures was thus decided through their content of different dimensions in the measures.

Fourth, the measures were evaluated with respect to *equity*. One question in this study was accordingly if there are suitable OHRQOL measures available for all kinds of individuals and populations irrespective of age, gender, ethnicity, and social class to make empowerment and participation possible for all stakeholders.

Quality assessment

The analysis was carried out by one of the authors (GJ) under the head-guidance of one of the co-authors (BS). All authors were involved in the analysis and writing process which imply that the analyses also were judged relevant by another four persons.

Results

A list of the measures is shown in Table 2. One of the measures was composite, including both the perspectives of the professional and the patient; the Oral Health Index, OHX (10) more recently called the Oral Health Score, OHS (11). The DELTA measure (31) was excluded from the analysis since no information could be found concerning the development of the measure. Some measures analysed in this study were parts of more extensive measures: Oral Health Quality of Life Inventory, OH-QoL (12), Dental Health Questions from the Rand Health Insurance Study (16) and Oral Health-Related Quality of Life, OHQOL (32).

The measures for OHRQOL were analysed from two perspectives, on one hand in relation to the development process and on the other hand in relation to their contents. Concerning theoretical starting-points, seven of the measures were based on a theoretical framework, emerging from the WHO classification of Impairments, Disability and Handicap (81), as presented by Locker (35). The seven measures were: The Dental Impact on Daily Living, DIDL (33), Oral Health Impact Profile, and OHIP 49 (66) including three short versions of OHIP (65, 2, 36), Subjective Oral Health Status Indicators, SOHSI (40) and Oral Impact on Daily Performances, OIDP (1). The OIDP was later modified in some studies (62, 42, 43). The aims of these indices were to measure the impact of dental disease on an individual level.

The Oral Health Quality of Life Inventory, OH-QoL (12) was developed to measure a person's subjective well-being in relation to his or her oral health and functional status. The measure was based on works by *Gerin et al.* (22), *Frisch et al*, (21) and *Frisch* (20).

The Social Impact of Dental Disease, SIDD (14) was one of the first socio-dental indicators. It was con-

Table 2. An overview of oral health-related specific measures (OHRQOL).

Author/ Year	Index	Aims to describe	Dimensions
Cushing et al., 1986	SIDD Social Impact of Dental Disease	social and psychological impact of dental disease	functional, social interaction, comfort and well-being, self-image
Atchison & Dolan, 1990	GOHAI General Oral Health Assessment Index	psychosocial impacts of dental disease	physical function, psychosocial function, pain or discomfort
Dolan et al., 1991	Dental Health Questions from the Rand Health Insurance Study	pain, worry and concern with social interaction from problems with teeth and gums	pain, worry, concern with social interactions
Strauss & Hunt, 1993	DIP The Dental Impact Profile	how natural teeth or dentures positively or negatively affects social, psychological and biological well-being and QOL	eating, health/well-being, social relations, romance
Locker & Miller, 1994	SOHSI Subjective Oral Health Status Indicators	the functional, social and psychological outcomes of oral disorders	chewing ability, speaking ability, oral and facial pain, eating impact, problems in communication and social relations, limitations in daily activities, worry and concern
Slade & Spencer, 1994	OHIP (49) Oral Impact Profile	self-reported dysfunction discomfort and disability, attributed to oral conditions	functional limitation, physical pain psychological discomfort, physical disability, social disability
Slade & Spencer, 1997	OHIP (14)	a sub-sets of items from OHIP (49)	see OHIP (49)
Locker & Allen, 2002	OHIP (14)	an alternative short form of OHIP with minimal floor effect	see OHIP (49)
Allen & Locker, 2002	OHIP 20 (OHIP-Edent) for edentulous people	a short form of OHIP appropriate for edentulous people	see OHIP (49)
Leao & Sheiham, 1996	DIDL, The Dental Impact Profile on Daily Living	a socio-dental method that measures the impacts of oral health status on the quality of daily living	comfort, appearance, pain, performance and eating restriction
Adulyan & Sheiham, 1996	OIDP, Oral Impacts on Daily Performances	the serious oral impact on the person's ability to perform daily activities	eating and enjoying food, speaking and pronouncing clearly, cleaning teeth, sleeping and relaxing, smiling and laughing without embarrassment, maintain usual emotional state, carrying out work and social role, enjoying contact with people
Kressin et al., 1996	OHQOL, Oral Health Related Quality of Life	the impact of oral health on quality of life	if problems with teeth and gums affected daily life and social activities, if appearance caused avoidance of communications
Cornell et al., 1997	OH-QoL, Oral Health Quality of Life Inventory	satisfaction and importance of oral health and functional status	performance and satisfaction
Östberg et al., 1999	POH, Self-perceived Oral Health	self-perception of oral and functional status	single-item rating of oral health, bleeding gums and dental appearance
McGrath & Bedi, 2000	OHQoL-UK, Oral Health- related Quality of Life	the impact of oral health on quality of life	physical, social and psychological aspects
Jokovic et al., 2002	CPQ 11-14 Child Perceptions Questionnaire	the impact of oral and oro-facial conditions	oral symptoms, functional limitations, emotional well-being and social well-being

Table 2. Continuation...

Author/ Year	Index	Aims to describe	Dimensions
Locker et al., 2002	FIS, Family Impact Scale	the family impact of oral and oro-facial disorders	parental/family activities, parental, emotions, family conflict
Jokovic et al., 2003	P-CPQ, Parental-Caregivers Perceptions Questionnaire	parental/care-givers perception perception of the oral health-related quality of life for children	oral symptoms, functional limitations, emotional well-being, social well-being
Burke et al., 2003	OHS, Oral Health Index	to provide numerical measure of the overall state of patient's oral health	comfort, aesthetics and functional combined with clinical data
Jokovic et al., 2004	CPQ 8-10, Child Perception Questionnaire	the impact of oral and oro-facial conditions	oral symptoms, functional limitations, emotional and social well-being
Gherunpong et al., 2004	Child-OIDP	the serious oral impact on childrens ability to perform daily activities	eating, speaking, cleaning mouth, doing activity, sleeping, emotion, smiling, study, social contact
Jocovic et al., 2006	Child Perceptions Questionnaire for 11-14 year old children	oral symptoms, functional limitations. emotional well-being, social well-being	see CPQ 11-14

structed in accordance with a health status model of *Wolinsky & Wolinsky* (78) and focused on how dental disease impacted on three major aspects of health status: physical, social, and psychological aspects (61).

The Oral Health Related Quality of Life – United Kingdom, OHQoL-UK was developed in UK (33-34), based on the results of a study with a qualitative approach. Data were collected through open-ended question interviews, capturing aspects that reduce as well as add to quality of life. The effect on, as well as the impact of, quality of life is measured by the 16 items in OHQoL-UK.

Some measures were partly built on literature reviews. The items in the Child Perceptions Questionnaire, CPQ 11-14 (29), Family Impact Scale, FIS (39) and CPQ 8-10 (28) were for example based on existing oral health and child health status measures, assessed by an expert panel and further adjusted after in depth interviews with parents and child patients. The theoretical base for the Parental-Caregivers Perceptions, P-CPQ index (27) was similar to that of CPQ 11-14. The items in the General Oral Health Assessment Index, the GOHAI (6) and OH-QoL were also partly based on synthesis of the literature in combination with expert judgement.

Dental Questions from the Rand Health Insurance Study were based on the WHO definition on health from 1948 (83), on a paper by *Ware et al.* (76), and on the Oral Health-Related Quality of Life measure, OHQOL which had its theoretical foundation in an earlier work by *Stewart & Ware* (69). The Self-perceived Oral Health index, POH (84) was based on a model used by *Hamp & Nilsson* (24). Theoretical starting-points were not described in the Dental Impact Profile, DIP (70), and in the Oral Health Score, OHS (11).

Empowerment

Elements of empowerment are shown in Table 3. Aspects of health literacy were not present in any of the measures. Neither were control, nor self-esteem. However, the level of education among the respondents was measured as a part of the socio-demographic data in some studies where GOHAI (75,79,53), OHIP (79,59) and OHIP 14 (15,49) were applied. In connection with the application of OHIP in Brazil, *De Olivera* (15) assessed the level of education of the mothers of adolescents and in a study in Brazil (11) interviews were used instead of questionnaire because some of the participants were illiterate. With a somewhat stretched interpretation, this could be considered as a concern for health literacy.

