

# Swedish Dental Journal

Scientific Journal of The Swedish Dental Association



Professor Jens Andreasen, Copenhagen receives the International Prize of the Swedish Dental Society from Professor Mats Trulsson

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Abstracts of free communications and posters presented at the 48<sup>th</sup> Annual Congress of the Swedish Dental Society, Göteborg, November 15-17, 2012

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# Swedish Dental Journal

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## Editorial address

Swedish Dental Journal  
Odontologiska Institutionen  
Box 1030, SE-551 11 Jönköping, Sweden  
Tfn: +46 (0)36 32 46 04  
Fax: +46 (0)36 71 22 35

## Subscription/business address

Swedish Dental Journal  
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Tfn: +46 (0)8 666 15 00  
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e-mail: SDJ.tit@tandlakarforbundet.se  
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# A replica technique for studying the effect of fluoride solutions on enamel erosion

CARL HJORTSJÖ<sup>1</sup>, ANDERS MJØLNERØD<sup>2</sup>, ANDERS SKAARE<sup>2</sup>,  
GRAZYNA JONSKI<sup>3</sup>, ALIX YOUNG<sup>4</sup>, ANDERS EKVELDT<sup>1</sup>

## Abstract

© The aim of this *in vitro* study was to develop a replica technique aimed at reproducing an enamel surface exposed to erosive challenge. The replica technique was then used to compare the effect of treating enamel with different fluoride (F) solutions using an *in vitro* erosion model.

Human molar teeth were split in two (total n = 34 specimens), and half of each specimen was isolated with impression material. Part I: 10 specimens were exposed to either 0.18% or 1.8% citric acid, the impression material was removed and replicas were prepared. All specimens and replica models were analysed by profilometry and SEM. Part II: 24 specimens were treated with native 0.1 mol/L F-solutions (HF, SnF<sub>2</sub>, NaF and TiF<sub>4</sub>), the impression material was removed, and the specimens were then exposed to 1.8% citric acid. Replicas were prepared and analysed by profilometry and SEM. The median height difference between the F-treated areas and the non-treated areas for each F-solution was measured. SEM micrographs were analysed qualitatively blind by two of the authors.

Results: Part I - Replicas showed good topographical reproduction of the tooth specimens. Part II - HF had a significantly greater erosion-inhibiting effect than the other fluoride solutions at 0.1 mol/L F as shown by profilometry. SEM revealed a clearly defined border between F-treated and non-treated surfaces only for specimens treated with HF- and TiF<sub>4</sub> solutions.

In conclusion, the present replica technique was able to differentiate between the effect of treating enamel with different fluorides against dental erosion *in vitro*. The technique should be tested further for possible use *in situ* and *in vivo*.

## Key words

Dental erosion, fluoride, profilometry, replica technique, scanning electron microscopy

<sup>1</sup>Department of Prosthetic Dentistry and Oral Function,

<sup>2</sup>Institute of Clinical Dentistry,

<sup>3</sup>Oral Research Laboratory,

<sup>4</sup>Department of Cariology and Gerodontology, Faculty of Dentistry, University of Oslo, Oslo, Norway.

## En replika modellteknik för att studera effekten av fluorlösningar på emaljerosion

CARL HJORTSJÖ, ANDERS MJØLNERØD, ANDERS SKAARE,  
GRAZYNA JONSKI, ALIX YOUNG, ANDERS EKVELDT

### Sammanfattning

🕒 Målsättningen med studien var att utveckla och beskriva en replikamodell teknik för att studera en eroderad emaljyta och att använda denna replikamodell teknik för att studera effekten av olika fluorlösningar på en *in vitro* simulerad erosions modell.

Till försöket användes 17 extraherade humana visdomständer som delades, till totalt 34 emaljprover. I del I användes 10 tandhalvor på vilka halva tandkronan isolerades med ett avtrycksmaterial. Den icke isolerade delen av emaljytan etsades med citronsyra i 10 minuter (1,8% eller 0,18%), för att simulera emaljerosion. Efter citronsyrabadet avlägsnades isoleringen och replikamodeller framställdes i akrylat (Technovit®) efter avtryck av tandytorna med ett tunnflytande avtrycksmaterial (A-silikon-light body). Alla emalj proverna och deras respektive replikamodell analyserades med profilometri och SEM.

I del II användes totalt 24 tandhalvor från 12 tänder. Den ena halvan av tandytorna isolerades på samma sätt som i del I. Den icke isolerade emaljytan behandlades i 10 minuter med en av fyra fluorlösningar, samtliga med en fluorkoncentration på 0,1 mol/L (HF- fluorvätesyra, SnF<sub>2</sub> - tennfluorid, NaF - natriumfluorid och TiF<sub>4</sub> – titante-trafluorid). Vardera emaljprov behandlades med en av de fyra fluorlösningarna. Sex emaljprover användes per lösning. Efter fluorbehandling avlägsnades isoleringen och hela emaljprovet etsades med 1,8% citronsyra för att imitera emaljerosion. Avtryck av hela tandytorna gjordes och replikamodeller framställdes. Modeller analyserades med profilometri och SEM för att studera höjd- och topografiskskillnader mellan den fluorbehandlade- och den icke fluorbehandlade emaljytan.

Resultat: Del I - Replikamodellerna gav en god reproducerbarhet av emaljytorna med hög överensstämmelse mellan modell och tandyta. Del II - Profilometrianalysen visade att HF hade en signifikant större erosion-inhiberande effekt jämfört med de andra fluorlösningarna vid en fluorkoncentration på 0,1 mol/L, HF gav den största höjdskillnaden mellan fluorbehandlad- och icke fluorbehandlad yta. Enbart för emaljtor behandlade med HF och TiF<sub>4</sub> framträdde en tydlig gräns på SEM bilderna mellan fluor och icke fluorbehandlad yta.

Sammanfattningsvis fungerade den utvecklade replikamodell- och isoleringtekniken bra. Den presenterade replika modelltekniken borde efter ytterligare tester kunna användas för att studera erosion av emaljen *in situ* och *in vivo*.

## Introduction

Dental erosion is acknowledged to be a clinical problem in many countries. Tooth surface mineral softening and loss as a result of non-bacterial derived acids can extend over large areas compared with the more concentrated demineralisation associated with dental caries. As a result, the detection of early stages of dental erosion is often difficult for the clinician. Improved methods for clinical diagnosis, recording of early dental erosions and *in vivo* study methods are therefore clearly indicated. Dental study casts and replica techniques could be used in patients at increased risk for dental erosion, as a means of recording early erosive lesions, and for the assessment of lesion progression.

The authors of a literature review on techniques to measure tooth wear and erosion concluded that there are problems associated with reference points and accurate validation (1). The techniques reviewed included replica techniques. These have previously been used for both qualitative and quantitative registration of tooth wear and erosion. A replica technique for describing the wear mechanism of dental materials was reported by *Ekfeldt* (7-9). More recently, a study using a replica technique investigated the protective effect of different toothpastes against erosion (20). In that study, scanning electron microscopy (SEM) was used in combination with a replica technique to evaluate the morphology of enamel surface before and after exposure to acidic soft drinks. In another recent study a replica technique was also used to examine non-carious cervical lesions (18). It has been suggested that a negative replica can be used for monitoring tooth erosion i.e. an impression of the teeth for example in a silicone impression material (2).

More recent research on dental erosion has shown that fluorides other than those traditionally used for caries prevention may hold promise as anti-erosion agents. *In vitro* and *in situ* studies have shown that acidic fluorides such as titanium tetrafluoride ( $\text{TiF}_4$ ) and stannous fluoride ( $\text{SnF}_2$ ) may be effective in reducing the erosive effect under certain conditions (5,15,17,21,23). It has been suggested that the formation of abundant amounts of calcium fluoride-like precipitates and/or a metal fluoride-initiated glaze layer are believed to be the mechanisms by which the acidic fluorides protect the tooth from acids (25). In addition to these metal fluorides, treating the enamel with dilute solutions of hydrofluoric acid (HF) has also been shown *in vivo* and *in vitro* studies to re-

duce the erosive effect of citric acid (11-13). Hydrogen and fluoride, as undissociated hydrogen fluoride, is an important active component in acidic fluoride solutions (4). However, even at low concentrations HF may be harmful for living organisms (3). In a recent *in vivo* study, the effects of low concentrated solutions of HF were tested on mice skin and fertilized hens eggs. The study was performed in order to assess the possible consequences of HF solutions accidentally contacting human oral tissues during local application to the teeth. Based on the results of that study it was concluded that concentrations of  $\leq 0.2\%$  v/v HF were found to be safe to use in controlled experiments in the human oral cavity (14).

The first aim of the present study was therefore to describe a replica technique for reproducing an enamel surface exposed to an *in vitro* erosive challenge. The second aim was to use this replica technique to compare the effect of a single treatment of enamel with different fluoride solutions using an *in vitro* erosion model.

## Material and methods

### *Teeth and test specimens*

The study was approved by the National Committee for Research Ethics in Norway (REK Sør S-0922d). The teeth used in this *in vitro* study were obtained by consent from patients requiring extractions, and were registered anonymously in a biobank. In total 17 surgically extracted human wisdom teeth were included in the study. The teeth had no cracks or other surface deficiencies as checked by examination with light microscope (Cambridge Instruments, Model Z30 E, Nussloch, Germany). Five teeth were used in part I, and 12 teeth in part II of the study. All teeth were divided using a saw with water cooling (Exakt-apparatbau, Norderstedt, Germany) resulting in two specimens per tooth - buccal and lingual halves ( $n = 34$ ). The prepared specimens were randomly assigned to each test group.

### *Erosive challenge*

In order to ensure a large variation in the provoked etching effect, in part I of the study two different concentrations of citric acid were used: 0.1 mol/L (1.8% w/v, pH 2.2) and 0.01 mol/L (0.18% w/v, pH 2.7) (Sigma-Aldrich Chemie, Steinheim, Germany). In part II only 0.1 mol/L citric acid was used as the acidic challenge. The citric acid solutions were prepared freshly for each study day using deionised water.

### Test fluoride solutions

For part II of the study F solutions containing 0.1 mol/L F<sup>-</sup> were prepared using deionised water: HF, SnF<sub>2</sub>, NaF and TiF<sub>4</sub>. TiF<sub>4</sub> solution (0.34% w/v) was prepared from titanium tetrafluoride and SnF<sub>2</sub> solution (0.87% w/v) was made from stannous fluoride (Sigma-Aldrich Chemie, Steinheim, Germany). NaF solution (0.47% w/v) was made from sodium fluoride (Ferak Berlin GmbH, Germany) and HF solution (0.20% w/v) was made from 40% hydrogen fluoride (Rectapur, Prolabo, Paris, France). The solutions were prepared at their native pH without further adjustments. pH values were as follows:- HF: pH 3.3, SnF<sub>2</sub>: pH 3.0, NaF: pH 7.3 and TiF<sub>4</sub>: pH 2.3.

### Scanning electron microscope analyses (SEM)

Qualitative scanning electron microscope analyses were performed for visual assessment of the tooth specimens and replicas. All specimens to be examined by SEM were coated with gold-palladium (108 Auto Sputter Coater, Cressington Scientific Instruments Ltd., Watford, England). Specimens and replicas were analysed using a Hitachi TM1000 tabletop microscope (Hitachi High-Tech Sciences System Corp., Japan) using magnification in the range of 150 – 10000x. For part I, micrographs were made of the acid-exposed and non acid-exposed surfaces, and of the borderline area between these surfaces. The micrographs were made of the same sites in both the tooth specimens and the corresponding replicas using landmarks as described later in this section.

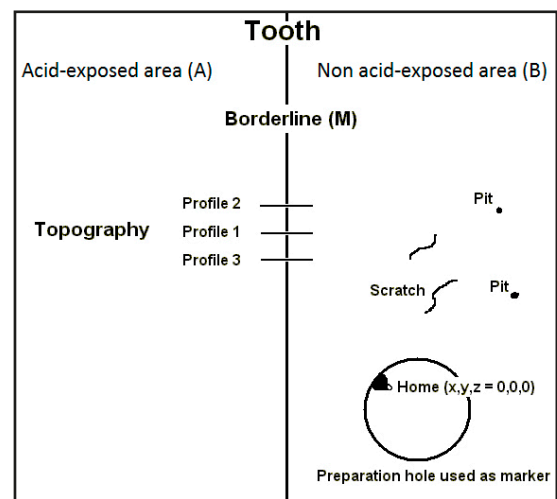
### Profilometric analysis

Profilometric analysis was performed first on tooth specimens and replicas after citric acid exposure using a high power LED blue light profilometer at 50 x magnification, with 0.2 µm step measurement as the detection limit ( $\lambda=470$  nm, PLµ2300 Optical Imaging Profiler, Sensofar-tech Terrassa, Spain). A profile with a length of 769 pixels; 254.64 µm was measured across the surface of the specimens. The data were analysed using Sensomap plus 4.1 software (Sensofar-tech Terrassa, Spain). For all profilometric analyses three tracings (profiles), 50 µm apart, were performed per tooth specimen/replica across the borderline (Figure 1: profiles 1, 2 and 3). Profile 1 was defined with x, y-coordinates from “home”. Home was a landmark on the tooth specimen and the corresponding replica that also could be easily identified (see Figure 1). A picture was taken at 50x magnification for easy identification of “home” on the replica. Using the profile picture as produced by

the profiler computer program, the height difference between the highest and lowest points in a horizontal distance of 120 µm (+/-10 µm) were measured. The tooth specimens/replica models were adjusted to the level plane prior to each analysis by moving the 3-dimensional adjustable table of the profilometer. All data were stored on the profiler computer until analysis.

In part I the height difference ( $\Delta$  height) between the acid-exposed and non-acid exposed surfaces for all tooth specimens and replicas was determined. The  $\Delta$  height was measured at all three profiles crossing the borderline providing a total of three readings/specimen. Surface roughness ( $P_a$ ) measurements were also performed in order to provide information about the surface topography. The  $P_a$  data extracted from the PLµ2300 software is described as the average surface roughness of the profile. The  $P_a$  was measured at the end marks of all three profiles at 50x magnification giving a total of six readings/specimen. In part II  $\Delta$  height between the F-treated and non F-treated areas was only measured on the replicas.

© **Figure 1** Geographical markers such as bur holes, borderline (M), pits and scratches were used to ensure that the same area on the tooth specimen was compared with the exactly the same corresponding area on the replica. ‘Home’ was defined with coordinates (x,y). Profile 1 was defined at the borderline with x,y-coordinates from Home. Three tracings, 50 µm apart were performed for each tooth specimen and replica (profile 1, profile 2 and profile 3).



*Part I: Description of the replica technique*

Ten tooth specimens were glued to self-made acrylic resin blocks (Technovit 7210 VLC and Technovit 7200 VLC; Heraeus Kulzer GmbH, Wehrheim, Germany). Three shallow holes were prepared on each specimen as reference points; two in the centre of the specimen and one in the lower left corner. The specimens were washed with deionised water in an ultrasonic bath for 10 min (Transonic 310, Elma, Germany). After air-drying, each of the 10 specimens were isolated with light body impression material (Express II light body, 3M-ESPE) leaving only half of the enamel surface non-isolated. Five specimens were then exposed to 0.01 M citric acid for 10 min using a peristaltic pump (flow rate=6 ml/min, Gilson model Minipuls 3, Villiers le Bell, France). The other five specimens were exposed to 0.1 M citric acid using the same peristaltic pump and exposure time.