Table 3. Empowerment and participation

Empowerment criteria	Measures
Control	none
Health literacy	GOHAI, OHIP 49, OHIP 14
Self-esteem	none
Participation criteria	**Measures**
Lay perspective	SIDD, GOHAI, DIP, OHIP, DIDL, OIDP, OHQoLUK, CPQ8, CPQ11-14, Family impact Scale, P-CPQ, Child- OIDP

Participation

Lay people's perspectives on oral health, shown in Table 3, were used for the development of some measures. CPQ11-14, CPQ 8-10 and FIS were for instance based on a selection of items in reviews of available oral health status measures, in combination with interviews with children and in P-CPQ with parents of child patients. An open-ended interview study was also performed during the development of OHIP 49, where patients were asked about statements of experiences of dental disorders. The foundation for items when developing the GOHAI was a combination of already existing items in reviews of available oral health status measures, and results of consultations with health providers and patients.

The DIP items were based on qualitative interviews with dentists, social scientists and consumers, while the items in the OHQoL-UK were developed using open-ended interviews with a large sample of United Kingdom residents. When developing the SIDD and the DIDL interviews with lay people were also used. The translation of OIDP to Greek was tested through lay peoples' perspective in interviews (74). In the measures Dental Health Questions from the Rand Health Study, OH-QoL, OHQOL, POH, and OHS contained no intentions to collect information of lay people.

Equity

Aspects connected with equity are shown in Table 4. OHRQOL measures are nowadays available appropriate for all ages. Some of the indices are developed for special target groups. Many of the existing measures, like GOHAI and OHIP 49, were primarily developed to measure impact of oral disease among older adults, but have been further validated and tested in populations where younger adults were included (5,8). Recently, there has been a development of measures especially adjusted for children: CPQ 11-14 (23), a short version, CPQ 8-10 (28), Child OIPD (56) and for parents P-CPO, and family FIS (39).

OIDP, GOHAI, and OHIP have all been applied and validated in populations with different ethnicity. For instance, OIDP and OHIP 14 have been tested in a study in the UK where 19 ethnic groups were represented (3), while GOHAI was used for measuring self-reported oral health among Hispanics and African-Americans (5). OHIP 49 has also been used to make cross-cultural comparisons between two Canadian populations and an Australian population (50). OIDP (including modified versions) has been frequently used outside English-speaking countries (43,74,68,13,47,52). During the development of OHRQoL-UK, it was tested among a general UK population representing different ethnic groups, and among South-east Asian and Chinese people. Newton et al. (50) used SOHSI for measuring self-assessed health in four different ethnic groups in England, while OH-QoL was used in three ethnic language groups in Texas, of which one was Spanish-speaking (12). DIP (70) and OHIP 20 (2) are other measures that were evaluated in different ethnic groups during their development.

As some of the measures have been applied in populations in other countries they have been translated into other languages. GOHAI, OHIP and OIDP are, for example, available in a number of different languages (Table 4).

Table 4. Equity

Equity criteria	Measures
Measures available and applicable for:	
Children, parents	POH, CPQ 11-14, Family Impact scale, P-CPQ, CPQ 8-10, Child-OIDP
Elderly (65+)	GOHAI, DIP, SOHSI, OHIP, DIDL; OIDP, OH-QoL, OHQoL-UK, OHS
Measures validated for:	
Ethnic minorities	GOHAI, DIP, SOSHI, OHIP, OH-Qol OHQoL-UK
Socio-economically deprived	SIDD, GOHAI, SOSHI, OHIP 14, DIDL, OHQoL-UK
Measures available in different	
Languages:	OHIP 14, OHIP 49, GOHAI, OIDP, SOHSI, CPQ 11-14, OHQoL-UK

The use of OHRQOL measures in different socio-economic groups was less widespread but GOHAI has been tested in a population of disadvantaged people with mainly unemployed, less educated Hispanic- and Afro-Americans (5). SOHSI was used for determining the relationship between self-assessed oral health status and age, gender, employment status and educational level (50). During the development of OHRQoL-UK the instrument was tested on groups with different socio-economic backgrounds and among employed as well as unemployed people (34). *Hyde et al* (38) used OHIP 14 to measure OHRQOL after an intervention for welfare recipients.

Holism

The holistic approach of the measures is presented in Table 5. Environmental aspects as well as physical, psychological and social dimensions were captured in most of the measures while spiritual dimensions

were absent. Physical, psychological and social dimensions were present in GOHAI, Dental Health Questions from the RAND Health Study, SOSHI, OHIP 49, OHIP 14 (65), OHIP 14 (36), OHIP 20, DIDL and OIDP. OHQOL contains social aspects of oral health, and POH captures physical aspects and appearance. Appearance is a dimension present in POH and in OHS.

Well-being aspects were present in the SIDD index, the DIP index, and in the more recently developed measures CPQ 11-14 and P-CPQ. OHQoL-UK measures positive as well as negative effects and impacts of oral health on the quality of life. The Dental Impact Profile DIP (70), measures how natural teeth and dentures positively and negatively affect quality of life.

Table 5. Holism

Holism criteria	Measures
Physical aspects, Psychological well-being and Social well-being	SIDD, GOHAI; Dental Health Questions from the Rand Health Insurance Study, DIP, SOHSI, OHIP, DIDL, OIDP, OHQoL-UK, CPQ 11-14, CPQ 8-11, Family Impact Scale, P-CPQ, Child OIDP
Social aspects of health	OHQOL
Physical aspects of oral health	POH
Physical and Psychological aspects of oral health	OH-QoL
Functional and Physical aspects of oral Health	OHS
Spiritual aspects	none
Salutogenetic perspective	DIP, OHQoL-UK

Discussion

There has been much effort devoted to the area of oral health measures the last fifteen years. A great deal of this work has focused on further applications of some of the measures developed in the middle of the 1990's, on different settings and populations. There has been a lack of measures for children and adolescents, but four new indices have been developed for this group during recent years. Still a main result of the present analysis is that the analysed measures to some extent are in agreement with the Public Health. A few traces, which can be interpreted as reflections of empowerment, participation, holism and equity were found in the development and use of the measures of OHRQOL.

Different aspects of public health were analysed in relation to the development of available OHRQOL measures. These principles were to some extent influencing and overlapping each other. Health literacy for example is connected both to empowerment and equity.

The lay peoples' perspective during the development of the measures was considered in some measures through qualitative interviews as far as could be documented. Most of the measures covered the physical, psychological and social aspects of oral health. Many of the OHRQOL measures were also equitable in that they were available for different age groups. Equity is a somewhat problematic concept in this circumstance since it cannot be secured though participation from samples of populations. To validate the measures among different populations can nevertheless be important because it is known that there might be differences between how people themselves define their needs and how professionals define them (57, p 215). Especially four of the measures, GOHAI, OHIP 49, OHIP 14 (61) and OIDP were tested among many groups. One limitation in this study was that only English language papers were assessed which can be misleading when judging the aspects of equity, since such aspects might be incorporated to a larger extent in papers written in other languages.

The development of different measures for self-rated oral health and later OHRQOL has to some extent followed the change in the health concept from WHO 1948, but the most frequently used indices have their theoretical starting-points in the WHO: International Classification of Impairments Disabilities and Handicap from 1980 (81). Based on this theoretical framework, they rather measure the negative aspects of oral disease than the oral health of an individual regarded as a resource for well-being and the possibility to live a good life. The more recently developed measure OHRQoL-UK, as well as the DIP, have a broader perspective and are also focused on well-being aspects of oral health and not only on negative consequences of oral disease.

Locker & Gibson (38) concluded that there was no consensus on how the concept *positive health* should be defined and that most definitions were lacking empirical referents or indicators. Positive aspects of health have been described as psychological wellbeing, life satisfaction and physical health. Salutogenic aspects can be captured by assessing the ability to cope with stressful situations (7). Values differ depending on the society people live in. A shift from survival values to self-expression values is evident,

following the economic development in the rich part of the world (26). Self-expression values are connected with human choices and autonomy emphasizing the well-being and promotive perspectives. However, the health concept and health promotion still develop and new OHRQOL measures will be following. Measures with their origins in ICDIH are based on social role theory and utilitarian tradition describing disability as a negative and unacceptable consequence of impairment (41).