After removal of the impression material, specimens were rinsed with deionised water for 5 s and gently dried with air. A sketch of each tooth was drawn showing the marking holes, the borderline between the acid-exposed and non acid-exposed areas and other landmarks that could be of assistance when identifying the landscape such as pits and minor cracks. Impressions were then taken of each tooth specimen using the same light-bodied impression material. After the recommended setting time, the specimens were gently removed and replica models were cast with acrylic resin (Technovit 7200 VLC, linear shrinkage = 2.8%) and light cured for 12 h. The specimens and replicas were analyzed by profilometry and SEM, as described above.

*Part II: Comparing the protective effect of different F solutions*

Twenty four tooth halves were randomly divided into 4 groups (n = 6 specimens/group). (q) Half of each tooth specimen was isolated with impression material using the same procedure as described in Part 1. The F-solutions were applied for 10 min to the non-isolated surfaces of the specimens using a peristaltic pump (flow rate = 6 ml/min, Gilson model Minipuls 3, Villiers le Bell, France). Specimens were then rinsed gently with distilled water for approximately 5 s, the isolation material was carefully removed, and they were rinsed again with distilled water. Specimens were then acid-challenged for 10 min in separate 10 ml baths of 0.1 mol/L citric acid that were gently agitated on a rotating machine (IKA® KS260 basic, 100 rotations/min). After this

the specimens were rinsed again with distilled water.

Landmarks were recorded and impressions were made in the same way as for part I. SEM images were made of the borderline area, stored digitally, and prepared for rating. A total of 96 images at 4 different magnifications were printed out on 24 coded sheets of paper, each sheet containing 4 pictures, all from the same tooth specimen allowing re-identification. Rating was performed blind and separately by two of the authors (CH and AE) according to how distinct the borderline between F-treated and non F-treated enamel appeared, in addition to visual signs of surface roughness. The SEM images were rated according to the following criteria: i) no difference in the surface structure between F-treated and untreated enamel, ii) indistinct borderline observed in the whole area between the F-treated and the untreated enamel, or iii) a distinct borderline distinguishable.

The repeatability of the measurements was tested on one replica in each F-treatment group. An easily recognizable reference point close to the borderline was identified and pictured. Coordinates were found on the borderline from this reference point and  $\Delta$  height was measured between the F-treated and non F-treated areas. The replica was then completely removed from the profilometer before being replaced for a repeated tracing and measurement. This procedure was performed 10 times per replica.

The accuracy of the profilometric measurements was tested by taking one tooth specimen in each F-treatment group (n = 4 specimens = 12  $\Delta$  height recordings) and comparing the results with its corresponding replica.

*Statistical analysis*

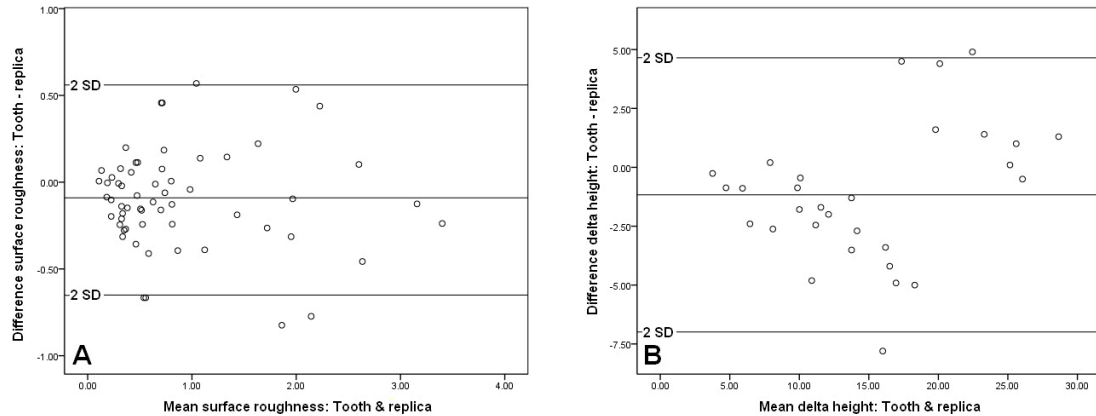
Part I: The replicas were compared with the corresponding tooth specimens and analyzed by Pearson correlation with regard to both height difference and surface roughness between acid-exposed and non acid-exposed tooth surfaces. The data was plotted in a Bland-Altman plot (SPSS version 16.0, SPSS Inc. Chicago, IL, USA).

Part II: In the interpretation of the SEM pictures of the different F-treated specimens any differences between ratings were tested using one way ANOVA and Bonferroni test (SPSS version 16.0, SPSS Inc. Chicago, IL, USA).

The  $\Delta$  height between the F-treated and non F-treated surfaces were measured for each replica, and mean and median values for each F-solution were calculated. The data passed the Kolmogorov-Smirnov normality test (SigmaStat v. 3.5, Systat software,



© **Figure 2.** Bland-Altman plots of values obtained from the teeth used in part I of the study. The plots show the relationship between tooth specimens and replicas for surface roughness (A) and  $\Delta$  height (B) both in  $\mu\text{m}$ .



San José, California, USA), and the results were analyzed using one way ANOVA and Bonferroni test. For all the statistical analyses the data were considered significant at the 0.05 level.

The test of the accuracy between tooth specimens and replicas treated with the different F solutions was performed using Pearson correlation analysis. The repeatability of the measurement procedure was tested with Chronbach's Alpha (SPSS version 16.0, SPSS Inc. Chicago, IL, USA).

## Results

### Part I

Profilometric analysis: Pearson correlation analysis showed a large correlation between the specimens and their replicas for surface roughness ( $r = 0.939$ ), indicating that the replicas exhibited good topographical reproduction of the tooth specimens. Pearson correlation analysis for  $\Delta$  height between the acid-exposed and non acid-exposed surfaces also showed a large correlation ( $r = 0.921$ ). A Bland-Altman plot

showed that the 95% limits of repeatability (mean  $\pm$  2 SD) were in the range 4.7 to  $-7.0 \mu\text{m}$  for  $\Delta$  height, and 0.5 to  $-0.7 \mu\text{m}$  for surface roughness (Figure 2). The median deviation was  $-0.89 \mu\text{m}$  for the  $\Delta$  height and  $-0.10 \mu\text{m}$  for surface roughness.

SEM analysis: Micrographs of the acid-exposed surfaces showed typical changes in surface characteristics that could be easily distinguished from the non acid-exposed surfaces (Figure 3). A prism pattern, showing typical arcade-shaped prism borders, was detectable on the acid-exposed surfaces for both the tooth specimens and their corresponding replicas.

### Part II

#### Visual interpretation of SEM analyses

The results of the visual interpretation of SEM are presented in Table 1. When a clear and distinct boundary between F-treated and non F-treated surfaces was visible in the micrographs, the non-treated surfaces exhibited a typical etched appearance. The borderline between the HF-treated and adjacent non

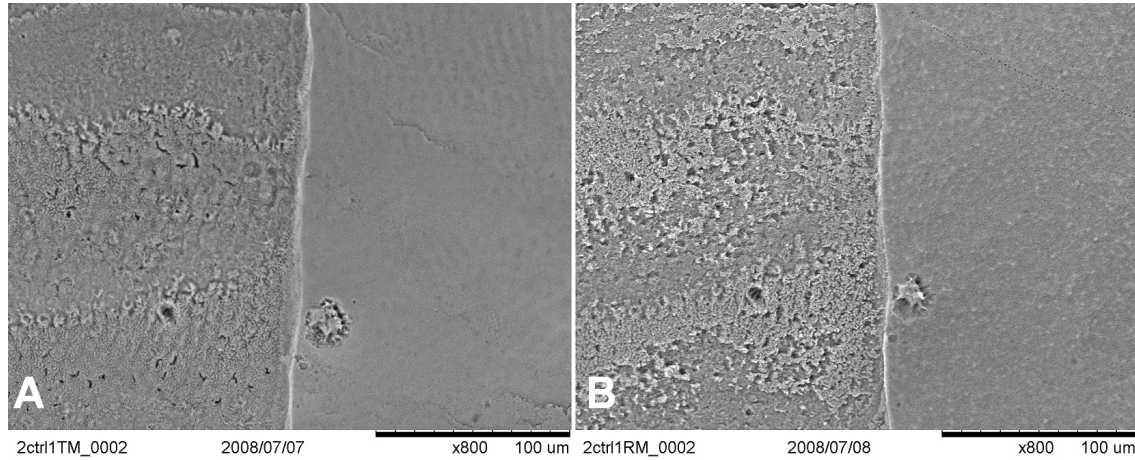
© **Table 1.** Visual interpretation using SEM of replicas analysed separately by two of the authors (CH and AE) at 150-10000 x magnification. The teeth specimens were treated with different fluoride solutions prior to acid challenge with citric acid.

F-solution* (0.1 mmol <sup>l</sup> F <sup>-</sup> )	Borderline between F-treated and non F-treated surfaces			Total
	Distinct	Indistinct	Not detectable	
NaF <sup>a</sup>	-	-	6	6
SnF <sup>b</sup>	1	4	1	6
TiF <sup>b, c</sup>	4	1	1	6
HF <sup>c</sup>	6	-	-	6

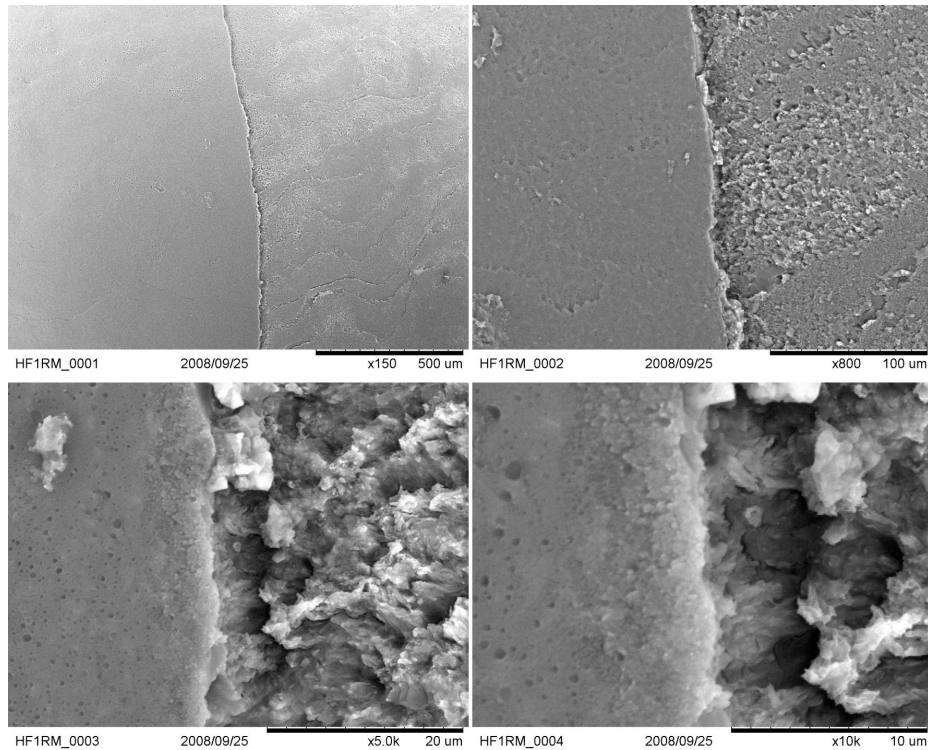
Differences between F-solutions when the distinctness of the borderline between the treated- and untreated surface areas was rated based on SEM images of the replicas.

\* Fluoride solution groups sharing the same superscript letter are not significantly different from each other ( $n = 6$  specimens/group, one way ANOVA, Bonferroni t-test,  $p < 0.05$ ).

© **Figure 3.** Part I – replica technique: A – Typical scanning electron micrograph of a tooth specimen showing the borderline between the tooth surface exposed to 0.01 mol/L citric acid and the non acid-exposed surface. B - Scanning electron micrograph of the corresponding replica (800x magnification).



© **Figure 4.** Representative SEM of the replicas showing the borderline area between HF-treated and non HF-treated (rough area) enamel shown at 150, 800, 5000 and 10000x magnification.



HF-treated surfaces was very distinct (Table 1, Figure 4). It was not possible to distinguish the borderline between the NaF-treated surfaces and the adjacent non NaF-treated surfaces (Table 1).

### Profilometric analyses

Results of the profilometric analyses for the specimens treated with the different F-solutions are shown in Table 2. The  $\Delta$  height between the F-treated and non F-treated surfaces was significantly greater for the specimens treated with HF than for the specimens treated with the other F-solutions. This result indicated that the HF-solution prevented etching of the enamel surfaces during the acid challenge. Comparison between tooth specimens and replicas exhibited a Pearson correlation of  $r = 0.943$ . The repeatability test using Chronbach's Alpha showed a reliability coefficient of 0.99.

### Discussion

In the present *in vitro* study an replica technique using unground enamel specimens was developed and applied to examine the protective effects of various F-solutions in an erosion model. The replica technique reproduced the enamel surfaces with good accuracy as shown in the first part of the study. The second part of the study showed that the technique was able to distinguish between enamel surfaces that were treated with different fluoride solutions in an erosion model.

Several important methodological factors should be mentioned with respect to the replica technique used in the present study. The acrylic used is a material that is commonly available in research laboratories, and in this study it was shown to give good reproduction of the tooth specimens when used as a replica material. The results showed a difference in median  $\Delta$  height of only  $0.89 \mu\text{m}$  and median roughness difference of only  $0.10 \mu\text{m}$  between the teeth specimens and their corresponding replicas. According to the manufacturer, Technovit 7200 VLC has a linear shrinkage of 2.8%, which will partly account of these small differences. However, any quantitative comparison between tooth and replica should take into account this shrinkage. This aspect will not be so critical when using this technique for longitudinal comparisons of patients replicas when following the progression of their erosion lesions.

The A-silicone impression material used clearly isolated the tooth surface from unintended exposure to the test solutions, and was also easy to remove without damaging the tooth surfaces. The presence

© **Table 2.**  $\Delta$  height ( $\mu\text{m}$ ) at the borderline between the fluoride-treated surfaces and the non fluoride-treated surfaces measured by profilometry following exposure to citric acid ( $n=6$  specimens/F solution).

Fluoride solution (0.1 mmol-1 F-)	$\Delta$ height ( $\mu\text{m}$ )			
	Mean*	Median	SD	SE
NaF	0.84 <sup>a</sup>	1.54	3.23	1.32
HF	8.34 <sup>b</sup>	7.95	1.84	0.75
TiF <sub>4</sub>	0.31 <sup>a</sup>	1.23	3.04	1.24
SnF <sub>2</sub>	-1.96 <sup>a</sup>	-1.77	3.73	1.52

\*Mean  $\Delta$  height: Fluoride solution groups sharing the same superscript letter are not significantly different from each other ( $n=6$  specimens/group, one way ANOVA, Bonferroni t-test,  $p<0.05$ ).

of a distinct borderline between acid-exposed and non acid-exposed surfaces indicated that the A-silicone material functioned well. Although the use of impressions and cast replicas can be useful tools in the study of the progression of dental erosion damage, it is paramount that the silicone impression material and the replica model material used have very good detail reproduction as well as acceptable dimensional stability. Satisfactory replica techniques for clinical application have been documented using various combinations of impression and model materials (7, 18-20). In the present study, use of the A-silicone impression material and the acrylic resin as replica model material seemed to meet the required standards. It is therefore suggested that this method, after further testing in a clinical situation, may be applicable for *in vivo* experimentation, especially for the examination of qualitative changes in the enamel surface texture in early enamel erosion.