Some authors' report lay participation with interview studies during the development of their measures. Since oral health is based on individual judgement (25), the perspective of the concept may differ between people, which make it difficult to establish an ideal measure. There might be other aspects that can be valuable to estimate. *Trulson* (73) for instance, found in interviews that orthodontic treatment could improve self-esteem and self-image. There is an on-going development of measures for children, but there is only one measure available for adolescents and no measure especially developed for young adults. Dental appearance, present among the items in some of the measures, can be considered valuable, especially among young people. Peoples' opinion of aspects being important when measuring OHRQOL might also change over time and other dimensions in the measures can then be demanded (44). Extensive longitudinal studies where processes can be estimated are also needed. GOHAI, OHIP and SOSHI have been used in longitudinal studies. Methodological problems have, however, been reported while using OHRQOL measures for that purpose (17, 64).

The analysed measures are to some extent in agreement with the Public Health. There are some elements that can be interpreted as a reflection of empowering, participatory, holistic and equitable content. The purposes for the measures were only slightly related to health promotion. Still, they are often used in such contexts, and the present analysis has shown that the anchoring of the measures in that discourse is very weak (71).

It might be possible to use the OHRQOL indices for measuring the outcome of health promotion activities. However, the indices may be rather insensitive for changes in the process of public health. *Weintraub* (77) recommended development of measures for health promotion programmes. That recommendation is still valid, as none of the currently available OHRQOL measures are compatible with the four aspects of Public Health that are assessed in this study.

Conclusion

The theoretical basis of the health concept is mirrored in its measurement. Concerning the development in the use of measures for oral health, the perspectives are still predominantly disease-oriented, while there are only a few measures available including positive or salutogenic aspects of oral health. It is an urgent task to develop measures that more obviously capture the positive aspects of health as well as the personal perspective of oral health. Measuring health in a public health perspective assumes longitudinal studies, as health is regarded as a dynamic process that cannot be measured only at one point of time. Fulfilling such tasks could be an important step towards a Public Health approach in dentistry.

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Effect of ozone treatment on different cariogenic microorganisms *in vitro*

TOBIAS G. FAGRELL [1,2], WOLFRAM DIETZ [3], PETER LINGSTRÖM [4], FRANK STEINIGER [3], JÖRGEN G. NORÉN [2]

Abstract

◉ Ozone treatment has been presented and discussed in the literature, as one of the "new" ways to treat dental caries. The aim of this paper was to study the in vitro effect of ozone on some common oral microorganisms related to dental caries using scanning electron microscopy (SEM). The effect of ozone was tested on three different strains of mutans streptococci and one Lactobacillus strain. After exposure of bacteria to ozone treatment for 0 to 60 sec, cultivation on different chair side strips and agar plates took place. Preparation and performance of scanning electron analyses in a field emission scanning electron microscope at 10 kV was then carried out.

It was found that gaseous ozone treatment for 20 seconds or more was effective to kill the different microorganisms in vitro. Treatment of 20, 40 and 60 seconds of ozone prevented the bacteria to grow on the different media. Treatment times shorter than 20 seconds resulted in varying results with a limited effect on bacterial growth for treatments of 5-10 sec, respectively.

The difference between ozone-treated and untreated specimens was macroscopically readily discernable. None of the strains treated with ozone for 60 seconds showed any bacterial growth. Only samples with untreated bacteria could be found in the SEM analyses in form of large and high colonies. This study presents a clear result of the bactericide effect of ozon (in vitro) on four different strains of bacteria associated with dental caries.

Key words

Dental caries, lactobacillus, scanning electron microscopy, oral streptococci, tooth

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Effekt av ozonbehandling på olika kariogena mikroorganismer *in vitro*

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Sammanfattning

◎ Ozonbehandling har under senare år diskuterats som ett av flera ”nya” sätt att behandla karies. Avsikten med denna studie var att *in vitro* undersöka effekten av ozonbehandling på några bakterier relaterade till kariessjukdom. Analyserna i studien utfördes med hjälp av ett svepelektronmikroskop (SEM).

Ozongasens bakteriecida effekt på tre stammar mutansstreptokocker och en stam laktobaciller analyserades. Bakterierna behandlades med ozon under 0 – 60 sekunder med en HealOzone™ utrustning. Efter ozonbehandling odlades bakterierna ut på olika medier, så som chair-side tester och på olika agar-plattor.

Analyserna visade att en ozonbehandling, *in vitro* under 20 sekunder eller mer hade en tydlig effekt på de olika mikroorganismerna. Ingen bakterietillväxt eller polysackaridbildning sågs vid ozonbehandling under 20 sekunder eller mer. Kortare behandlingstider (5-10 sek) gav ett mer varierande och svårtolkat resultat med en begränsad effekt på bakteriernas vitabilitet.

Även på makroskopisk nivå sågs tydliga skillnader mellan behandlade respektive obehandlade mikroorganismer. Ingen av bakterierna behandlade i 60 s uppvisade någon som helst tillväxt. Endast obehandlade bakterier kunde ses som bakteriekolonier i SEM-analyserna. Denna studie visar ett tydligt resultat av ozons baktericida effekt *(in vitro,)* på 4 bakteriestammar som är förknippade med kariessjukdommen.

Introduction

When oxygen (O_2) reaches the upper atmosphere and is exposed to the sun's ultraviolet rays, it naturally turns into ozone (O_3). This forms the protective "ozone layer", which is filtering out UV-radiation. Since ozone is heavier than air it falls back to earth where it is known to naturally purify air and water. The powerful ability of ozone to inactivate microorganisms has led to its use for water disinfection, food sterilization and in the chemical industry (6,9). Furthermore, ozone has been used within the field of medicine during the last century and has today a wide range of indications (5,7).

It is well documented that ozone kills bacteria, virus and fungi upon contact with the various organisms (9). Ozone treatment has also a potential application in reducing bacterial counts in dental unit water delivery systems (6). One of the major environmental advantages is its low cytotoxicity which, in clinical situations, may be caused by a rapid degradation of ozone just after contact with organic compounds (5). It has been shown that the HealOzone™ device, a dental ozone-generator, is safe to use and does not create any detectable levels of ozone outside the treated area (10).

Dental caries is a bacterially mediated disease characterized by demineralization of the tooth surface (15). This may lead to cavitation, discomfort, pain and eventual tooth loss to the patient. If bacteria involved in the caries process, such as streptococci and lactobacilli, were removed or killed, arrestment of the demineralization process would more likely occur. In the presence of fluoride and other minerals this will allow remineralization to take place (8). Previous studies have shown that gaseous ozone may be used for antimicrobial treatment in order to arrest root-, fissure- and smooth surface caries (1,2,3,12,16). An antimicrobial effect of ozone on S. mutans and S. Sobrinus, bacteria known to play an important role in the caries process, has previously been found (12,16). Furthermore, ozone treatment has been reported to be used for sterilizing cavities and root canals, as well as treatment of periodontal pockets and herpetic lesions (3,16).

Microorganisms remaining beneath restorations may cause secondary caries and pulp damage. The antimicrobial effect of ozone results from oxidation of microbial cellular components (5). A recent study by *Polydorou et al.,* (14) confirmed that ozone treatment may have the potential to eliminate residual microorganisms even in deep cavities. However, there is limited information about the treatment time needed in order to inhibit bacterial growth.

The aim of this paper was to study the *in vitro* effect of different treatment times with ozone on some oral microorganisms related to dental caries using scanning electron microscopy (SEM).

Materials and methods

Study design

The study design is shown in Figure 1. The effect of ozone was tested in vitro on three different strains of oral streptococci and one Lactobacillus strain. The bacteria were exposed to ozone treatment, cultivated on different chair side test strips and agar plates and then prepared for the scanning electron analysis.

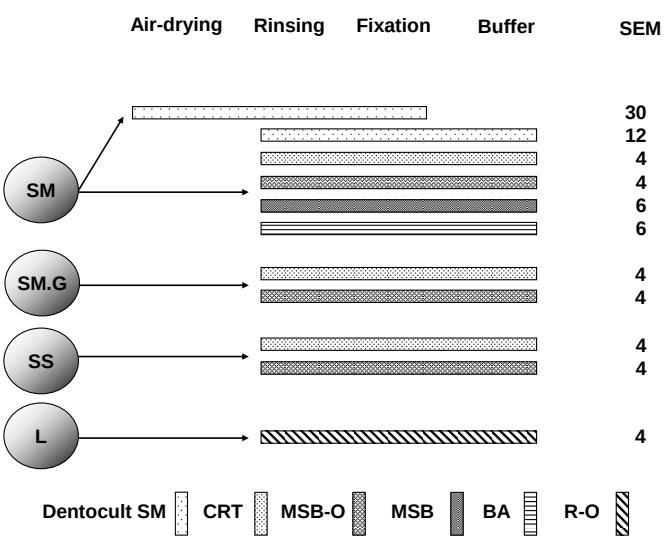


Figure 1. Schematic drawing of the experimental design showing the treatment of the specimens after cultivation and ozone treatment, air-drying, rinsing, fixation and storage in buffer. The figures below SEM denote the number of samples analysed with this technique. (SM = S. Mutans strain IB; SM.G = S. Mutans OMZ65; SS = S. Sobrinus B13; L = Lactobacilli 90; DSM = Dentocult SM Strip Mutans; CRT = Vivacare line CRT; MSB-O = MSB-agar on object-glass; MSB = MSB-agar in petri disks; BA = Blood-agar; R-O = Rogosa-agar on object-glass.)

Ozone generation

An ozone-generating commercially available dental device, HealOzone™ 2130C (KaVo Dental, Biberach, Germany), was used for the ozone treatment. HealOzone is a self-contained device that produces ozone at a fixed concentration of 2100 ppm through a connected hand piece (4). The ozone generator conforms to all European Union legislation covering medical devices [CE: 93/42/EWG (EEC)].

Preparation of microorganisms

The following four strains of microorganisms were used: S. Mutans strain IB, S. Mutans OMZ65, S. Sobrinus B13 and Lactobacilli 90. The microorganisms were cultured on blood agar plates and incubated in Candle Jar at 37° C for 24 hours. The bacteria were then collected from the plates, centrifuged and resuspended in 0.05 M phosphate buffer. Optical density (OD) was determined using a Spectrophotometer at 550 nm. The following OD values were used for the ozone treatment: 0.1, 0.2 and 0.5. Different amounts of bacteria-suspensions (1, 3 and 5 µl) were placed on the different test surfaces.

Chair side

A chair side strip test (Dentocult SM Strip Mutans™, Orion Diagnostica Oy, Espoo, Finland) was used for cultivation of S. Mutans strain IB. After application of the bacteria to the surfaces of the separates strips, the areas with bacteria were treated with ozone for 0, 5, 10, 20, 40 and 60 seconds, respectively. A cup with a diameter of 8 mm was used for the ozone treatment in order to avoid mechanical destruction of the bacteria. Altogether 42 strips were treated and cultivated. The strips were cultured incubated (Incubator 380L, Electrolux, Sweden) according to the manufacturer's instructions for 48 hours in 37° C. After incubation, they were gently rinsed with a phosphate buffer and then air-dried. Another twelve strips were fixated in 4% glutaraldehyde for 1 minute and then stored in a 0.1 M sodium cacodylate buffer (pH 7.2) after which they were kept in refrigerator (8° C) until further preparation. Thirty strips were air dried after which they were stepwise dehydrated in ethanol (30, 50, 70, 90, and 100%) and critical point dried. (15) (Critical Point Dryer, The Bomar Co., Tacoma, WA, USA. S. Mutans strain IB was also cultivated on eight CRT-agar plates (Vivacare line CRT™, Vivadent, Lichtenstein). The plates were left untreated or were treated by ozone for 60 seconds. The CRT was incubated according to the manufacturer's instructions. The strips were fixated in 4% glutaraldehyde for 1 minute and then stored in a 0.1 M sodium cacodylate buffer (pH 7.2) and kept in refrigerator (8° C) until further preparation. The strips were then stepwise dehydrated in ethanol (30, 50, 70, 90 and 100%, respectively) and critical point dried.

Agar cultivation

All four strains of microorganisms were cultivated on Blood-agar (BA), the three streptococci strains on MSB-agar (MSB) and the lactobacillus strain on Rogosa-agar (RO). Each strain of bacteria was cultivated on separate agar plates. For MSB- and Rogosa-agar, layers of approximately 2 mm agar were placed on object-glasses. After incubation of the bacteria on the agar, the bacteria were treated with ozone for 0 and 60 seconds, separated into two groups. After incubation for 48 hours the agar plates were fixated by 4% glutaraldehyde for 1 minute, rinsed in phosphate buffer and then immediately placed in 0.1 M sodium cacodylate buffer (pH 7.2) and kept in a refrigerator (8° C) until stepwise dehydration in ethanol (30, 50, 70, 90 and 100%) and critical point dried. If any colonies were macroscopically seen on the agar plate it was regarded as a negative response to the ozone treatment. Only descriptive statistics was performed.

SEM analysis

Fifty-two agar specimens and thirty Dentocult SM strips were prepared for the SEM analyses. All specimens were sputter coated with gold. After this scanning electron microscopy examination was carried out using a field emission scanning electron microscope (Gemini IMB™, LEO 1530, Germany) at 10 kV. The entire specimen was analyzed in magnification of x5.000, x10.000, x20.000 and x40.000. In the analyzes the quantity, structure and arrangement of bacteria were subjectively evaluated by two of the authors (TGF, JGN). Some of the treated specimens were also analyzed in a higher magnification of x80000.

Results

Optical Density (OD)

No differences were, regardless of OD, seen between the untreated groups after 48 hours of incubation. However, in the ozone treated groups an increased number of bacteria were seen with increased OD. An OD of 0.2 appeared to be satisfactory for the SEM examinations and was thus used for further studies.

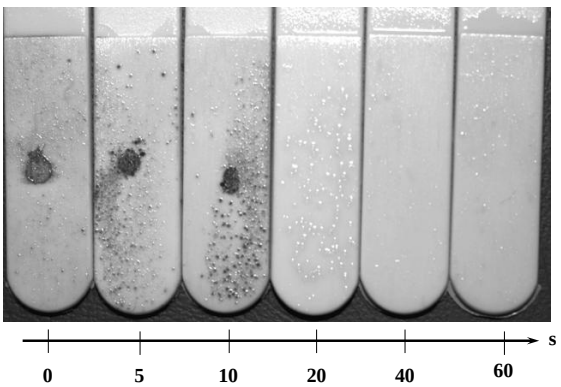


Figure 2. Growth of S. Mutans strain IB on Dentocult SM Strip Mutans after no treatment (0 sec) and after ozone treatment for 5, 10, 20, 40 and 60 seconds, respectively.