In order to use this technique *in vivo*, use of naturally occurring landmarks such as pits, cracks and fillings will be necessary, as it is not acceptable to prepare any form of permanent marker on the natural tooth. This dilemma is not present when performing *in situ* studies where it is possible to prepare artificial landmarks in the tooth specimens to be placed temporarily in the oral cavity of a test participant. For *in vivo* studies, impressions can be taken of the tooth surfaces, and replicas made during different stages of such studies, allowing the researcher to follow the progression of the erosion lesions.

Several other factors may also influence the result of such replica methods. These include the impression technique, the casting procedures, the actual profilometric measurements and the handling and

limitations of the profilometer software. The introduction of these more random errors may be important factors contributing to measured, or observed differences between the teeth and their replicas.

As mentioned, it is well known that the use of replica techniques can provide some special challenges. For the profilometric technique used in this study it was necessary not only to re-identify the sites from the tooth specimens on their respective replicas, but the replicas had to be placed in exactly the same position in a 3D-perspective. This was a somewhat time-consuming procedure, especially when natural teeth have an irregular and curved surface. However, although this step was important in order to obtain reliable data and the procedure was given priority, this factor may help explain some of the differences in profilometric measurements between the tooth specimens and their replicas. The enamel surface irregularity may be a problem even when not using a replica technique, and many researchers grind the enamel surfaces of tooth specimens. This is a requirement for some measurement methods, and it makes for easier analysis (10, 13, 16). However, grinding of the enamel surface will affect the response of the enamel to acidic challenge, as the natural outer enamel surface is modified by the oral environment and is more resistant to acidic challenge. Furthermore, clinical studies on patients involve natural tooth surfaces that are never completely flat. For these reasons, non-ground tooth specimens were used in the present study.

Previous replica technique studies have reported using markers cemented to the enamel as a fixed reference point and these seemed to function well *in vitro* (22). However, under clinical conditions these markers tended to fall off in almost 50% of the index teeth (2). Furthermore, the area of the enamel surface examined in some of these replica studies for quantitative evaluation of enamel wear is very limited, and it could be questioned how representative this measured area is for evaluation of the dental wear process (2, 22). If the present technique is to be used by dentists to follow the progression of dental erosion lesions in their patients, replicas should be standardised in form, for easier analysis and comparison by profilometry. The high reliability coefficient ( $r = 0.99$ ) shown in the second part of the study indicated that the same replica could be evaluated several times with very low variation in the readings (6).

The choice of the fluoride concentration for the different solutions was based on previous studies in-

vestigating the protective effect by fluoride solutions against enamel dissolution by citric acid (11, 12). It is well known that the effect of fluorides on enamel will be highly dependent on the fluoride concentration and the pH of the solutions. In the present study, equimolar fluoride solutions at their native pH were tested. The results of this study suggest that HF had a significantly better protective effect against human enamel erosion than the other fluoride solutions. Based on previous *in vivo* results, it was not expected that the neutral NaF-solution would provide any significant protection (12). The most acidic solution, TiF<sub>4</sub>, was unable to provide protection enough against the citric acid challenge and at this fluoride concentration. The negative value for SnF<sub>2</sub> indicated that this solution may have etched the enamel prior to the acidic challenge. This result was not statistically significant compared with the results for NaF and TiF<sub>4</sub>, and should therefore be interpreted with caution. Given that this was an *in vitro* study, and no attempt was made to condition the specimens with saliva, the effect of the fluoride solutions cannot be directly extrapolated to the clinical situation. Furthermore, in the clinical situation, additional factors such as form of delivery of the fluoride and substantivity, will also play an important role in the efficacy of the fluoride treatment. These considerations have been studied by other researchers and are beyond the scope and aim of the present study. Citric acid was chosen for the acidic challenge as it is commonly used in *in vitro* studies (26). The concentration was based on previous erosion studies using citric acid as acidic challenge (11, 12, 13). In part I, challenging the enamel specimens with 0.1 mol/L (1.8%) citric acid resulted in a visually more distinct difference between the acid-exposed and non acid-exposed surfaces, thus making it easier to identify the borderline between the two areas. By exposing the specimens to the solutions for 10 min and having a rotating table to agitate the acid complete exposure of specimens was ensured. In the second part of the study the more concentrated citric acid solution was used for the erosive challenge. This acidic challenge is stronger than a typical challenge from orange juice, which is equivalent to approximately 1% citric acid (24), and may partly explain why stannous fluoride and titanium tetrafluoride did not demonstrate any significant erosion-inhibiting effect in this erosion model. These solutions have been shown by other researchers to be effective in reducing erosion (12, 13, 16, 23), and further experimental *in vivo* studies are needed to confirm these results.

It can be concluded from the present study that this is a promising replica technique. The technique was also able to detect differences in the protective effect achieved by a single treatment of enamel with different equimolar fluoride solutions in order to reduce the effect of acid challenges. After further testing *in vivo*, this technique could be suitable for use not only in the clinical diagnosis and monitoring of the early signs of dental erosion, but also for follow-up of possible preventive treatments.

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Corresponding author:  
Dr Carl Hjortsjö  
Department of Prosthetic Dentistry and Oral function  
Institute of Clinical Dentistry  
University of Oslo  
P.O Box 1109 Blindern  
NO-0317 Oslo  
Norway  
E-mail: carl.hjortsjo@odont.uio.no

# The effect of a toothpaste containing Aloe Vera on established gingivitis

HOMA NAMIRANIAN<sup>1,3</sup>, GIOVANNI SERINO<sup>2,3</sup>

## Abstract

© The aim of the study was to evaluate the effect of a toothpaste containing high concentrations of Aloe Vera on the reduction of plaque and gingivitis in patients attending regular dental care by a dental hygienist.

Fifteen subjects participated in this randomized, double-blind, intra-individual and controlled clinical study. Participants were non-smokers, with signs of gingivitis (bleeding index  $\geq 30\%$ ) and no signs of periodontitis. Subjects were followed for three 6-month periods during which they used either their own toothpaste, or an Aloe Vera or a control toothpaste. Plaque and gingival indices were recorded at the start and end of each period.

There was a statistically and clinically significant reduction of about 20% of the plaque and gingivitis indices at the end of the clinical trial compared to baseline values, but no differences between the Aloe Vera and the control toothpaste.

It may be concluded that in patients motivated to improve their oral hygiene habits, the use of a toothpaste containing Aloe Vera showed no additional effect on plaque and gingivitis compared to a control toothpaste.

## Key words

*Gingivitis, tooth pastes, oral hygiene, dental plaque, aloe*

<sup>1</sup> Public Dental Service, Ulricehamn, Sweden.

<sup>2</sup> Department of Periodontology, Specialistic Dental Clinics, Borås, Sweden.

<sup>3</sup> Research and Development Unit, Borås, Sweden.

## Effekt av tandkräm innehållandes Aloe Vera på etablerad gingivit

HOMA NAMIRANIAN, GIOVANNI SERINO

### Sammanfattning

☉ Syftet med studien var att utvärdera effekten av tandkräm innehållande höga koncentrationer av Aloe Vera med avseende på reduktion av plack och gingivit hos patienter som får regelbunden tandvård hos tandhygienist.

Femton personer deltog i denna randomiserade, dubbel-blinda, intra-individuella och kontrollerade klinisk studie. Deltagarna var ickerökare med tecken på gingivit (blödnings index  $\geq 30\%$ ) och inga tecken på parodontit. Patienterna följdes under tre 6-månaders perioder under vilka de använde antingen sin egen tandkräm eller en Aloe Vera innehållande tandkräm eller en kontrolltandkräm. Plack och gingivala förhållande noterades vid start och slut av varje period.

Det var en statistisk och klinisk signifikant reduktion av omkring 20% av plack och gingivit vid slutet av den kliniska studien jämfört med värdena vid Baseline, men ingen skillnad mellan Aloe Vera och kontrolltandkrämen.

Man kan dra slutsatsen att hos patienter som är motiverade till att förbättra sin munhygien tillför inte tandkräm innehållande Aloe Vera någon ytterligare reducerande effekt på plack och gingivit jämfört med en kontrolltandkräm.

## Introduction

Gingivitis is a clinical sign of inflammation in the gingival tissue caused by bacterial plaque accumulation on tooth surfaces (13, 20). The bacteria produce toxic antigens that lead to an inflammatory reaction in the gingival tissue. Gingivitis can eventually evolve to periodontitis with loss of supporting bone and periodontal attachment around the teeth (11).

Plaque-induced gingivitis is a frequent finding among populations. Epidemiologic studies have shown a high prevalence of gingival inflammation ranging from 74% to 100% in the Brazilian population (2), and 62% in the adult population of the United States (15) and about 30% in population with high standard of oral hygiene (9). The gingival fluid forming at sites presenting gingivitis contains substances enhancing initial adherence of bacteria to tooth surfaces and consequently promoting bacterial proliferation (8, 17). Thus established gingivitis enhances plaque accumulation on the tooth surface.

It has been recognized for many years that some Aloe Vera derivatives have a significant anti-inflammatory activity mediated by the inhibition of prostanoid production in damaged tissue (6, 18) and anti-inflammatory mechanisms by blocking integrins (7, 16), which are proteins that mediate cell adherence. Additionally, Aloe Vera appears to inhibit the proliferation of diverse oral microorganisms in vitro (12, 5).

Two double-blind, controlled clinical studies (19, 3) have proven the efficacy of the application of an Aloe Vera gel in the treatment of patients with the oral lichen planus (OLP); patients receiving Aloe Vera gel had a reduction of symptoms related to OLP.

Few studies have evaluated the effect of Aloe Vera on dental plaque and gingivitis. *Villalobos et al.* (21) found a significant reduction of plaque and gingivitis by the use of a mouth rinse containing 50% Aloe Vera, while *De Oliveira et al.* (4) found no additional effect on plaque and gingivitis by daily use (30 days) of a toothpaste containing 1% Aloe Vera compared to a control toothpaste. Whether the diverging results of the two studies were due to differencing concentrations of Aloe Vera or other modalities and time of application (toothpaste versus rinsing) is an open question. Aloe Vera Original® is a toothpaste with a 45% concentration of the biological ingredient Aloe Vera Barbadensis; an extract from the leaves of the Aloe Vera plant.

The aim of the present study was to examine whether the daily use of a toothpaste containing a

high concentration of Aloe Vera could reduce the clinical signs of gingivitis in patients attending regular dental care by a dental hygienist twice yearly.

## Material and Method

### Patient recruitment

The subjects invited to participate in this intra-individual, randomized, controlled clinical study were selected from adult patients ( $\geq 20$  years of age) attending dental hygienist treatment twice yearly at the public dental services of Ulricehamn, Sweden. At the initiation of this clinical study, the first 20 consecutive volunteers to fulfil the inclusion criteria were selected.

### Inclusion criteria

Inclusion criteria consisted of good general health, no signs of destructive periodontal disease (having a probing pocket depth  $< 5$  mm and no clinical evidence of attachment loss), non-smoker, a gingival bleeding index of more than or equal to 30%, non-user of anti-plaque rinsing solutions, and non-pregnant. All the clinical examinations and treatment were performed by one calibrated dental hygienist.

### Patient sample

The 20 patients selected were informed of the purpose of the study and gave their consent. The Ethical Board of the Gothenburg Region, Gothenburg, Sweden (Dnr: 027-08) approved the study.

### Clinical Examination

At each visit, the following clinical variables were recorded:

Plaque index (PLI) as a percentage of sites (in each subject) with the presence of plaque as determined on four surfaces (Mesial, Distal, Buccal, Lingual) per tooth after the application of a staining solution (Rondell Blu®, Nordenta, Enköping, Sweden).

The Gingival Bleeding Index (GBI) (*Ainamo & Bay 1975*) (1) calculated by the percentage of sites (in each subject) with the presence of bleeding when the periodontal probe was passed along the gingival margin of four surfaces (mesial, distal, buccal, lingual) per tooth.

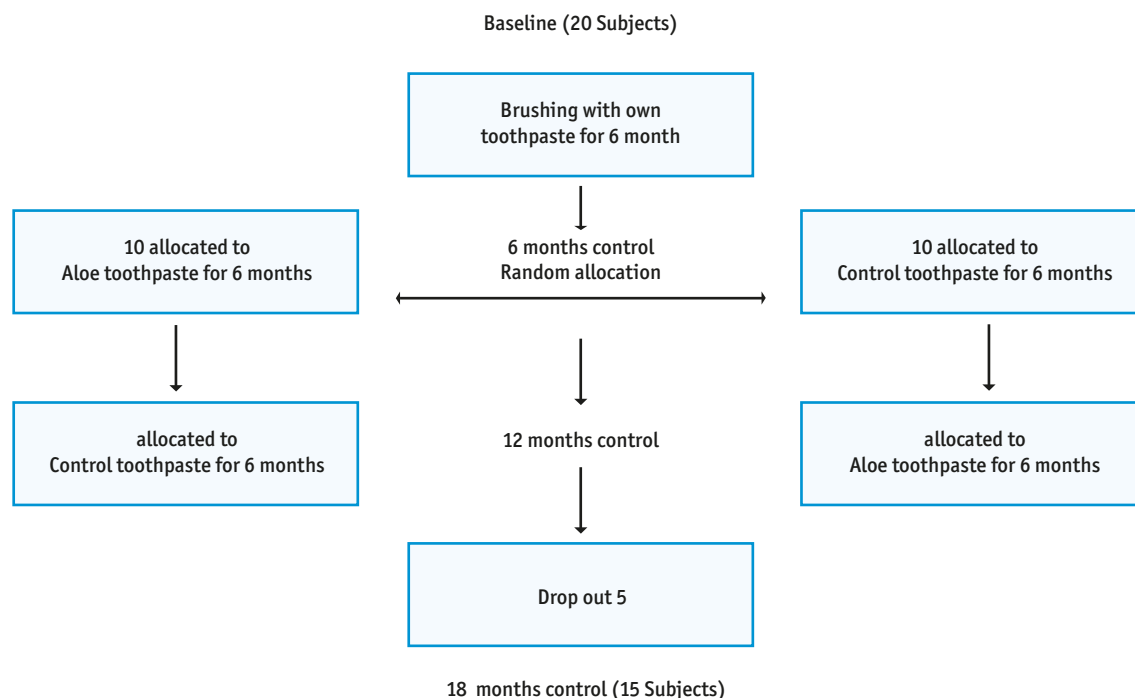
### Treatment (Figure 1)

#### Baseline

Following the registration of PLI and GBI, patients received routine treatment consisting of oral hygiene instruction and motivation (according to individual needs) and mechanical supra- and sub-gingival



© Figure 1. Flow chart of the study



tooth instrumentation (using a hand and/or ultrasonic device) to remove plaque and calculus.