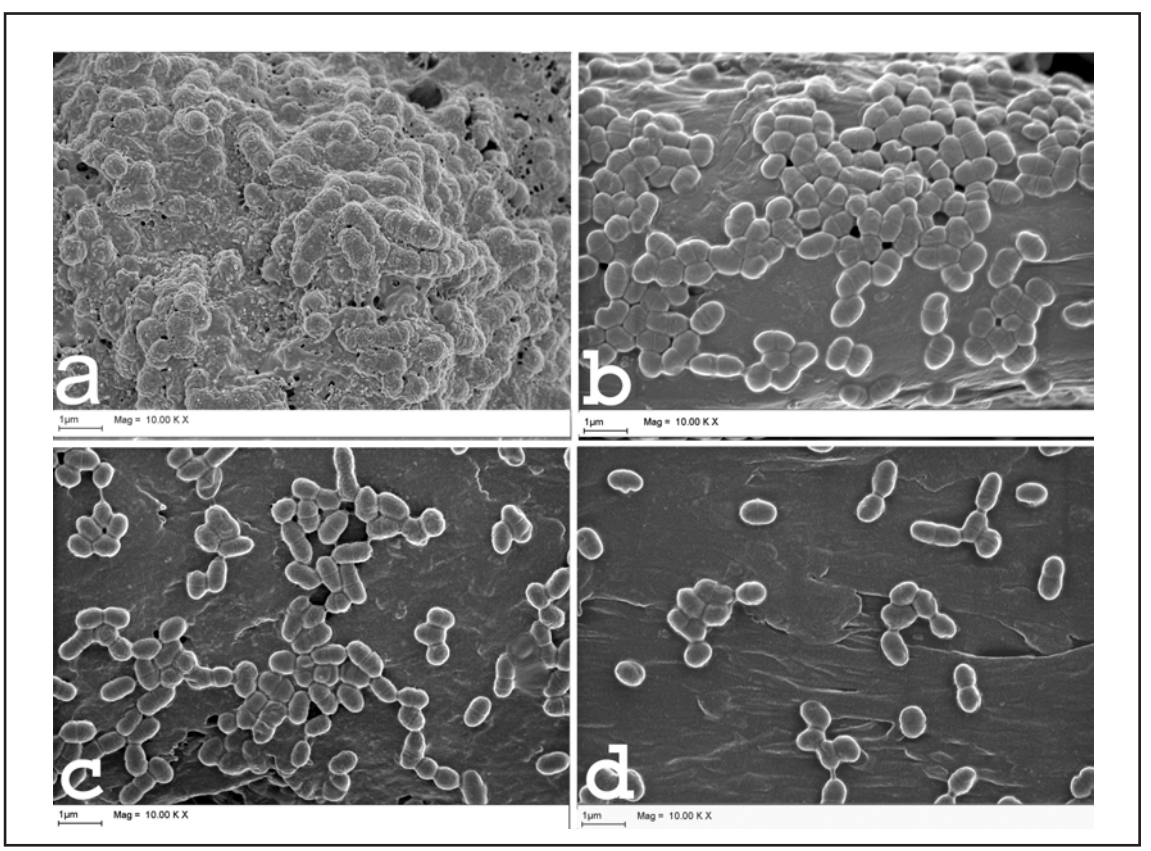
Chair side cultivation strips

Prior to the SEM analyzes a macroscopical evaluation of the specimens was performed in order to get a first impression of the treatment effect. Only a limited effect was found for *S. Mutans IB strain IB* grown on the strips when exposed for 5 and 10 seconds. Thus, bacteria exposed for less than 20 seconds showed a reduced growth. No bacterial growth could macroscopically be seen for the samples treated with ozone for 20, 40 or 60 seconds (Fig. 2), while all non-treated samples showed an extensive growth. No differences were macroscopically seen between the air-dried specimens or the specimens which were critical point dried.

In the SEM analysis of the strips, bacteria were found in all samples. For the non-ozone treated specimens and the samples treated for 5 and 10 seconds, the bacterial colonies had grown in height and a large numbers of bacteria in different stages of cell-division were found. For the samples treated for 20, 40 and 60 seconds, only a few bacteria arranged in a monolayer were observed (Figs. 3a-d).

Strips treated with critical dry-point drying did not differ from the air-dried strips. However, the overall appearance of the bacteria was sharper and more distinct.

Figure 3.
SEM images of S. Mutans strain IB, magnification x10,000.
a) Non-treated bacteria with massive growth. b) Bacteria treated for 20 seconds with growth only in a mono layer. c) Bacteria treated for 40 seconds with limited growth in a mono layer, and d) Bacteria treated for 60 seconds with no growth in a mono layer.



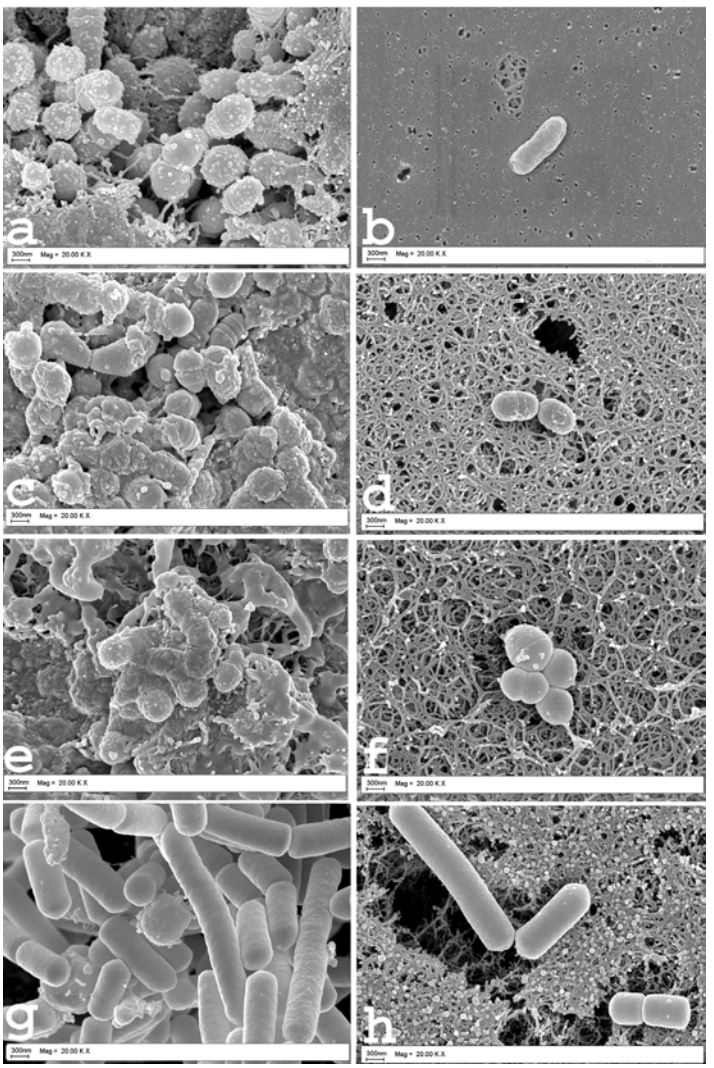


Figure 4.
SEM images of four different strains of microorganisms (0 = no ozone treatment; 60 s = ozone treatment for 60 seconds). Magnification x20,000.
a) S. Mutans strain IB (0).
b) S. Mutans strain IB (60 s).
c) S. Mutans OMZ65 (0)
d) S. Mutans OMZ65(60 s).
e) S. Sobrinus B13 (0).
f) S. Sobrinus B13 (60 s).
g) Lactobacilli 90 (0).
h) Lactobacilli 90 (60 s).

Agar cultivation

The difference between ozone-treated and untreated specimens was macroscopically readily discernable. None of the three streptococci strains treated with ozone for 60 seconds showed any bacterial growth.

The same pattern as for the Streptococci was seen for the Lactobacillus strain with large colonies in untreated samples, but no growth of bacteria after 60 seconds of ozone treatment (Figs. 4a-h). Only a limited number of bacteria were found after ozone treatment for 60 seconds on the agar.

Since the CRT agar has a large content of water it became severely disrupted during critical dry point drying. Nevertheless, the same appearance as for bacteria cultivated on blood agar after different ozone treatment was seen (not shown). Large and high bacterial colonies were found for untreated samples, while ozone treated samples only had few bacteria with the least growth in samples treated for 60 seconds.

The object glasses covered by MSB or Rogosa agar showed no growth of microorganisms in the ozone treated samples irrespective of time length of ozone treatment or type of streptococci. Only samples with untreated bacteria could be found in the SEM analyses in form of large and high colonies. (Fig 5a-b). Since the agar layer was very thin, artifacts from preparation and critical point drying were less noticeable in these samples. A larger production of polysaccharides was also found for untreated samples of S. mutans strain IB as well as after shorter treatment times with ozone (Figs. 6a-b).

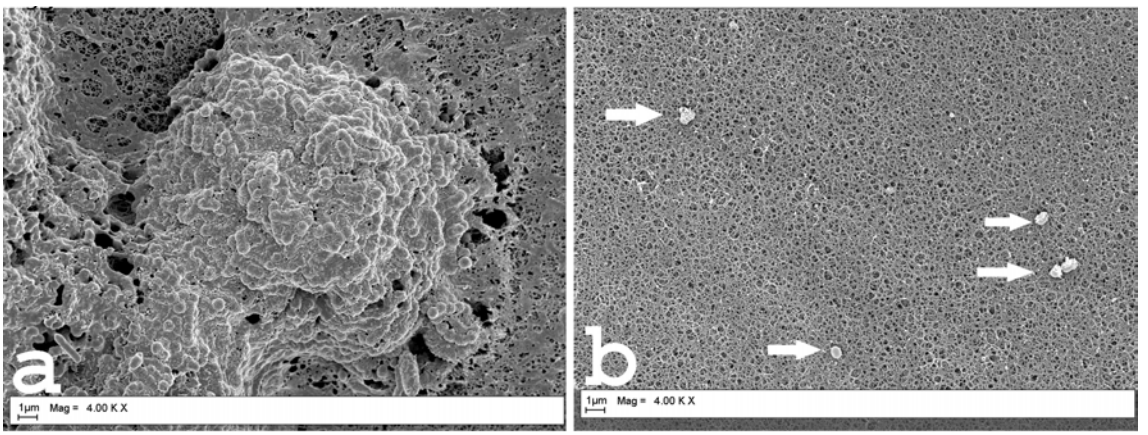


Figure 5.
SEM images of S. Mutans strain IB. Magnification x4,000 for evaluation of bacterial growth.
a) No ozone treatment. b) Ozone treated for 60 seconds.

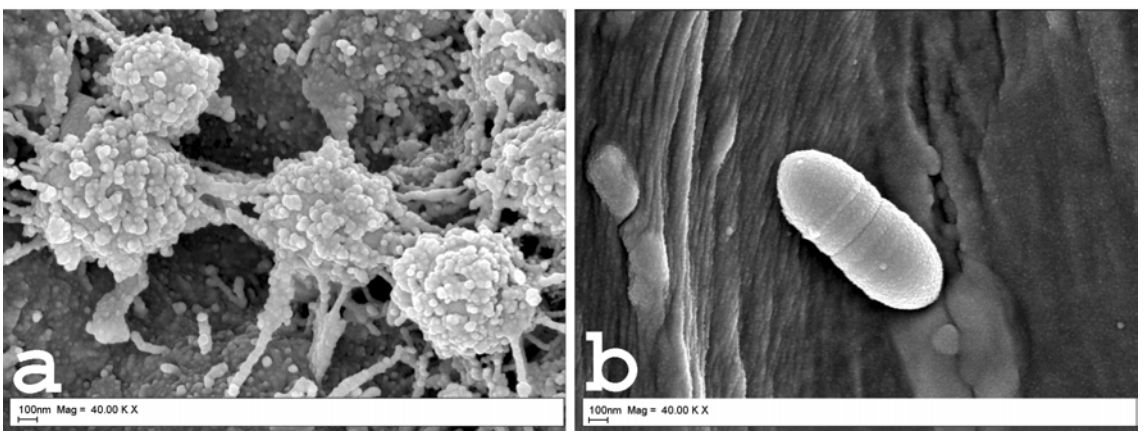


Figure 6.
SEM images of S. Mutans strain IB. Magnification x40,000 for evaluation of polysaccharide production.
a) No ozone treatment. b) Ozone treated for 60 seconds.

Discussion

This study has shown that gaseous ozone-treatment for 20 seconds or more is effective in order to kill different oral microorganisms involved in the caries process. It was found that 20 seconds or longer treatment of ozone prevented the bacteria to grow on the different remedies. Treatments less than 20 seconds had only a limited effect on the growth of microorganisms. With an ozone concentration of 2100 ppm, a treatment time less than 20 seconds seems to be too short to kill all microorganisms.

The oral microorganisms used in this study are all known to play a central role in the caries process. Similar results were seen for all four strains after ozone treatment. No differences were seen between the two fixation methods, air-drying and critical point drying, used prior to the SEM analysis. However, samples on MSB- and Rogosa-agar fixated with glutaraldehyde and kept wet with cacodylate buffer provided the best quality for the SEM analyses. This is as expected because of the low risk for contamination.

In a previous study, shorter treatment with ozonated water resulted in pores and distortion in the membrane of Streptococcus Mutans and complete membrane destruction was seen after 120 seconds of treatment (12). When the membrane is damaged by oxidation its permeability increases and ozone molecules may readily enter the cells (8). Membrane permeability is a key element to cell viability and

changes in permeability involve the loss of several vital processes linked to the cytoplasmic membrane (17). However, in this study no structural changes of the cell membrane was seen in any bacteria after ozone treatment for 60 seconds, irrespective of species. Even though no holes or destruction of the cell membrane of the bacteria was seen, not even in x80,000 magnification (Fig. 7), no bacterial growth was found in ozone treated samples. This is in contrast to non-ozone treated samples where an extensive growth of bacteria was found, which shows that treated bacteria lacked viability.

One reason for the discrepancy between the findings of destructed cell membrane after ozone-treatment in aqueous form as in the study of *Nagayoshi et al.* (16) and the present study may be the higher effectiveness of aqueous ozone compared with gaseous zone. However, even if the gaseous form is less effective, no bacterial growth was seen, for the specimens when treated for 20 seconds or more. No creation of colonies or bacterial mutuality was found. It may, therefore, be concluded that gaseous ozone treatment for more than 20 seconds effectively hinder bacterial growth on the strips and the agar plates.

No production of external polysaccharides was found in the treated specimens. This may indicate that the few bacteria found in the analyzes were inactive.

A recent study (11) has discussed the effectiveness of ozone in the oral environment, influenced by the oral bio film. It must be remembered that the ozone treatment in this study was carried out under laboratory conditions and the results may therefore not be directly transferred to the more complex clinical situation. This study has only shown the effect of ozone on single strains why conclusions cannot be drawn concerning dental caries with a more complex situation with different bacteria present and different anatomical conditions on the tooth. Therefore, factors such as penetration depth of the ozone, different anatomical variations and the influence of the oral bio film must be subjected to future research.

Declaration of interests

This study was not conducted on behalf of any commercial interest. Some of the analyzes in this study were supported by KaVo Dental GmbH, but no honoraria or employment were funded.

KaVo Dental GmbH has not in any way mean been involved in any part of this study.

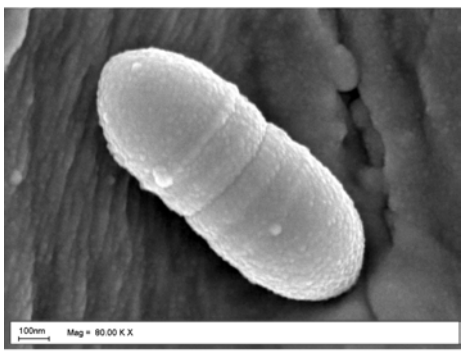


Figure 7.
SEM images of Magnification x80,000 for evaluation of cellwall deformation.

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Work environment factors affecting quality work in Swedish oral and maxillofacial surgery

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Abstract

◎ The aim of this study was to investigate how work environment influenced attitudes to and knowledge of quality among employees of Oral and Maxillofacial Surgery (OMFS) clinics in Sweden.

Data were collected with a questionnaire of 67 questions, related to quality management at the clinic, working situation, content of "good work", physical environment and health. 22 clinics with 297 employees responded, 65 % of the clinics and 86 % of the employees.

A multiple regression analysis with the dependent variable "Attitude towards quality work" showed that only "work environment" ($p=0.010$) revealed a significant association ($p<0.05$). The personnel will have a more favourable attitude to quality work if they regard work environment to be important.

Dental nurses and assistant nurses had more than four times more knowledge of the used quality management system than had the maxillo-facial surgeons. Women had nearly four times more knowledge of quality management than men. Clinic size was important, with better knowledge of quality management in bigger clinics. Soft demands were defined as demands for "flexibility, creativity, quality, service, engagement/commitment and ability to work together, and competence". Hard demands included economy as important, and emphasis on efficiency and productivity. There was a weak association with knowledge of quality management systems if soft demands increased, but negative if hard demands increased.

In conclusion, mainly work environment was of significance for the attitude towards quality work among the employees of OMFS clinics in Sweden. Profession, gender, clinic size, and the hard demands were significantly associated with knowledge of the quality management system used.

Key words

Quality, quality management, physical and social work environment, psychosocial work environment, maxillofacial surgery.

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Värdering av arbetsmiljöfaktorer som påverkar kvalitetsarbete på käkkirurgiska kliniker i Sverige

GÖRAN PILGÅRD, BJÖRN SÖDERFELDT, KARIN HJALMERS, JAN ROSENQUIST

Sammanfattning

◉ Målsättningen med studien var att se hur arbetsmiljö påverkar attityder till och kunskap om kvalitet bland medarbetarna på käkkirurgiska kliniker i Sverige.

Frågeformuläret innehöll 67 frågor som berörde kvalitetsarbetet på klinikerna, innehållet av det goda arbetet och kopplingen mellan fysisk arbetsmiljö och hälsa. 22 kliniker med 297 anställda svarade. 65 % av klinikerna svarade, och 86 % av de anställda som erhöll frågeformuläret svarade.

En multipel regressionsanalys med ”attityd till kvalitetsarbete” som beroende variabel gav endast arbetsmiljö som signifikant samband ($p<0.05$). Medarbetarna hade en positivare attityd till kvalitetsarbete om de ansåg att arbetsmiljön var viktig. Här inkluderade arbetsmiljö variablerna ”kamratskap på kliniken”, ”välbetalt arbete” och ”riskfri arbetsmiljö”.

Hårda krav, definierade som krav på att ekonomin går i första hand, krav på effektivitet och produktivitet och ökade krav på hårda ekonomiska kvalifikationer, hade en negativ påverkan på kunskapen om kvalitetssystem.

Studien visade också signifikanta ($p<0.05$) skillnader för sköterskor jämfört med käkkirurger, kvinnor jämfört med män, klinikstorlek och hårda krav i förhållande till den beroende variabeln ”kvalitetssystem används eller inte”. Tandsköterskor och tandvårdsbiträden hade över fyra gånger mer kunskap om kvalitetssystem än käkkirurgerna. Oberoende av det hade kvinnor nära fyra gånger mer kunskap om kvalitetssystem än män.