### 6 months

Registration of PLI and GBI and treatment was performed as at the Baseline examination. At the end of the dental hygienist session, a receptionist, not involved in the study, provided the patients with four tubes of toothpaste taken from one of two boxes containing either the test toothpaste (Aloe Vera Original®, Håden Dental, Göteborg, Sweden) Box 1, or a control toothpaste (Sensodyne®, GSK Pharma AB, Solna, Sweden), Box 2. Black tape was used to mask the test and control toothpaste tubes in a way that patients were unaware of which toothpaste they received.

### 12 months

Registration of PLI and GBI and treatment was performed as at the Baseline and the 6-month examination. At the end of the dental hygienist session, patients were presented with four tubes of toothpaste by a receptionist. The patients who, at the 6-month examination, received toothpaste from Box 1, received the toothpaste from Box 2 and vice versa. The patients returned the toothpastes not used during the previous 6 months.

### 18 months

At this final examination, registration of PLI and GBI was repeated followed by a routine dental hygienist treatment.

### Dropouts

Five of the 20 initially recruited subjects moved from the city and could not complete the 18-month investigation.

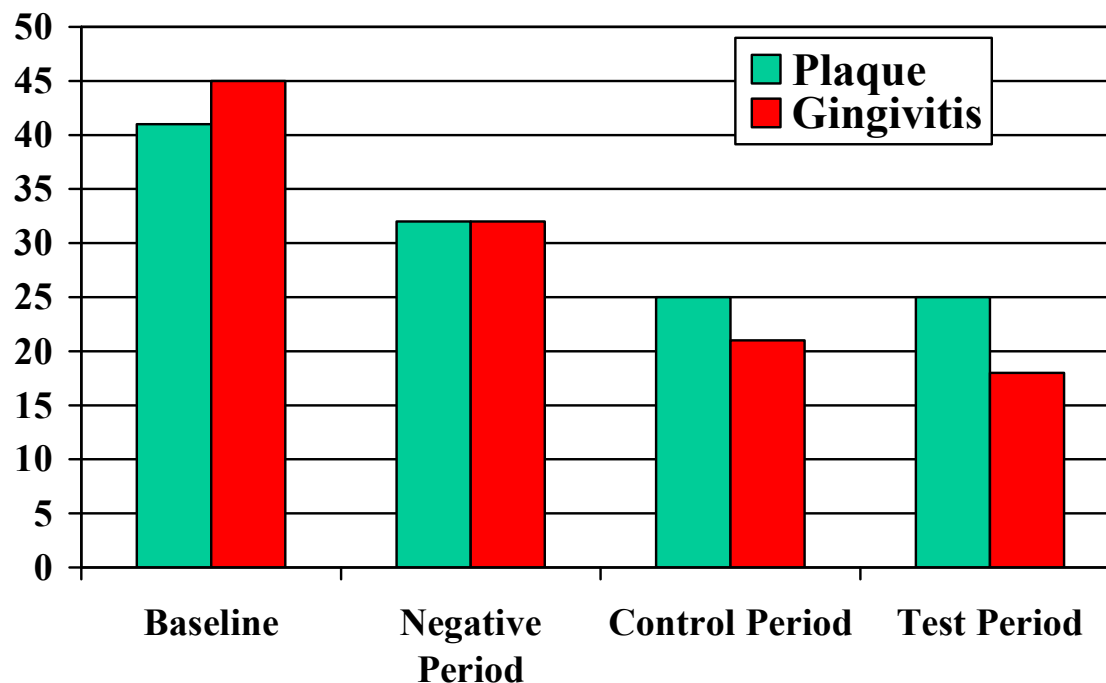
### Statistical Analysis

A paired T-test analysis for intra-individual differences was used to test difference in values between the Plaque and Gingival Bleeding Indexes following the six-month test period, the six-month control period and the initial negative control six-month period.

### Sample size calculation

Based on an anticipated difference in the mean of 20%, a standard deviation of 14%, power = 80% and Type 1 error = 0.001, the sample size calculation resulted in an estimate of 14 subjects needed for this study.

© **Figure 2.** Percentage of sites with presence of Plaque and Gingivitis at Baseline and following the three tested periods. A: difference compared to the baseline value, B: difference compared to the value at the end of the negative period. NS: non statistical difference



	Baseline Mean( $\pm$ ) SD	end of Negative Period Mean( $\pm$ ) SD	end of Control Period Mean( $\pm$ ) SD	end of Test Period Mean( $\pm$ ) SD
Plaque	41% ( $\pm$ 18)	32% ( $\pm$ 25) A: p= 0.02	25% ( $\pm$ 7) A: p= 0.007 B: NS	25% ( $\pm$ 12) A: p= 0.0001 B: NS
Gingivitis	45% ( $\pm$ 17)	32% ( $\pm$ 13) A: p= 0.0008	21% ( $\pm$ 16) A: p= 0.0004 B: p= 0.02	18% ( $\pm$ 5) A: p= 0.0001 B: p= 0.001

## Results

The 15 subjects completing the study had an age range of 20 to 55 years, consisting of five females and ten males. The mean number of teeth at the baseline examination was 28.1 ( $\pm$  2.2 SD), and the mean percentage of plaque and gingivitis was 41% ( $\pm$  18 SD) and 45% ( $\pm$  17 SD), respectively (Table 1). Following the first six months of observations (negative control period), during which the patients continued with their personal oral hygiene habits, the Plaque index decreased to 32% ( $\pm$  15 SD) and the Gingival index to 32% ( $\pm$  13 SD);

both reductions were statistically significant ( $p= 0.02$  for plaque and  $p= 0.0008$  for gingivitis).

At the clinical examination following the 6-month test period, (during which patients were brushing with the Aloe Vera toothpaste) the Plaque and Gingival index further decreased to 25% ( $\pm$  12 SD) and 18% ( $\pm$  5 SD), respectively. Compared to the baseline value a reduction of 16% for the Plaque Index ( $p= 0.0001$ ) and 27% for Gingivitis ( $p= 0.0001$ ) was observed; when compared to the end of the negative

© **Table 1.** Data from the Baseline clinical examination.

Number of patients	15
Female	5
Age (years, mean $\pm$ SD)	33.4 (13.6)
(range)	20-55
Number of teeth (mean $\pm$ SD)	28.1 (2.2)
(range)	23-30
Plaque Index % (mean $\pm$ SD)	41 (20)
Gingival Index % (mean $\pm$ SD)	45 (20)

period, the reduction was 7% for plaque (not statistically significant) and 14% for gingivitis ( $p=0.001$ ) (Fig 2).

A similar pattern was observed following the six-month control period when the patients were brushing their teeth with Sensodyne®, toothpaste. Thus at the end of the control period, the Plaque Index was reduced to 25% ( $\pm 7$  SD) and the Gingival Index to 21% ( $\pm 16$  SD). The reduction from the baseline values was also statistically significant ( $p=0.007$  for Plaque and  $p=0.0004$  for Gingivitis). Compared to the end of the negative period, the reduction was 7% for Plaque (not statistically significant) and 9% for Gingivitis ( $p=0.02$ ) (Fig. 2).

No statistical differences in plaque and gingivitis values between test and control periods were recorded.

### Discussion

The results of this study showed that patients involved in this clinical trial had a marked improvement in their plaque control and gingival health independent of the two toothpastes tested. This improvement was related to the motivation to participate in a clinical study of oral hygiene practice through the use of new toothpastes. A decrease in plaque and gingival indexes was noticeable as early as the first 6 months of the study without the introduction of toothpaste. A further decrease was recorded following the introduction of test and control toothpastes. Both circumstances resulted in a reduction of 20% of the plaque and gingival indexes compared to baseline values.

These results are in agreement with a similar study conducted by *De Oliveira et al.* (4) where the authors tested an Aloe Vera dentifrice and a control fluoride dentifrice in two groups of patients for a period of 30 days. There was a significant reduction of plaque and gingivitis in both groups, but with no significant differences between two groups.

The improvement in oral hygiene habits noticed

during the experimental period both in our study and in the study by *De Oliveira et al.* (4) is a common finding in studies evaluating the effect of fluoride or herbal dentifrices (14, 22) and can be attributed to the *Hawthorne* effect which is the process where human subjects of an experiment change their behaviour, simply because they are being studied (10). This “testing effect” could have masked the potential anti-inflammatory properties of Aloe Vera. *In vitro* studies have shown an antimicrobial effect of Aloe Vera products against microorganisms from supra-gingival biofilm (12, 5) and a clinical study has shown an effect on the reduction of clinical signs of gingival inflammation (20). High concentrations (70%) of an Aloe Vera gel applied twice daily for eight weeks were also tested by *Choonhakarn et al.* (3) in a double-blind placebo study of the treatment of patients with a diagnosis of Oral Lichen Planus (OLP). The authors reported a beneficial effect on reducing and resolving the symptoms related to OLP in the test group compared to the placebo group. A similar study was conducted by *Salazar-Sánchez et al.* (19) but with a rinsing solution containing 70% Aloe Vera three times daily for twelve weeks in patients with OLP. The authors reported clinical improvements in the test compared to a placebo group, but the difference did not achieve statistical differences. In our study the concentration of Aloe Vera in the dentifrice was 45% compared to 1% in the study by *De Oliveira et al.* (4) and the observation period was longer (6 months vs. 1 month). The question of whether toothpaste is an appropriate vehicle for Aloe Vera to reach oral concentrations needed to activate its anti-inflammatory properties compared to a gel or rinsing solution remains unresolved.

An important finding of this study was the self-improvement in oral hygiene related to motivation as an aspect which resulted in a decrease of the bleeding index by roughly 20%. The behavioural aspects in the effort of the patients to remove supra-gingival plaque have been highlighted by Öhrn & Sanz (23) as an important factor in the prevention and therapeutic approaches to gingival inflammation. The authors also stated that “despite the simplicity of plaque control measures, the majority of the population is not able to comply effectively and, as results, develop gingivitis”.

Conclusion: With the limits of this clinical study, it may be concluded that in patients self-motivated to improve their oral hygiene habits, the dentifrice containing Aloe Vera showed no additional effect on plaque and gingivitis compared to the control toothpaste.

### Acknowledgements

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Corresponding author:  
Dr Giovanni Serino  
Department of Periodontology  
Södra Älvsborgs Hospital  
SE-501 82 Borås  
Sweden  
Email: giovanni.serino@vgregion.se

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# Effect of nicotine-free and nicotine-containing snus on plaque pH *in vivo*

LENA HELLQVIST<sup>1,2</sup>, ANITA BOSTRÖM<sup>1</sup>, PETER LINGSTRÖM<sup>2</sup>, ANDERS HUGOSON<sup>1</sup>, MARGOT ROLANDSSON<sup>1</sup>, DOWEN BIRKHED<sup>2</sup>

## Abstract

© The aim was to investigate pH changes in plaque *in vivo* during the use of nicotine-free and nicotine-containing snus. The carbohydrate content of the products was also analysed. Ten subjects, all regular snus users, participated in an experimental cross-over study, on eleven occasions with an interval of one week. Six nicotine-free and four nicotine-containing products, which are sold on the Swedish market, were included and a sucrose solution was used as a control. The subjects did not brush their teeth for three days before coming to the laboratory, without eating, drinking or using snus/smoking for two hours prior to the test. pH was measured at three approximal sites up to 45 min with the test product placed under the upper lip. The carbohydrate analysis showed that the nicotine-containing products contained only traces of glucose, fructose and sucrose (0.5-1%) and starch ( $\approx$ 1.5%). Some of the nicotine-free products contained up to 6.5% low-molecular-weight carbohydrates and 26.0% starch. The intraoral pH measurements showed that four nicotine-containing products increased the plaque pH, in contrast to three of the six nicotine-free products, which lowered the pH. These pH changes may have an effect on the caries risk, both positively and negatively, depending on which product is used.

## Key words

*Caries, fructose, glucose, nicotine-containing snus, nicotine-free snus, plaque pH, starch, sucrose*

<sup>1</sup>Department of Health and Environmental Sciences, Karlstad University, Sweden

<sup>2</sup>Department of Cariology, Institute of Odontology, Sahlgrenska Academy, University of Gothenburg, Sweden

## Effekten av nikotinhaltigt och nikotinfritt snus på pH i plack *in vivo*

LENA HELLQVIST, ANITA BOSTRÖM, PETER LINGSTRÖM, ANDERS HUGOSON,  
MARGOT ROLANDSSON, DOWEN BIRKHED

### Sammanfattning

☉ Syftet med studien var att utvärdera pH-förändringar i plack *in vivo* vid användning av olika nikotinfritt och nikotinhaltigt snus. Kolhydratinnehållet i produkterna analyserades också. Tio deltagare, alla snusanvändare, deltog i en experimentell tvärsnittsstudie, vid elva tillfällen, med en veckas mellanrum. Sex nikotinfria och fyra nikotininnehållande produkter på den svenska marknaden ingick i studien och en sackaroslösning användes som kontroll. Deltagarna borstade inte tänderna under tre dagar innan besöket och avstod från att äta, dricka och snusa/röka två timmar före varje test. pH mättes i tre approximalrum upp till 45 minuter med snusprodukten placerad under överläppen. De nikotininnehållande produkterna innehöll endast spår av glukos, fruktos och sackaros (0.5-1%) och stärkelse ( $\approx 1.5\%$ ), medan de nikotinfria produkterna innehöll upp till 6.5 % lågmolekylära kolhydrater och 26.0 % stärkelse. Resultatet av pH-mätningarna i plack visade att alla fyra nikotininnehållande produkter höjde pH, till skillnad från tre av de sex nikotinfria produkterna, som sänkte pH betydligt. Dessa pH-förändringar i plack kan ha såväl positiv som negativ effekt på kariesrisken beroende på vilken produkt som används.

## Introduction

Tobacco and dietary habits, as well as oral hygiene, are associated with lifestyle factors. In an earlier study it was shown that tobacco users did not brush their teeth as frequently as non-tobacco users nor they visit a dentist as often as non-tobacco users, thereby running an inherent risk of a subsequent deterioration in oral health (8). According to a study of attitudes to oral health among Swedish adolescents with a high caries risk, most of them believed that snuff might inhibit the development of caries (7). There are relatively few epidemiological studies of the relationship between caries, snuff use and smoking, but Hugoson et al (11) found no indication that Swedish snus had an effect on the number of teeth and/or decayed and filled tooth surfaces.

Swedish oral moist snuff, called "snus", is a product that traditionally has been used in Sweden for many years. It differs from many other smokeless tobacco products due to its lower content of tobacco-specific nitrosamines (5,20). In a systematic review of the relationship between smokeless tobacco and non-neoplastic oral disease in Europe and the United States (13), it was concluded that chewing tobacco is associated with dental caries. The study was based on tobacco products from different countries that contain fermentable carbohydrates in contrast to Swedish snus. It has also been shown that sugar-containing smokeless tobacco could stimulate the growth of mutans streptococci and according to the authors thereby increase the risk of caries (14). This stimulating effect on cariogenic micro-organisms has also been shown in the case of nicotine (10). Definitions of "smokeless tobacco", "chewing tobacco", "snuff" and "snus" are presented in Table 1. From a cariological point of view, the traditional Swedish snus may not increase the caries risk, according to a recent study by Hugoson et al. (11). They showed that snus users had actually had fewer DFS than non-tobacco users and a higher buffer capacity in saliva than smokers.