Klinikstorleken var viktig. Kunskapen om kvalitetssystem ökade med en och en halv gång för varje storleksklass på klinikerna. ”Mjuka krav” definierades som krav på ”flexibilitet, kreativitet och initiativrikedom, serviceinriktning, engagemang, samarbetsförmåga och kompetens”. ”Hårda krav” innehöll frågor om ekonomin är viktig med betoning på effektivitet/produktivitet. Det var ett svagt samband till ”kunskapen om kvalitetssystem” ifall de ”mjuka kraven” ökade, men sambandet var negativt om de ”hårda kraven” ökade.

Sammanfattningsvis visade medarbetarna på käkkirurgiska kliniker i Sverige att det huvudsakligen var arbetsmiljö som var signifikant när det gällde attityden till kvalitetsarbete. Profession, kön, klinikstorlek och faktorn för ”hårda krav” visade ett signifikant samband till kunskapen om ”kvalitetssystem används”.

Introduction

Quality has in recent decades attracted great interest as a competitive factor, probably being more important today than ten years ago. Patients, being more aware with tougher demands, have prompted greater efforts in achieving quality management. The growing interest has its foundation in what is called Total Quality Management (TQM). There, the overarching goal is to meet the demands and expectations of the customers at the lowest price. This is achieved by encouraging everyone to take part in the process of continuous improvement.

Bergman & Klefsjö [2] use the expression *Progressive quality development* as synonymous to TQM. The term 'progressive' indicates active prevention, change and improvement instead of checking and repairing after a problematic event. The term 'development' indicates that quality work is a continuous process, not only for products and processes, but also for people. Quality management needs a committed leadership. For the quality work to be successful, it is essential to create conditions for participation in the work towards customer satisfaction with a continuous quality improvement. An important means for quality improvements is therefore to facilitate the opportunities for all employees to be committed and to participate actively in decision making and improvement work. Keywords here are communication, delegation and training [2]. A minimum requirement would be that the employees at least know the nature of the quality work done and have a favourable attitude to it.

There is a growing understanding of the fact that the chances of achieving high quality are linked to the work environment and the opportunities of work development that the company can offer [2]. *Lagrosen* [6] showed that there was a high statistical association in a manufacturing company in Sweden between the perception of the organizational value of 'leadership commitment' and the perception of own health.

There is also a relationship between several work environment related factors and quality [1]. Participation is one of the main factors affecting quality. To be able to perform good work, the employees must feel engagement, responsibility and pride in their profession.

It is important for most employees to have a good psychosocial work environment. There are many different factors at work affecting the employee physically and mentally [13]. Together, these factors make up the employees' total work environment. Based on a series of interviews at seven Swedish companies, a number of important factors in the interplay between people, working people, working organization and technology can be discerned that lead to a variation in quality such as management, participation, competence, social relations, stress, and physical environment [1].

Internal control of work, a part of a good working environment, will result in the personnel experiencing greater job satisfaction and more easily avoiding injury at work. This in turn can lead to fewer disruptions, fewer manufacturing defects and fewer output losses. Production will be made steadier and productivity increased. Quality can be elevated and the environment improved. All things considered, content and healthy employees are most often the foundation of profitable business [7].

Oral and Maxillofacial Surgery (OMFS) is a dental speciality; the surgical treatment of pathological lesions and malformations of the jaws and surrounding tissues. It comprises minor procedures such as dentoalveolar surgery, and major procedures such as orthognatic surgery, temporo-mandibular joint surgery, traumatology and reconstructive surgery [11].

Pilgård, Rosenquist, Söderfeldt [8] showed that more than half of the respondents of clinics of Oral and Maxillofacial Surgery (OMFS) stated that they worked with a quality management system, but there was uncertainty as to the type of quality system. Only at two clinics, all the respondents agreed on the system used at the clinic. This showed that one of the most important aspects of a quality system, i.e. to inform everyone, was unsatisfactory.

The study [8] also showed that dental nurses and assistant nurses were more appreciative of quality as a tool for improvement than the maxillo-facial surgeons. There was no such difference concerning the importance of quality work. Dental nurses thought that the quality was more important for the working situation concerning the physical environment than did the maxillo-facial surgeons.

The aim of this study was to find out how work environment influenced attitudes to and knowledge of quality among employees of OMFS clinics in Sweden.

Material and method

Study base

The material has previously been described [8]. A letter explaining the study was sent (January 2002) to all 34 heads of the hospital based OMFS clinics in Sweden (including one prosthetic clinic). If the

heads of the clinics agreed that the clinic would participate, they were asked to acknowledge their participation by returning a list of names of their staff. Then, a questionnaire was distributed to each individual staff member during April 2003. All employees at the clinics were involved. After completion of the questionnaire, the employees returned their responses directly to the Department of Oral Public Health, Malmö University. The study was approved by the Research Ethics Committees (March 2003). The study design is reported in detail elsewhere [8].

Of the 34 clinics, four clinics never responded and another five declined participation. Questionnaires were distributed to 453 persons at 25 clinics. Three additional clinics declined participation when the questionnaires were sent out. 40 persons had either left the clinic or had other duties and 66 worked at clinics that later declined participation. Of the remaining 347 persons at 22 clinics, the net sample (65 %), 50 did not return the questionnaires and thus 297 persons responded, i.e. 86 % of those having the possibility to do this [8].

Questionnaire

The questionnaire consisted of 67 questions. They concerned quality management at the clinic, health, work, working climate, working situation, profession, questions about the content of healthy work, the connection between physical environment and health, emphasis on physical environment, health and support.

The first question used here was about employee category – maxillo-facial surgeons, dental nurses, assistant nurses, dental hygienists, secretaries, and dental technicians. One question was about gender. Another question was about the number of co-workers/staff at the clinic. The response alternatives were "less than 6 persons", "6-10 persons", "11-15 persons", "16-20 persons" or "more than 20 persons".

One question was "Do you work full-time?" with the response alternative per cent of full-time. The question "How many years have you worked in your profession?" had the response alternative in years. "Yes" or "no" were the response alternatives to "Do you need competence development?" The question "Do you have the possibility to influence the development of the clinic?" had five response alternatives ranging, from "not agree" to "agree". "Do you get enough support by colleagues?" and "Do you feel alone in work?" had five response alternatives ranging from "always" to "never".

The following questions concerned the quality work at the clinic. The question concerning the use of any quality management system at the clinic, had "ISO 9000", "ISO 14000", "QUL", "SPRI´s Organization Audit", "other", "none" or "do not know" as alternatives. If the answer was "other", the respondents were asked to tell which quality system they used [8].

A principal components analysis (PCA) was performed on the raw scores of three questions concerning influence at work resulting in a one-factor solution. The variance explanation was 64.8 %. This factor was called *influence*. The three questions co-varied strongly, "Influence on development of clinic" (factor loading 0.67), "Influence on choice of co-workers" (factor loading 0.71) and "Influence on timetable of the work" (factor loading 0.57). For these three questions, there were five frequency oriented response alternatives ranging from "almost never" to "almost always".

Another two questions were also subjected to PCA and concerned quality work also with one factor solution. The first one asked if quality work was regarded as important for the working situation concerning the clinical work (factor loading 0.86) and the second one concerned importance for the physical environment (0.86). Both questions had their responses on Likert scales with five grades from "not important" to "very important". The answer could also be "I do not know" which was set as missing data. The variance explanation was 85.6 %. The factor was called *attitude to quality work* and used as dependent variable in Table 1.

Three further questions were subjected to PCA with one factor solution, "economy is the first" (factor loading 0.54), "efficiency and productivity" (factor loading 0.66), and "demand on efficiency and productivity" (factor loading 0.63). For the questions "economy is most important", and "efficiency and productivity", there were five frequency oriented response alternatives ranging from 1 (do not agree) to 5 (agree), and for "demand on efficiency and productivity", there were five frequency oriented response alternatives ranging from "reduced" to "increased". The variance explanation was 61.0 %. This factor was called hard *demand*.