Swedish snus and other smokeless tobacco products are usually placed under the upper lip in close contact with the enamel and exposed root surface and they are often kept in place for a long time (2,19). This makes the product interesting from a cariological point of view. Sweden has the highest consumption of nicotine-containing snus in the world, even if it has become increasingly popular in other countries, such as Norway, Finland and the United States (1,9,12). Nowadays, there are several nicotine-free products on the Swedish market. They were intro-

© Table 1. Definition of various smokeless tobacco products

Products	Definition
Smokeless tobacco	The powered tobacco leaves are inhaled through the nose, chewed, or stored in cheek pouches.
Chewing tobacco	Twist, plug or scrap leaf of tobacco. Used orally and chewed intermittently to mix with saliva.
Snuff	Dry or moist form of tobacco. Can be used orally or nasally.
Snus	Swedish oral moist snuff, which is placed under the lip and used orally.

duced at the beginning of this millennium and many new products have come onto the Swedish market. One case report, showing root surfaces caries at the location where the nicotine-free snus is placed has been published (6). The aim of the present investigation was to study changes in plaque pH in vivo when using different snus products, both nicotine-free and nicotine-containing, and to analyse their carbohydrate content.

## Material and methods

### Subjects and design

Ten subjects, seven males and three females, with a mean age of 36 years, participated in the study; they were all snus users and non-smokers. They were recruited from staff and students at the university. All the subjects had their full dentition and were considered to be healthy. Each subject came to the laboratory eleven times for a one-hour visit. There was a minimum of one week between visits to the laboratory. The volunteers were asked not to brush their teeth for three days prior to testing and they were not allowed to eat, drink or use snus for two hours before each test. Before the study started, on a separate occasion, a whole saliva sample was collected by chewing a piece of paraffin wax to determine the secretion rate, buffer capacity and number of cariogenic microorganisms.

The study was approved by the Ethics Committee at the University of Karlstad, Karlstad, Sweden (2008/672). Informed consent was obtained from all subjects prior to the start of the study.

### Measurement of plaque pH

Plaque pH was measured using a microtouch electrode with a diameter of 0.1 mm (Beetrode; NMPH-1, W.P. Instruments, Sarasota, FL, USA) (17,21). It was connected to a pH/ISE meter (Orion SA 720, Orion Research, Boston, MA, USA). The electrode was cali-



brated against standard buffers at pH 7.00 and 4.00, to verify the electrode slope and function, before and during each test session. Measurements were made at three approximal sites in the upper jaw, one in the premolar region and two in the front region (mesial 15, distal and mesial 13). A salt bridge was created by having the subject dip one of his/her fingers into a beaker with a 3 M KCl solution, into which a reference electrode was also placed.

Plaque pH was measured before and at eight time points within 45 min after a one-minute mouth rinse with a 10% sucrose solution (positive control). On the remaining ten occasions, pH was measured after a portion of the snus product (weighing approximately 1 gram) was placed under the upper lip, region 13, and pH was measured at the three sites after 1, 3, 5, 10, 15, 20, 30 and 45 min. The ten products were tested in randomised order. All the subjects tested all the products.

#### Test products

The ten products used in the present investigation are presented in Table 2. Six nicotine-free and four nicotine-containing products were selected from the Swedish market. They were all purchased on the open market. They were analysed for the percentage of low-molecular-weight carbohydrates, using high-pressure liquid chromatography (HPLC) at a commercial laboratory (Eurofins Food and Agro, Linkö-

ping, Sweden). The amount of starch was analysed at the Department of Cariology using an enzymatic method (Biocontrol Systems Raisia Diagnostics, Rome, Italy).

#### Statistical methods

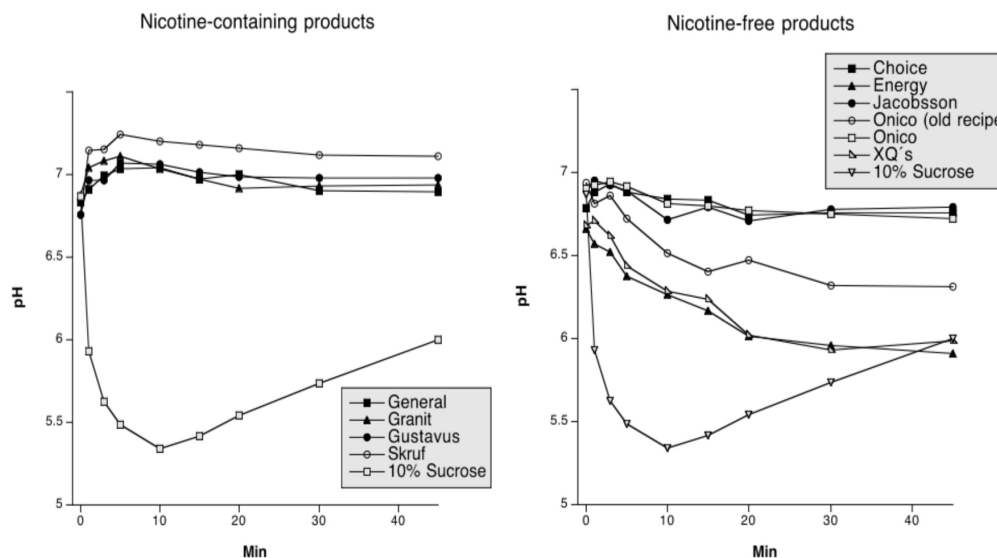
The mean pH values of the three sites were calculated for each time point and each individual and were used to construct the individual pH curves for all 10 test products and sucrose. The area under the curve (AUC) for the six nicotine-free products and the area over the curve (AOC) for the four nicotine-containing products were analysed using a computer program (15). The AUC/AOC was compared with analyses of variance (ANOVA).  $p < 0.05$  was considered statistically significant. No power calculation was made and the number of subjects was based on earlier experience in pH studies.

#### Results

The subjects had a mean salivary secretion rate of  $2.9 \pm 2.2$  ml/min, high levels of buffer capacity and medium numbers of mutans streptococci and lactobacilli ( $4.2 \pm 1.4$  and  $3.0 \pm 1.2$  log CFU/ml, respectively).

The mean plaque pH values are shown in Fig. 1 and the AUC/AOC values (pH x min) in Fig. 2. Three of the six nicotine-free products reduced the plaque pH. These three products resulted in low values, with the final pH ranging between 5.7 and 6.0,

© **Figure 1.** Mean values of pH in plaque of the different nicotine-containing and nicotine-free snuff products. Mean values for three sites and ten subjects



© Table 2. Test products used and their ingredients

Products, manufacturer and batch number	Ingredient (on label)
<b>Nicotine-free products (n=6)</b>	
Choice Original Pepper Nicofree AB 7350016271011	Mint, pepper in different proportions and flavouring
Energy Rebel Tobacco AB 5450524004025	Organic apple fibre, corn grits, water, E 1520, salt, flavourings-V.1.0
Jakobsson Classic Gotlandssnus 7350014735003	Green tea, panax ginseng, water, flavour enhancer (salt), acidity regulator (E500), humectants (E1520), vegetable fibres obtained from carrots, sodium fluoride (fluorine), flavouring including smoke flavour
Onico (old recipe) Swedish Match 7311250094026	Corn fibre, water, humectants (E422), flavour enhancer (salt), acidity regulator (E500), sal ammoniac, colorant (E 150c), flavouring including smoke, flavour, liquorice
Onico Swedish Match 311250094125	Water, oats and cocoa fibres, humectants (E422), flavour enhancer (salt), acidity regulator (E504, E500), sal ammoniac, flavouring including smoke flavour
XQ´s Svenska XQ´s AB 7350016850261	Wheat, spices, ginseng and a source of phenylalanine (aspartame)
<b>Nicotine-containing products (n=4)</b>	
General Original Portion Swedish Match 7310870008802	Water, tobacco, vegetable fibres, acidity regulators (E500, E170), humectants (E1520), flavour enhancer (salt), flavouring including smoke flavour contains: water 50%, nicotine 8mg/g, salt 2.4 %
Granit White FLsnus 7350015503397	Water, tobacco, humectants (E422, E 1520), flavour enhancer (salt), acidity regulators (E500), flavouring including smoke flavour.
Gustavus Original Portion Swedish-snus 7350001511078	Water, tobacco, flavour enhancer (salt), acidity regulator (E501), humectants (E1520), flavouring including smoke flavour
Skruf Original Portion Skruf Snus AB 7350013610028	Water, tobacco, humectants (E1520), flavour enhancer (salt), acidity regulator (E500), flavouring

which was almost identical to the results found with 10% sucrose. The other three nicotine products had only a minor effect on plaque pH. On the other hand all four nicotine-containing products increased the pH during the whole 45-min test period, with the final pH varying between 6.8 and 7.2. A wide variation in AUC/AOC was found in the 11 tests. The control (10% sucrose) resulted in the largest area, followed by three of the nicotine-free products. Only small AUC values were found for the four nicotine products. The statistical analyses showed that all four nicotine-containing products differed significantly from the six nicotine-free products and that all these ten snus products (4+6) differed significantly from the sucrose control ( $p < 0.001$ ). There were no statistical differences in the AOC among the four nicoti-

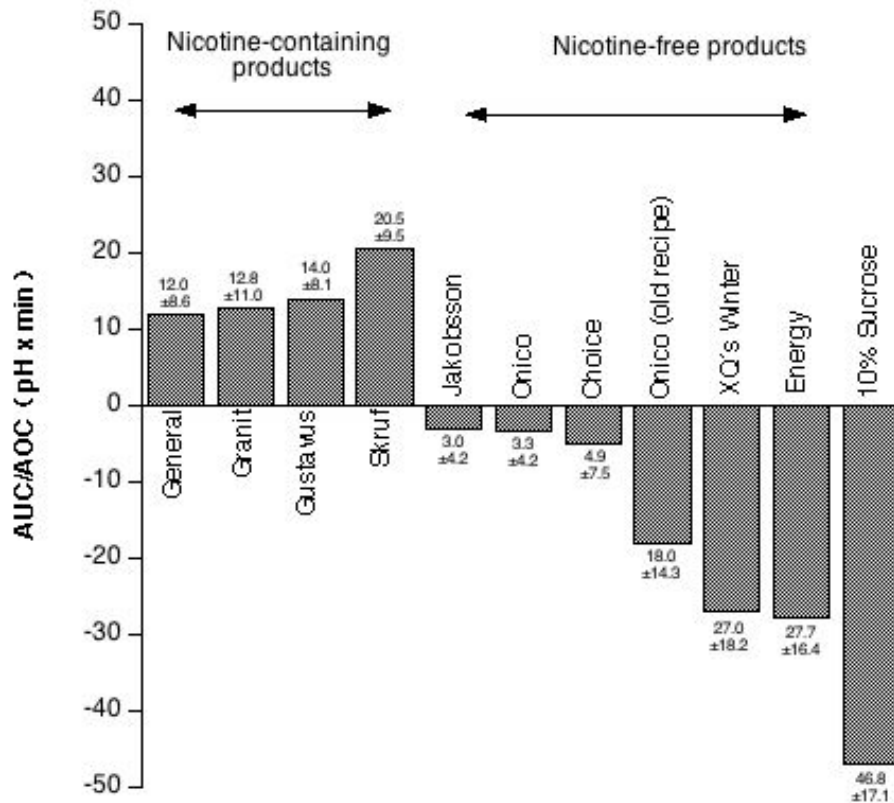
ne-containing products. When comparing the AUC for the six nicotine-free products with one another, Energy, XQ´s and Onico old recipe differed from the other three products ( $p < 0.01$  or  $p < 0.001$ ).

The carbohydrate content of the 10 products is shown in Table 3. The nicotine-free snus (apart from the new formula of Onico) contained fermentable carbohydrates up to 6.5% sugars and 26% starch (XQ´s). The four nicotine-containing products contained only traces of glucose, fructose and sucrose (varying from 0.5 to 1.0%).

### Discussion

Dental caries is a multifactorial disease with an interaction between the host, the oral microorganisms and the substrate/diet (22). The net result, i.e. the

© **Figure 2.** Mean  $\pm$  SD values of AUC/AOC (pH x min), given in ranking order



© **Table 3.** Concentration (%) of starch, glucose, fructose and sucrose in each product

	Starch	Glucose	Fructose	Sucrose	Total sugar
<b>Nicotine-free products</b>					
Choice Original Pepper	2.5	0.3	0.4	0.5	1.2
Energy	26.0	1.7	2.3	0.1	4.1
Jakobsson Classic	2.3	0.1	0	0.9	1.0
Onico (old recipe)	8.9	0.3	0.3	0.1	0.7
Onico	1.2	0	0	0	0
XQ's	26.0	0.5	0.1	5.9	6.5
<b>Nicotine-containing products</b>					
General Original Portion	1.5	0.2	0.3	0	0.5
Granit White	1.6	0.4	0.4	0.2	1.0
Gustavus Original Portion	1.5	0.3	0.3	0.1	0.7
Skruf Original Portion	1.5	0.2	0.3	0	0.5

demineralisation of the dental hard tissue (enamel and dentine), is caused by a lowering of plaque pH (23). Plaque pH is an important variable in the dental caries process and it is therefore an interesting tool when assessing the individual risk of caries and evaluating food and other risk products, such as snus (3).

The main findings in the present investigation were that the intraoral pH for nicotine-containing products increased in contrast to three of the six nicotine-free products, which lowered the plaque pH considerably and may thereby constitute a risk of dental caries. This is in agreement with a recently published case report (6). Even if the six nicotine-free products contained starch and sugars, especially Energy, XQ's and Onico old recipe, they did not reach such low plaque pH values as the sucrose control. There are several possible reasons for this. First, the sucrose solution (10 ml) was administered as a mouthrinse for one minute, resulting in a high concentration of sugar. Second, the snus was placed as a portion ( $\approx$ 1 gram) under the upper lip, which means that it takes time for the carbohydrates to be released from the snus and reach the surrounding tooth surfaces. Moreover the amount of solution and snus (10 ml vs. 1 gram) may play a role in the pH drop.

Studies have shown that snuff placed under the lip and kept in place for a large part of the day will result in the loss of gingival attachment (18,19). If the root surfaces are exposed, the risk of caries is significantly higher, because dentine is more susceptible to demineralisation than enamel (4). It is possible to speculate about why the nicotine-containing products increase pH, although they contain small amounts of carbohydrate. The possible reason could be the content of bicarbonate and nicotine, which may raise the plaque pH, in combination with the salivary stimulation effect. Some new snus products on the Swedish market contain various levels of nicotine (75, 50, 25 and 0%) and are therefore recommended to help people stop using nicotine snus. A pilot study carried out at our laboratory indicates that the amount of nicotine in the product is important in this context, as a larger amount of nicotine raises plaque pH more than a smaller amount.

In the present study, plaque pH measurements were used as an indicator of the cariogenic potential. The microtouch method is well accepted in dental research and has been used extensively for the past 25 years (17,21). It is reliable and easy to use. However, the electrode is very thin and easy to damage, especially when there is very close contact at the proxi-

mal site. In the present study, only single exposure of each product was used. A different result might have been obtained if the plaque acidogenicity had been tested in a longitudinal study, where the different individual risk factors in the mouth may have influenced the results.

All the products, both with and without nicotine, contained starch. Many food products containing starch are easily fermented in the oral cavity (16). The content of starch was low in the nicotine-containing products, as well as in some of the nicotine-free variants. This small amount of starch may not be harmful to the teeth, especially if the product contains nicotine and bicarbonate. On the other hand, if the starch content is high, it may constitute a risk of dental caries by lowering the plaque pH, especially on exposed root surfaces. This situation is the same if the products contain the low-molecular-weight carbohydrates glucose, fructose and sucrose. These products may have a negative effect on exposed tooth surfaces in addition to the snus and may therefore represent a risk of caries if an individual changes from a nicotine-containing product to a nicotine-free product, which lowers the plaque pH.

The results of this study show that three of the nicotine-free products reduce plaque pH considerably, with the final pH ranging between 5.7 and 6.0. However, three nicotine-free products did not change the final pH at all. New nicotine-free products are constantly being introduced onto the Swedish market and they need to be evaluated from a cariological point of view. Some of these products are promoted with a health claim. The nicotine-free snus is a better alternative from a general health point of view, but the present study shows that snus must also be evaluated from a cariological perspective.

The present study was based on analyses of six nicotine-free snus products that were available on the Swedish market at the time when the study was carried out in 2009. The selection of the four nicotine-containing products was made to obtain a picture of both popular products and products that are not so common. Moreover, the sales rates differed in different parts of the country. All the products were of the so-called "portion type" in order to standardise the amount ( $\approx$  1 gram) and placement of the snus under the lip.

The overall impression from the present study is that there appears to be a relationship between the content of fermentable carbohydrates in the snus and the pH fall in dental plaque after the application of the product intraorally. The various products

contained different amounts of sugars and starch, which are known to be easily fermented in the oral cavity (16,23). Further clinical studies of snus users and the way the use of nicotine-containing snus influences the risk of dental caries are currently being conducted by our research group.

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Corresponding author:  
Dr Lena Hellqvist  
Karlstad University,  
Department of Health and Environmental Sciences,  
SE-651 88 Karlstad, Sweden  
E-mail: Lena.Hellqvist@kau.se

# Factors related to persons with health problems attributed to dental filling materials - part one in a triangular study on 65 and 75 years old Swedes

KATRI STÅHLNACKE<sup>1</sup>, BJÖRN SÖDERFELDT<sup>2</sup>

## Abstract

© The aim of the present study was to investigate persons having problems with dental filling materials in a Swedish population, their perceived oral health, and their reception from dental care personnel. The development over time (between 1992 and 2007) has also been studied concerning the presence of problems from dental filling materials.

In two counties in Sweden, Örebro and Östergötland, all persons born in 1942 have been surveyed by mail every fifth year since 1992. In the year 2007, all persons born in 1932 also received the same questionnaire. The total number of respondents in 2007 were 9813 persons (response rate 72.6 %). Logistic regression models were constructed with those having had problems or not from dental filling materials as dependent variable. Multiple regression analysis was done with selfperceived oral health as dependent variable.

There were about 10 % (868) reporting problems from dental filling materials. There were clear differences between the two groups, having problems or not. The group reporting problems from dental filling materials perceived both their general and oral health as being worse compared with others. More frequently they had asked questions about adverse effects from dental filling materials, had changed dental fillings and crowns, and had amalgam present. They also felt less well treated by dental personnel and were not so pleased with dental care in general as others.

In conclusion, there were many persons perceiving problems from dental filling materials. For those, both perceived general health and oral health was worse and they were less satisfied with dental care in general. No consistent common characteristic, neither as to socioeconomic nor lifestyle factors, could be shown for those having experienced problems from dental filling materials.

## Key words

*Dental amalgam, questionnaire, regression analysis, oral health*

<sup>1</sup>Örebro County Council, Örebro, Sweden

<sup>2</sup>Department of Oral Public Health, Malmö University, Malmö Sweden

## Faktorer relaterade till människor med hälsoproblem tillskrivna dentala material – del ett i en trianguleringsstudie på 65 och 75 år gamla personer från två svenska län”

KATRI STÅHLNACKE, BJÖRN SÖDERFELDT

### Sammanfattning

☉ Syftet var att i en svensk population från Örebro och Östergötlands län, bestående av 65 och 75-åriga personer, undersöka ett antal variabler relaterade till personer med upplevda besvär från material i tandfyllningar. Andra syften var att studera bemötande-problematik samt självupplevd oral hälsa. Utvecklingen över tid (mellan 1992 och 2007) beträffande förekomsten av problem från tandfyllningsmaterial har också studerats.

I två svenska län, Örebro och Östergötland, har populationen födda 1942 studerats med hjälp av enkätundersökningar vart 5:e år sedan 1992. År 2007 undersöktes även alla personer födda 1932 med motsvarande enkät. Totala antalet respondenter var 9813, svarsfrekvensen 72.6 %. Två frågor i enkäten har använts som grund för denna studie; upplevda besvär från material i tandfyllningar och om man under det senaste året frågat någon i tandvården om biverkningar från tandsättningsmaterial. Logistiska regressionsanalyser med ”har haft problem från dentala fyllningsmaterial eller inte”, som beroende variabel har utförts såväl som multipel regressionsanalys med självupplevd oral hälsa som beroende variabel.

Omkring 10 % (868 personer) hade upplevt problem från material i tandfyllningar. Det var ganska tydliga skillnader. Personer som upplevt problem från dentala material uppfattade både sin allmänhälsa och munhälsa som sämre jämfört med de som inte haft problem. De med upplevda besvär hade oftare frågat om biverkningar från dentala fyllningsmaterial och bytt fyllningar och kronor oftare. De ansåg sig också sämre behandlade av tandvårdspersonal och var inte så nöjda med tandvård i allmänhet som de utan problem.

Ungefär 10 procent av denna studiepopulation upplevde någon form av problem från material i tandfyllningar. Personer med besvär upplevde såväl sin allmänhälsa som orala hälsa sämre och kände sig i större utsträckning mindre nöjda med tandvården i allmänhet, jämfört med gruppen utan besvär. Ingen konsekvent gemensam egenskap, vare sig beträffande socioekonomiska eller livsstilsfaktorer, kunde visas för de som upplevt problem från material i tandfyllningar. Denna studie är en del i en trianguleringsstudie där samma frågeställningar även analyseras kvalitativt.

## Introduction

Problems related to dental filling or replacement materials, predominately dental amalgam, is an ongoing subject of discussion. Dental amalgam has been the most commonly used dental filling material during the past 150 years. Amalgam is usually an alloy of silver, copper, tin, and mercury. In the early 1980s, it was discovered that amalgam restorations could release mercury vapor during chewing (26). There are suspicions of a link between exposure to mercury from dental amalgam and general disorders, but this has not been established. There are several studies, reviews and reports investigating whether dental amalgam has an adverse effect on human health. Almost all studies have come to the same conclusion: There is no scientific support that mercury from dental amalgam has an adverse effect on general health, especially not in epidemiological studies (5-6, 10-11, 17-19, 23, 25, 28, 30-32, 41, 43). However, it is also pointed out that there is a lack of data for some diseases, like Alzheimer and Multiple Sclerosis (2, 4, 26).

Despite the lack of evidence, there are a number of persons who attribute their health problems to dental filling materials, predominantly dental amalgam. The most common general health symptoms being reported are: headache, dizziness, diffuse joint- and muscle pain, problems with concentration, and general weakness and fatigue. There are also reports on psychosomatic problems like tiredness, depression, tremor, tinnitus, anxiety and sleeping difficulties (12, 30). In 1988, Locker presented a conceptual model of oral health, including a patient perspective. It is a multidimensional model for understanding oral disease and its clinical as well as psychosocial dimensions, useful for these groups of patients. The model established that there are five consequences of oral disease; impairment, functional limitation, pain and discomfort, disability and handicap. These consequences are sequentially related, impairment leads to functional limitation and pain/discomfort, which in turn leads to disability and then to handicap (21).

In a study from Australia, about 30 per cent of the adult population stated concerns about mercury from dental fillings (33). Another study showed that about 17 % of the Dutch population regarded dental amalgam to be potentially harmful (29). In a report from the Swedish National Board of Health and Welfare, it has been estimated that between 1-5 % of the adult Swedish population perceive health problems related to dental materials, giving a number of 70 000 – 350 000 people (32). Since June 2009, it is prohibited to use dental amalgam in Sweden.

Patients attributing their problems to dental filling or replacement materials often point out that they perceive a bad reception from medical and dental care providers, regarding their problems as imagined or psychiatrically related (31). This problem is recognised by the Swedish National Board of Health and Welfare. In 1998, general advice was published concerning patients attributing their problems to amalgam (31). One commonly used treatment of amalgam problems is to replace them with other materials, like composite, glass ionomer, porcelain or gold. There are no unequivocal results whether patients symptoms or discomfort have ceased due to the change of filling materials. In some studies, the majority of patients have reported persistent problems after the removal, and in some, improvements have been seen (16, 20, 27, 34, 40, 42).

Several hypotheses have been suggested to explain why some people may be more sensitive than others to the effects of dental amalgam, from a susceptible immune system to a somatizing psychological status. *Bailer et al* (3) concluded that amalgam sensitive subjects had a self-concept of being weak and unable to tolerate stress, had more cognitions of environmental threat, and increased habitual anxiety. *Cederbrandt et al* (8) investigated whether a susceptible immune system could be a factor, but they found that none of the investigated immune parameters revealed any significant differences between amalgam patients and controls (8). From an amalgam unit at the Huddinge University Hospital in Sweden, various explanations were reported for the complaints of patients fearing "amalgam disease". In all, 379 patients referred for health problems attributed to dental amalgam were examined. Toxicological, clinical, odontological, and psychiatric examinations were performed. More than 30 % had medical causes for their complaints. The psychological examination revealed a high prevalence of somatization. No cases of mercury intoxication were found (17-18).

The aim of the present study was to investigate variables related to persons reporting problems with dental filling materials in a Swedish population from two counties, Örebro and Östergötland, as well as their perceived oral health and reception from dental care personnel. The development over time (since 1992) for a study-group born in 1942 concerning the presence of problems from dental filling materials has also been studied.

## Material and methods

### *Population and response rate*

In 2007, a mail questionnaire was sent to all persons



born in 1932 or 1942 who at the time of the study were living in the counties of Örebro or Östergötland in Sweden, altogether 13508 persons (Örebro county 5438 and Östergötland county 8070). Their names and addresses were obtained from public population records (Statistics, Sweden). If a questionnaire was returned with unknown address, that person was excluded from the population. Individuals not responding within two weeks were given a reminder in the form of a letter. For those still not answering after an additional two weeks, a new questionnaire was issued. No further efforts were made. The response rate was 72.6 %, giving a net study sample of 9813 individuals. The studied age group born in 1932 consisted of 3735 persons (response rate 71.9 %) and those born in 1942 were 6078 persons (response rate 73.1 %). The population born in 1942 has been studied every fifth year since 1992. A number of studies have been presented based on this population (9, 14, 15, 36, 39).

#### *Non-response*

Non-response analysis was done according to available variables: gender, age group, and county. In analysis of the whole population, no difference was found concerning gender (48.4 % / 48.6 % male responders / non-responders). However, there were significant gender differences controlling for age groups (49.3 % / 53.3 % male responders/non-responders born 1942 and correspondingly 46.8 % / 41.3 % for those born 1932). County showed no differences, neither for the whole population nor when controlled for the two age groups. In analysis of associations and differences, data can be used with greater confidence as long as it cannot be deemed probable that the differences or covariations are deviant in the non-response group.

#### **Questionnaire**

The questionnaire was designed with six different sections:

1. general socio-economic conditions (age, gender, vocation etc.)
2. general health (physician visits, tobacco habits, drug consumption, etc.)
3. oral conditions (satisfaction with teeth, oral problems, oral hygiene habits, number of teeth, etc.)
4. attitude questions concerning function and appearance of teeth
5. experiences and use of dental care
6. questions about the most recent visits to a dentist. Data were scanned into a SPSS data file.

*Dependent variables in the logistic regression analysis*  
As dependent variable in the logistic regression analysis, the following question was used.

- One can have many different troubles from the mouth and teeth. Do you for yourself experience that you have problems from tooth filling materials: no troubles; some troubles; quite many troubles; big troubles. A dichotomisation was done between having no troubles and any extent of troubles.

As a dependent variable in the multiple regression analysis, an index for self perceived oral health was used. This index has been used in other studies on this study population (37, 38). Satisfaction with teeth, chewing ability and number of teeth were used as a summed index approximating an interval level variable. Summing the response alternatives for the three used variables gave an index range of 3 to 13, the higher value the worse self-perceived oral health. The questions used, and their response alternatives were:

- Are you in general satisfied with your teeth: yes, very satisfied; yes, mostly satisfied; no, not very satisfied; no, absolutely not satisfied
- Can you chew all kinds of food: very good; rather good; not so good; poorly
- How many of your own teeth (except primary teeth) do you have left: all teeth left; missing some single tooth; missing rather many teeth; have almost no teeth left; edentulous

#### *Independent variables in the regression analysis*

In the analyses, some of the questions were dichotomized. In the following presentation of questions used, dichotomizations are marked with // in the response alternatives.

#### **Socioeconomic factors**

- Age group – Born in 1932 // 1942
- Gender – male // female
- Ethnicity - Country of birth: Sweden; // Nordic country; other country
- Education - What education do you have: primary education; // secondary education; high-school/grammar school; college education; other
- Marital status - What is your present marital status: married-cohabiting, // single – amended with sub-question: unmarried; divorced; widow/widower
- Social network - How many persons, that you know, do you meet or talk to during an ordinary

week? (Don't count in people that you meet temporary and hardly ever will see again, like customers in a shop): None; 1-2; 3-5; // 6-10; 11-15; more than 15

#### Individual factors:

- Perceived general health – Do you consider yourself as completely healthy: yes, absolutely; yes mostly; // no, not particularly; no, absolutely not
  - What are your smoking habits: daily smoker; // occasional smoker; have smoked but stopped; // never smoked
  - Attitudes regarding teeth – Here follow some statements and opinions that can occur. We ask you to give your opinion: absolutely agree; mostly agree; // mostly disagree; absolutely disagree
1. To have beautiful and perfect teeth is very important for how you are treated by other people
  2. Minor imperfections in teeth are of no importance as long as they are functional
  3. Visible toothlessness is something to be ashamed of
  4. It doesn't matter how you look in your mouth, as long as you can chew the food you like

Two attitude indices were formed. "Appearance" and "Function". Questions used forming the index appearance were 1 and 3, and 2 and 4 for function. Both indices ranged between 2–8.

- Attitude: Do you believe that you can keep your teeth all life through: yes, absolutely; yes maybe; // I don't know; no, probably not; no, absolutely not
- You can have many different materials and designs in fillings and dental replacements. What is it like in your teeth? Enter all the options that apply to you! Presence of amalgam fillings: yes
- Have you over the last year asked anyone from dental care about adverse effects from dental replacement materials: yes; // no; do not remember
- Have you had dental fillings or crowns replaced because you have experienced that they created problems for you: yes, all I have; yes, some; yes, one or two; // no

#### Dental care habits:

- Care organization - Where have you mainly received dental care during the last five years: private dental care; // public dental care. The response alternatives; no dental care and other, were treated as missing in the regression analysis.