An additional four questions were analysed in PCA once more with one factor solution, "demand on flexibility" (factor loading 0.65), "demand on creativity" (factor loading 0.76), "demand on quality, service, engagement/committed and ability to work together" (factor loading 0.75), and "demand on competence" (factor loading 0.57). There were

five frequency oriented response alternatives ranging from "reduced" to "increased" of each question. The variance explanation was 68.4 %. This factor was called *soft demand.*

A question about "good work" was subdivided into 12 parts covering different aspects. Each part was in two sections, "what defines 'good work' for you and to what degree is this fulfilled in your present work?". In PCA, question of "good work" revealed three factors, which explained more than half of the variance (52 %). The factors were defined by *Hjalmers, Söderfeldt, Axtelius* [4] and *Pilgård et a*l [9] as *moral values, career development,* and *work environment.*

Pilgård et al [10] finally made a PCA analysis of a battery of questions related to psychosomatic health aspects. The factors were defined as *psychosomatic troubles, somatic troubles, and muscle and joint troubles,* and explained more than half of the variance (58 %).

Statistical methods

Principal components analysis (PCA) was used with the Kaiser criterion and inspection of scree plots for determination of the number of factors. The factor solutions were varimax rotated when there was more than one factor [5]. An OLS regression analysis as well as a logistic regression analysis were also done with calculation of adjusted R^2, and inspection of residual plots in OLS and classification plots, Nagelkerke R^2, and -2LL calculation in logit analyses. All data were processed in the statistics programme SPSS 13.0.

Results and Discussion

The responses for all employees of OMFS clinics in Sweden are shown in Tables 1- 2.

Table 1 shows a multiple regression analysis. The dependent variable was "Attitude towards quality work". Only "work environment" (p=0.010) revealed a significant association (p<0.05). Just above significant associations were "competence development" (p=0.087) and "moral values" (p=0.106). The relation was considerably stronger for work environment as shown by the b-values. The model explained only 9 % of the variance, but it was significant.

Table 2 shows a logistic regression. The dependent variable was knowledge of "Quality management system used or not". Nurses compared to surgeons, women compared to men, clinic size, and "hard demands" all showed significant associations (p<0.05). The predictive power of the model was relatively good, giving an improvement of almost 15 %. One

Table 1. Multiple regression analysis. Dependent variable "attitude towards quality work". (n=217), (range 2-10)

Independent variables	b	P	
Nurses (ref. cat dentists)	0.38	0.384	
Women (ref. cat men)	-0.35	0.396	
Clinic size (5 classes)	0,11	0.285	
Quality management systems used (ref. cat "not used")	-0.13	0.575	
Work full-time (ref. cat part-time)	0.27	0.279	
Muscle and joints troubles (3-15)	0.01	0.970	
Psychosomatic troubles (5-25)	0.04	0.265	
Somatic troubles (3-15)	0.03	0.567	
Soft demand (4-20)	0.01	0.925	
Hard demand (3-15)	-0.01	0.811	
Support by colleagues (1-5)	-0.06	0.652	
Feel alone in work (1-5)	-0.07	0.616	
Competence development (ref. cat "no")	-0.51	0.087	(*)
Influence (3-15)	0.03	0.485	
Career development (3-9)	-0.01	0.980	
Work environment (3-9)	0.30	0.010	**
Moral values (5-15)	0.12	0.106	

R^2 = 0,09
F= 2.146, 17/191 df, p=0.007
(*) P≤0.10
* P≤0.05
** P≤0.01
*** P≤0.001

Table 2. Logistic regression. Dependent variable "Knowledge of quality management system used or not". (n=241)

Independent variables	b	OR	p	
Nurses (ref. cat maxillofacial surgeons)	1.47	4.346	0.005	**
Women (ref. cat men)	1.33	3.797	0.014	*
Clinic size (5 classes)	0.45	1.575	0.001	***
How long in the profession (in years)	0.01	1.009	0.534	
Work full-time or part-time (ref cat)	0.28	1.328	0.360	
Factor for hard demand (3-15)	-0.16	0.849	0.016	*
Factor for soft demand (4-20)	0.09	1.089	0.116	

Modell $\chi 2$ 34.1, 7 df, p≤0,0001
Nagelkerke R^2 0.18
(*) P≤0.10
* P≤0.05
** P≤0.01
*** P≤0.001

should note that the associations with nurses and with women are independent of each other and both very strong as can be seen from the odds ratios. It is further noteworthy that the associations with "hard" and "soft demands" have different directions.

The results show that regarding work environment as an important component of good work had the strongest impact on attitude towards quality work. The personnel will have a more favourable attitude if they regard work environment as a part of good work. This can be compared with the observations in the introduction about the association between organization and health [6]. If there is a good work environment, perceived health is also good.

Axelsson [1] showed that there is a relation between several work environment related factors and quality. Some of these constitute what *Axelsson* [1] calls basic requirements, prerequisites for achieving acceptable quality. Other factors form the basis for motivation and commitment and are prerequisites for Total Quality Management. In this study, the factor "work environment" included variables containing aspects of fellowship, well-paid job, and a hazard-free work environment [9], just the same as Axelsson's work-environment-related factors [1]. The employees of OMFS clinics rated "stimulating fellowship" (78 %), "innovative thinking and initiative-taking are appreciated" (77 %), "intellectually stimulating" (76 %), "the work provides opportunities to have an influence on important decisions" (72 %), and "hazard-free work environment" (69 %) as most important [9]. *Pilgård et al*_[8, 9] showed that some of the most important aspects of a quality system, i.e. to inform everyone and let everybody be committed, were unsatisfactory. These are also important work environment factors. *Axelsson* [1] also reported that deficiencies in information handling, management, work tasks, workplace design and motivation were important causes of poor quality. Work environment includes many necessary aspects of a good job [1]. All employees must be given the necessary conditions for doing a good job [1]. Then and only then they will become committed to their work and its quality [1].

This study showed that profession, gender, and clinic size had significant associations to the dependent variable "Knowledge of quality management system used". This study also showed that the factors of hard demand, which included economy as important, and put emphasis on efficiency and productivity had a negative influence on "Knowledge of quality management system used".

Many variables were significantly associated with the dependent variable "Knowledge of quality management system used or not". Dental nurses and assistant nurses had more than four times more knowledge of quality management than had the maxillo-facial surgeons. Independent of that, women had nearly four times more knowledge of quality management than men. The independent associations with being a nurse and being a woman were interesting. *Erlingsdóttir* [3] showed that in the beginning, the doctors of the University Hospital of Lund were very sceptical to the introduction of a quality system and an external quality control. The reason was that they controlled their own work and that the standard for what was accepted or good relied upon their professional judgement, based on medical and humanitarian norms. The doctors meant that the quality system was connected to other norms and valuations. The result here may indicate that maxillo-facial surgeons' work is similar to that

of the doctors, and a quality system might similarly be regarded as a threat against values of the maxillo-facial surgeons. The difference between maxillo-facial surgeons and dental nurses could be explained by this mechanism.

Pilgård, Rosenquist, Söderfeldt[8] showed that dental nurses and assistant nurses were much more appreciative of quality as a tool for improvement than the maxillo-facial surgeons. This was here confirmed multivariately and shown not to be an issue of gender. There was no similar difference in the opinion of the importance of quality work for their working situation concerning the clinical work. The dental nurses also thought that the quality was much more important for the working situation concerning the physical environment than did the maxillo-facial surgeons. Quality assurance in health care engaged more nurses than doctors –nurses did not feel threatened by an external control in the way that doctors did [3]. The nurses regarded the quality assurance as a way to improve their professional standing, raising their own job status. Maybe more surprisingly, this result held although the gender composition was controlled. Both profession and gender affected the knowledge of quality system. In this study 75 % of the respondents were women and 54 % of the respondents were dental nurses and assistant nurses [8]. The explanation of this surprising result can only be speculated. It might be that women are more holistic in their way of thinking.

Clinic size was very important, with one and a half time greater probability for every size class for knowledge of quality management. There was almost a positive association to knowledge of quality management systems if the soft demands increased, but there was less knowledge of quality management systems if the hard demands increased.

The non-response in the models was high due to list-wise deletion of missing data. As to the inclusion of variables in the models, the criteria of Studenmund were used [12]. These four valid criteria were: *Theory*: Is the variable's place in the equation unambiguous and theoretically sound? *t-Test*: Is the variable's estimated coefficient significant in the expected direction? R^2: Does the overall fit of the equation (adjusted for degrees of freedom) improve when the variable is added to the equation? *Bias:* Do other variables' coefficients change significantly when the variable is added to the equation?

In conclusion, the employees of OMFS clinics in Sweden showed that only work environment was significant for the attitude towards quality work. Profession, gender, clinic size, and the factor for hard demand had significant associations to the dependent variable knowledge of "Quality management system used".

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