- Visiting habits – About how often do you visit dental care: twice or more per year; once a year; // every second year; more seldom
- Are you in general satisfied or dissatisfied with the dental care you have received previously: very satisfied; mostly satisfied; // rather dissatisfied; very dissatisfied
- Have you any time during the last five years changed, or wanted to change, your dentist because you were dissatisfied: yes, several times; yes, once or twice; // no; do not remember
- We want to know how you experienced your most recent dental care visit in different respects: VAS/Tick-boxes with endpoints; good reception to bad reception
- Have you during the last year refrained from visits to dental care because you could not afford it: yes, several times; yes occasionally; // no

#### Ethical aspects

Ethical approval for the questionnaire study was given when it was initiated in 1992. An ethical approval was also obtained for this specific study by the Ethical regional board in Lund, 2009/343.

#### Statistical analysis

Data were bivariately analyzed with descriptive statistics and contingency tables with  $\chi^2$  analysis. A significance level of  $P < 0.05$  was considered significant. Multivariate analysis was performed by using multiple as well as logistic regression analyses. In the regression models, residual plots were inspected for the detection of heteroscedasticity. Test for multicollinearity was performed by inspection of bivariate correlations. Inclusion of variables followed the checklist of Studenmund (35). For multiple regression, model fit was determined by the F-test and by calculation of  $R^2$ . For logistic regression model fit was determined by model  $\chi^2$ , calculation of improvement in correctly classified cases and Nagelkerke pseudo  $R^2$ . All data were processed in the statistics program SPSS, version 17.0.

#### Results

There was a number of persons feeling concerned/troubled or having problems with dental filling materials. About 10 %, 868 persons, had, ranging from some to big, problems with dental filling materials, 5 %, 439 persons, had asked questions about adverse effects from dental replacement materials, and 10 %, 890 persons, had changed fillings or crowns due to problems.

In Tables 1-3, descriptive data from the study po-

pulation are presented together with results from bivariate analyses, comparing the group having problems with dental filling materials with those having no problems. Concerning the socio-economic factors gender, marital status and number of social relations per week, there was no relation to having had problems with dental materials. However, there was a higher proportion reporting problems of those being born in 1942, compared with being born in 1932. (Table 1)

The group having had problems with dental filling materials perceived both their general health and their oral health as worse. They had higher presence of amalgam fillings, had more often changed dental fillings or crowns, and more often asked dental personnel about adverse effects from dental materials, (Table 2.)

Concerning dental care factors the group having problems with dental materials, showed a larger share going to public care compared with private care, they were more dissatisfied in general with dental care and had more often changed or wanted to change dentist, (Table 3.)

In a logistic regression analysis, with having had problems with dental filling materials or not as dependent variable, some of the bivariate associations disappeared. The only remaining socioeconomic as-

sociation was age, with higher probability to have problems being born in 1942. The individual association with general health as well as oral health remained (higher probability to have problems with worse health) as did presence of amalgam fillings, having changed dental filling or crowns or asked about adverse effects from dental materials. From dental care factors, the association to care organisation, changed or wanted to change dentist, refrained from care due to cost and how you were taken care of at your most recent dental visit remained, (table 4.)

Multiple regression analysis was performed with perceived oral health as dependent variable (range 3-13). Comparisons were made between the two groups, problems with dental filling materials or not. There were differences concerning the socioeconomic independent variables; ethnicity, marital status and social network. All these were significantly related to perceived oral health in the group with no problems but not for those having problems. The same applied for the individual factors, smoking habits, changed fillings or crowns, presence of amalgam fillings and from dental care factors; taken care of at most recent dental visit and changed or wanted to change dentist. It is noteworthy that desire to change dentist revealed an association that was not significant for those with problems, and that there

© **Table 1.** Socioeconomic variables - Presentation of the study-population from 2007. The group reporting no problems with dental materials (n=8216) and the group reporting problems with dental materials (n=868). Bivariate analysis, Pearson's chi-square.

Age cohort	Born 1932	Born 1942					p-value
Having no problems	37 %	63 %					<0.000
Having problems	28 %	72 %					
Gender	Women	Men					
Having no problems	51 %	49 %					<0.153
Having problems	49 %	51 %					
Country of birth	Sweden	Other Nordic country	Other country				
Having no problems	94 %	3 %	3 %				<0.008
Having problems	92 %	3 %	5 %				
Education	Primary school	Secondary school	College	Other			
Having no problems	45 %	26 %	17 %	12 %			<0.000
Having problems	38 %	30 %	20 %	12 %			
Marital status	Married/cohabiting	Single					
Having no problems	74 %	26 %					<0.078
Having problems	72 %	28 %					
Social relations per week	None	1-2	3-5	6-10	11-15	>15	
Having no problems	1 %	7 %	22 %	26 %	13 %	31 %	<0.905
Having problems	1 %	8 %	20 %	24 %	15 %	32 %	

© **Table 2.** Individual factors - Presentation of the study-population from 2007. The group reporting no problems with dental materials (n=8216) and the group reporting problems with dental materials (n=868). Bivariate analysis, Pearson's chi-square

Perceived general health	Completely healthy	Mostly healthy	Not particularly healthy	Not healthy at all	p-value	
Having no problems	22 %	56 %	15 %	8 %	<0.000	
Having problems	14 %	52 %	21 %	13 %		
Smoking habits	Daily smoker	Occasionally smoker	Have smoked but stopped	Never smoked		
Having no problems	11 %	39 %	4 %	47 %	<0.072	
Having problems	10 %	38 %	3 %	50 %		
Attitude - appearance important	Yes, definitely	Yes, more or less	Not so much	Not at all		
Having no problems	10 %	67 %	22 %	1 %	<0.318	
Having problems	8 %	69 %	23 %	0 %		
Attitude - function important	Yes, definitely	Yes, more or less	Not so much	Not at all		
Having no problems	18 %	60 %	21 %	1 %	<0.000	
Having problems	14 %	58 %	26 %	1 %		
Attitude to possibility of keeping teeth all life through	Yes, all life through	Yes, maybe	No, probably not	No, definitely not		
Having no problems	32 %	49 %	12 %	6 %	<0.000	
Having problems	17 %	52 %	23 %	9 %		
Asked about adverse effects from dental replacement materials	Yes	No	Do not know			
Having no problems	4 %	95 %	1 %		<0.000	
Having problems	13 %	85 %	2 %			
Presence of amalgam fillings	Yes	No				
Having no problems	78 %	22 %			<0.000	
Having problems	84 %	16 %				
Changed dental fillings or crowns due to problems	All fillings	Some fillings	Single fillings	No		
Having no problems	0 %	2 %	6 %	93 %	<0.000	
Having problems	1 %	9 %	16 %	74 %		
In general satisfied with teeth	Yes very	Yes mostly	No, not very	No, not at all		
Having no problems	15 %	66 %	15 %	4 %	<0.000	
Having problems	4 %	48 %	36 %	12 %		
Can chew all kind of food	Very good	Rather good	Not so good	Poorly		
Having no problems	65 %	30 %	4 %	1 %	<0.000	
Having problems	36 %	47 %	12 %	5 %		
Number of own teeth left	All left	Missing some	Missing rather many	Almost no left	Edentulous	
Having no problems	12 %	57 %	25 %	3 %	3 %	<0.000
Having problems	7 %	51 %	37 %	4 %	1 %	

was no real difference in dissatisfaction with dental care, (Table 5.)

The development over time (between 1992-2007) was analyzed for the age group born in 1942. Those having had problems from dental filling materials revealed a slightly descending slope, from 14 % in 1992 to 11 % in 2007. There was a clear decrease in the number of those asking about adverse effects from dental filling materials, both in the group having problems with dental filling materials (from 37 % to

13 %) as well as those having no problems (from 10 % to 4 %). As to the reception by dental care, there were continuously differences between the groups. Those having problems with dental filling materials perceived that they were taken care of in a worse way, compared to those having had no problems, at all four study occasions (percentage differences between 9-14 %). This should, however, be considered in the light of the multivariate models.

© **Table 3.** Dental care factors - Presentation of the study-population from 2007. The group reporting no problems with dental materials (n=8216) and the group reporting problems with dental materials (n=868). Bivariate analysis, Pearson's chi-square.

Care organisation	Public care	Private care	No dental care	Other	p-value	
Having no problems	27 %	70 %	3 %	0 %	<0.000	
Having problems	36 %	59 %	5 %	1 %		
Dental care visiting habits	> Twice a year	Once a year	Every second year	More seldom		
Having no problems	26 %	60 %	7 %	7 %	<0.003	
Having problems	28 %	53 %	9 %	10 %		
Generally pleased with dental care	Very satisfied	Mostly satisfied	Rather dissatisfied	Very dissatisfied		
Having no problems	47 %	48 %	3 %	1 %	<0.000	
Having problems	19 %	65 %	13 %	3 %		
How did you feel at your most recent dental care visit	Taken good care of	A five step scale from good to bad	A five step scale from good to bad	A five step scale from good to bad	Taken badly care of	
Having no problems	93 %	5 %	1 %	0 %	0 %	<0.000
Having problems	81 %	12 %	5 %	1 %	2 %	
Wanted to change dentist due to dissatisfaction	Yes, several times	Yes, occasionally	No	Do not remember		
Having no problems	1 %	8 %	90 %	1 %	<0.000	
Having problems	4 %	21 %	74 %	1 %		
Refrained dental care due to economy	Several times	Occasionally	No			
Having no problems	3 %	5 %	92 %		<0.000	
Having problems	11 %	14 %	75 %			

## Discussion

The aim of this paper was to investigate variables related to persons being concerned/troubled about dental filling materials in a Swedish population and their perceived general and oral health, as well as perceptions about satisfaction with dental care and dental personnel's reception. As a marker for these issues, one main question was used; Have you had problems or not from dental filling materials. There was a number of persons having had problems from dental filling materials as well as concerned/troubled feelings about dental filling materials, not in terms of percentages but rather many in numbers. In an investigation about dental materials, done by the Swedish National Board of Health and Welfare in 2003, about 70.000 – 300.000 adult persons in Sweden were estimated having problems with mercury from dental amalgam fillings, a lower percentage figure than found here (32). In this study, only persons being 65 or 75 years old where included, probably influencing the differences.

Primarily, the study group was investigated as one population. However, the population was divided into two groups, those having had problems from dental filling materials or not, to allow comparisons. There were quite clear differences between the groups in several respects. The group reporting problems from dental filling materials perceived both their general and oral health worse, compared with those reporting no problems. As a group, they had more often asked questions about adverse effects from dental replacement materials, had changed dental fillings and crowns more often and had amalgam present more often. They also felt less well treated by dental personnel and were not so satisfied with dental care in general.

In a number of studies, it has been showed that there are no unequivocal relations between having dental amalgam and specific diseases like renal, neurodegenerative and neurobehavioral diseases/problems (6, 11, 25, 41, 43). In this study, there was a stronger probability for those perceiving their ge-

© Table 4. Logistic regression model of concerns about dental filling materials.

Dependent variable: Having problems from dental filling materials 0= No, have no problems, 1 = Yes, have problems

Socio-economic factors	OR	CI 95 %	p-value
Age group - born in 1942 (ref.cat: born 1932)	1.62	1.30 – 2.03	<0.000
Gender – male (ref.cat: female)	1.17	0.97 – 1.41	<0.107
Ethnicity -born in Sweden (ref.cat: born outside Sweden)	1.35	0.91 – 2.00	<0.140
Education – more than primary school (ref.cat: primary school)	1.21	0.99 – 1.49	<0.057
Marital status - married/cohabiting (ref.cat: single)	1.06	0.85 – 1.32	<0.622
Social network - (range 1-6, none to many)	1.01	0.94 – 1.09	<0.807
<b>Individual factors</b>			
Perceived general health – not healthy (ref.cat: healthy)	1.29	1.04 – 1.60	<0.022
Smoking habits - not daily smoking (ref.cat: daily smoking)	1.73	1.22 – 2.44	<0.002
<b>Attitudes regarding teeth -</b>			
appearance important, (range 2-8, agree to not agree)	0.91	0.82 – 1.00	<0.048
function important, (range 2-8, agree to not agree)	1.07	0.99 – 1.16	<0.085
belief in keeping teeth all life through (ref.cat: no believe in keeping teeth al life through)	1.20	0.90 – 1.60	<0.204
Self-perceived Oral Health (range 3-13, good to bad)	1.37	1.27 – 1.47	<0.000
Changed fillings or crowns due to problems (ref.cat: not changed)	3.63	2.89 – 4.57	<0.000
Amalgam fillings present (ref.cat: no amalgam fillings)	1.95	1.48 – 2.58	<0.000
Asked about adverse effects from dental filling or replacement materials (ref.cat: not asked)	3.14	2.33 – 4.26	<0.000
<b>Dental care factors</b>			
Care organization – public care organization (ref.cat: private care organization)	1.28	1.04 – 1.57	<0.020
Visiting habits – >once a year (ref.cat: more seldom than once year)	1.07	0.80 – 1.45	<0.647
Not satisfied with dental care – (ref.cat: satisfied)	1.36	0.95 – 1.95	<0.093
Taken care of (range 1-5, good to bad)	1.32	1.11 – 1.57	<0.002
Wanted to change dentist due to dissatisfaction- (ref.cat: not wanted to change)	1.83	1.41 – 2.38	<0.000
Refrained from dental care due to economy (ref.cat: not refrained)	1.97	1.47 – 2.65	<0.000
Model $\chi^2$ / df	577,0*** / 21		
Nagelkerke, pseudo R-square	0.192		
Correctly classified cases %	90.9		

neral health as not so good to have problems from dental filling materials, although here lacking knowledge about specific diseases. In bivariate analysis, socio-economic factors differed between the two studied groups. This result disappeared in regression analysis, showing no impact for socio-economic factors on having problems from dental materials. There was no common characteristic for the group having problems from dental filling materials. This is in accordance with a study by *Malt et al* in 1997, finding that the studied group of patients with health complaints attributed to dental amalgam was heterogeneous (24).

Self-perceived oral health was the other issue to investigate, i.e. how persons having problems with dental filling materials perceived their oral health. The multi-item measure of perceived oral health used here has been used and validated in other studies (37, 38). There were clear differences in relation

to those not reporting problems with filling materials. Socioeconomic factors that affected self perceived oral health among those having no problems disappeared in the group having problems.

Another issue here was to investigate how persons having problems/concerns with dental filling materials perceived the reception by dental personnel, since that is said to be a problem (31). The results in this study confirm this. A higher proportion among those having problems were dissatisfied with the reception from dental personnel, as well as more persons wanting to change dentist due to dissatisfaction. There may not always be an agreement between the patient and the dentist as to problems from dental filling materials, nor concerning the solution to the problems.

Results are here based on self-reported data from a questionnaire study, where the issue of perceiving problems from dental materials was not in focus.

© **Table 5.** Multiple regression analyses of the population in 2007, those with no problems from dental filling materials and those having had problems, with self-perceived oral health as dependent variable.

Dependent variable: Self perceived oral health, range 3-13 units. High value = bad perceived oral health				
	Having had no problems from dental filling materials		Having had problems from dental filling materials	
Independent variables	b	P	b	P
<b>Socio-economic factors</b>				
Gender female - (ref.cat: man)	-0.012	0.699	0.146	0.197
Ethnicity, born outside Sweden - (ref.cat: born in Sweden)	0.239	0.001	0.279	0.207
Education, more than primary school - (ref.cat: primary school)	-0.170	0.000	-0.356	0.003
Marital status single - (ref.cat: married/cohabiting)	0.080	0.036	0.098	0.454
Social network - (range 1-6, none to many)	-0.047	0.000	-0.006	0.882
<b>Individual factors</b>				
Perceived general health as not healthy - (ref.cat: healthy)	0.298	0.000	0.450	0.000
Smoking habits, not daily smoking - (ref.cat: daily smoking)	-0.206	0.000	-0.036	0.862
Attitudes regarding teeth -				
appearance important (range 2-8, agree to not agree)	0.069	0.000	0.032	0.579
function important (range 2-8, agree to not agree)	0.000	0.974	0.057	0.231
Attitude no belief in keeping teeth all life through - (ref.cat: believe in keeping teeth all life through)	2.213	0.000	1.840	0.000
Not changed fillings or crowns due to problems - (ref.cat: have changed:)	-0.140	0.021	-0.193	0.128
Amalgam fillings present - (ref.cat: no amalgam present)	-0.233	0.000	-0.321	0.052
Not asked about adverse effects from dental filling or replacement materials - (ref.cat: have asked)	0.042	0.608	0.338	0.035
<b>Dental care factors</b>				
Public Care organization - (ref.cat: private care organization)	0.206	0.000	0.358	0.003
Visiting habits more seldom than once year - (ref.cat >once a year)	0.061	0.266	0.174	0.326
Not satisfied with dental care - (ref.cat: satisfied)	1.002	0.000	0.867	0.000
Taken care of - (range 1-5, good to bad)	0.156	0.001	0.159	0.069
Not wanted to change, dentist due to dissatisfaction - (ref.cat: wanted to change)	-0.321	0.000	0.214	0.137
Refrained from dental care due to economy (ref.cat: have not refrained dental care)	0.534	0.000	0.407	0.011
Adjusted R2	0.414		0.452	
F/df 1/df2	212.3/19/5678		26.0/19/577	
Model significance	0.000		0.000	

This was the first step in a triangulation study, were the next step was an interview study. Still there was in this study a clear relation between having had problems from dental filling materials and perceiving general health as not so good, also controlling for a host of confounding variables.

There are signs that filling materials may have become a less intense issue. The development over time since 1992, for the age cohort born in 1942, shows a decreasing share for the number of persons reporting problems with dental filling materials, as well as for those having asked questions about adverse effects from dental materials. At least in Sweden, the issue of problems from amalgam as a dental filling material will cease over time, since amalgam is prohibited to use. However, there are also other materials than amalgam which the patient interest group "Tandvårdsskadeför-

bundet", has described as problematic when used as dental replacement materials, as gold and composites.

As always there are strengths and weaknesses in studies, so in this one. Some aspects can be seen as both strengths and weaknesses. One is the construction of the questionnaire, not primarily aimed at investigating these issues, meaning that some questions probably should have been phrased more precisely. On the other hand, responders were not biased by the knowledge about this issue being the main target. However, the questionnaire has been thoroughly tested and been used in four comprehensive studies with reliable outcomes (36, 38, 39). Another strength is the high share of responders and the longitudinal design for the age group born in 1942. A weakness is of course the design itself, consisting of self-reported data, which always have some amount of bias, both underestimating and

exaggerating (7, 22). The only way to study perceptions and opinions, on the other hand, is by asking people.

This study is performed with quantitative method, intended to be followed by a qualitative study with interviews. Combining these research methods can be done in two ways. The most common way is probably to perform interview studies as step one and then, as step two, to capture issues to be investigated in a larger quantitative study. In this study, it was done the other way around. Issues found in this quantitative study will be followed up with questions in the forthcoming interview study.

In conclusion there was a number of persons perceiving problems from dental filling materials. No common characteristic can be discerned for the group having experienced problems from dental filling materials. The development over time since 1992 shows a decreasing share of persons having problems with dental filling materials, as well as for those having asked questions about adverse effects from dental replacement materials. In contrast, there were stable results over time for those having problems as to the perception of being less satisfied with dental care in general. As a final conclusion, the absolutely best way to combat the problem of dental replacement materials must be to invest in the healthy, so that no replacement will be needed.

#### Acknowledgements

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Corresponding author:  
 Dr Katri Ståhlacke  
 Dental Public Health  
 Örebro County Council  
 P.O. Box 1126  
 SE-701 11 Örebro  
 Sweden  
 E-mail: katri.stahlacke@orebroll.se

# Abstracts

of free communications and posters presented at  
the 48<sup>th</sup> Annual Congress of the Swedish Dental  
Society, Göteborg, November 15-17, 2012

Subjects	Nos
Community and Hospital Dentistry, Others .....	1-6
Cariology, Endodontics, Surgery.....	7-8
Periodontology .....	9-13
Orthodontics, Paediatric Dentistry.....	14-23
Prosthodontics.....	24-27
Stomatognathic Physiology, Others.....	28-37



Professor Jens Andreasen, Copenhagen receives the International Prize of the Swedish Dental Society from Professor Mats Trulsson



## Follow-up of treatment of dental phobic patients in Östergötland, Sweden

A Ahlvin, S Ordell

Dental Unit, County Council Östergötland, Linköping, Sweden

### Aim:

The prevalence of dental phobia is reported to be 5% in general population. Since 1999 patients suffering of dental phobia in Sweden have right to subsidized dental treatment combined with cognitive behavioral therapy in order to treat the phobia. The aim of this follow-up was to study whether the earlier treated patients had visited dental health care again after completed treatment, and how their experience of that was.

### Materials and Methods:

All dental phobia patients in the county of Östergötland, Sweden, who finished treatment by psychologist and dental service during the year 2008 received a postal questionnaire. The number of questionnaires were 722 and the response rate was 49% (n= 351)

### Results:

The collected data showed that 64.5% (n= 225) of the respondents had visited dental health care again after completed treatment with psychologist. 58% of those who had visited dental service again went to the same dentist as during the phobia treatment. Regarding self-perceived experience the group treated for dental phobia estimated higher level of anxiety, discomfort and pain during latest dental visit compared to a normal population, using a population study for those born 1962 for comparison.

### Conclusion:

The majority of the respondents had visited dental health care again after completed treatment with psychologist. However, the number of non responses was quite high and further analysis will be needed to interpret the causes for this.

Contact E-mail: anna.ahlvin@lio.se



## Economic evaluation in dentistry - a systematic review

H Christell<sup>1</sup>, S Birch<sup>2,3</sup>, K Horner<sup>4</sup>, M Rohlin<sup>1</sup>, C Lindh<sup>1</sup>, The SEDENTEXCT consortium<sup>5</sup>

<sup>1</sup>Department of Oral and Maxillofacial Radiology, Faculty of Odontology, Malmö University, Malmö, Sweden, <sup>2</sup>Centre for Health Economics and Policy Analysis, McMaster University, Hamilton, Canada, <sup>3</sup>School of Community Based Medicine, University of Manchester, Manchester, UK, <sup>4</sup>School of Dentistry, University of Manchester, Manchester, UK, <sup>5</sup>Listing of partners on [www.sedentext.eu](http://www.sedentext.eu)

### Aim:

To elucidate the distribution of research articles by year of publication and form of economic evaluation for different intervention methods used in dentistry and specifically analyse the results of economic evaluations of diagnostic methods.

### Materials and Methods:

Literature searches were made in four electronic databases. Publications were selected via a two-step process where three reviewers first identified research articles by assessing the titles and/or abstracts independently with focus on cost analysis, cost-effectiveness, cost-utility and cost-benefit analyses. In the second stage of article retrieval, the same reviewers independently read the full-text publications and included those that met the predefined and explicit selection criteria. The included articles were classified based on (i) intervention method (preventive, diagnostic, predictive, treatment), (ii) year of publication and (iii) form of economic evaluation (cost analysis, cost-effectiveness, cost-utility, cost-benefit). The interpretation of data of publications on diagnostic methods was assessed by three authors including a health-economist.

### Results:

The searches identified 3 058 publications out of which 446 were read in full-text and 148 of the 446 publications were considered as being economic evaluations. The principal reasons for exclusion of a publication were if it (i) not comprised a presentation of an analysis of the costs or differences of costs, (ii) not comprised an analysis of intervention

methods used in dentistry, (iii) was a non-systematic review. During 1973 to 2012 the number of publications ranged between 0 and 13 per year. Most publications presented economic evaluations of preventive (n=72) and treatment (n=64) methods. Cost-effectiveness analysis was the most frequently used analytic method. None of the publications were dealing with predictive methods. In only 12 publications diagnostic methods were analysed. In one of these methods for periodontal probing were analysed, six studies compared methods for screening and five evaluated imaging methods. Five studies were experimental, and two were systematic reviews. Five studies comprised model analyses, and three of these included a systematic review of the literature.

#### Conclusion:

There is a need for studies that analyses the outcome of methods used in dentistry from various perspectives and with well-defined research questions and measures of cost and effectiveness. In particular there is a need for studies on economic evaluation of diagnostic and predictive methods used in dentistry.

Contact E-mail: Helena.Christell@mah.se



### **A 10-year follow-up of a Mandibular Protruding Device in patients with obstructive sleep apnea and snoring**

E Wiman Eriksson<sup>1</sup>, L Leissner<sup>2</sup>, G Isacson<sup>3</sup>,  
A Fransson<sup>1,4</sup>

<sup>1</sup>Department of Dental Sleep Medicine, Postgraduate Dental Education Center, Örebro Sweden; <sup>2</sup>Sleep Unit, Department of Neurology, Örebro University Hospital, Örebro, Sweden; <sup>3</sup>Department of Orofacial Pain, Västmanland Hospital, Västerås, Sweden; <sup>4</sup>Department of Orthodontics, Postgraduate Dental Education Center, Örebro Sweden

#### Aim:

The aim of this prospective long-term study was to evaluate the effect on respiratory parameters and subjective symptoms when using a Mandibular Protruding Device, MPD.

#### Materials and Methods:

Seventy-seven consecutive patients with the baseline diagnosis of obstructive sleep apnea, OSA, and snoring were treated with an MPD. At baseline, a polygraphic examination provided oxygen desaturation index, ODI and minimum oxygen saturation, SaO<sub>2</sub> nadir. Weight and neck circumference were registered and questionnaires focused on sleep-related qualities. At the 10-year follow-up the examinations were iterated. An "ODI-responder" was defined as an ODI decrease of >50% or ODI<5. A "Symptom responder" reduced the baseline questionnaire data with >50% at follow-up assessed on an 11-graded numerical rating scale.

#### Results:

At the 10-year follow-up 64 patients were examined with their current treatment, 45 still used MPD, 9 used CPAP and 10 had no treatment. Fifty patients answered the questionnaires.

Compared to baseline the OSA MPD-users significantly lowered the ODI value (P=0.002), and increased the SaO<sub>2</sub> nadir (P=0.015), and 70% were "ODI-responders". Among the "ODI-responders" 89% considered themselves as "Symptom responders" regarding the apneas. To notice is that all "ODI-non-responders" referred themselves as "Symptom responders" concerning apneas. The "ODI responders" maintained their baseline neck circumference and weight. This was in contrast to the "ODI-non-responders" who increased the neck circumference by mean 1 cm and the weight by mean 6 kg at the 10-year follow-up. The snorers still using their MPD, 93% remained with ODI values of <5. All CPAP users had ODI values of <5. Both OSA and snoring patients with an MPD, significantly reduced their own and their relatives' complaints of snoring, apneas, daytime tiredness and poor night sleep quality (P<0.001).

#### Conclusion:

This 10-year follow-up showed that MPD is a valuable long-term treatment modality but weight gain may jeopardize the effect of the MPD. Both the patients and their relatives significantly reduced the complaints of snoring and apneas, but still some overestimated the effect. That emphasizes the need of a complimentary polygraphic registration for the evaluation.

Contact E-mail: eva.wiman-eriksson@orebroll.se

▷ ◎ ◎ ◎ 4

**Different levels of fluoride – can the caries prevalence be distinguished among 18–19-year-old adults growing up in areas with different levels of fluoride in their drinking water in Sweden?**

A Hartwig<sup>1</sup>, A Prah<sup>2</sup>, L Unell<sup>3</sup>, B Svenson<sup>4,5</sup>

<sup>1</sup>Dental public health service at Lindesberg, Örebro County Council, Lindesberg, Sweden, <sup>2</sup>Department of Pedodontics, Postgraduate Dental Education Center, Örebro, Sweden, <sup>3</sup>Department of Dental Research, Postgraduate Dental Education Center, Örebro, Sweden, <sup>4</sup>Department of Oral Radiology, Postgraduate Dental Education Center, Örebro, Sweden, <sup>5</sup>School of Health and Medical Sciences, Örebro University, Örebro, Sweden

Fluoridated drinking water has been reported to reduce dental caries, but with varying results, depending on the level of fluoride ions in the fluoridated water. In Örebro County two communities had naturally fluoridated drinking water with diverse fluoride levels: Fellingsbro 2.5 ppm F and Storå 0.5 ppm F.

The aim of this study was to investigate how the level of fluorides in the drinking water affected the occurrence of caries in two neighbourhoods, using data from clinical and radiographic examinations made in 2000–2001. The natural high fluoride water used in Fellingsbro was changed to 0.3 ppm F in 2001.

This retrospective, blind, cross-sectional study comprised bitewing radiographs and examination protocols from 83 adolescents, 18–19 years of age. Proximal surfaces ranging from the mesial surface of the second molar to the distal surface of the first premolar were examined for dental caries and evaluated by one of the authors.

The result show no statistically significant differences between Fellingsbro and Storå for the variable decayed surfaces (DS;  $p = 0.137$ ), but when filled surfaces were added to the variable DS, a statistically significant difference between Fellingsbro and Storå was found ( $p = 0.009$ ). When filled surfaces alone were analysed a statistically significant difference was obtained ( $p = 0.000$ ). There were no statistically significant difference between Fellingsbro and Storå for age ( $p = 0.546$ ) or gender ( $p = 0.805$ ). Approximately 28% of the individuals

were free of caries and/or fillings; 72% had caries and/or fillings. Around 57% of the individuals had 0–4 carious proximal surfaces, and one individual had 17 filled and carious surfaces.

To conclude, a high level of fluorides in the drinking water may result in a lower prevalence of proximal caries. The caries prevalence differed between individuals within these two communities in 2001, and the difference between the two communities is planned to be followed by a new cross-sectional study after 10 years.

Contact E-mail: [lennart.unell@comhem.se](mailto:lennart.unell@comhem.se)

◎ ◎ ◎ 5

**Response rates to postal surveys during 20 years - some notations**

S Ordell, G Ekbäck

Dental Unit, County Council Östergötland, Linköping, Sweden

Aim:

The Swedish Dental Act places a responsibility for planning of dental services on the County Councils. The planning is to be based on the needs of the population and include also the service by the private practitioners. One way to quantify the needs of a population is by asking them in a survey. Critical in any survey is the response rate and this presentation reports those for a series of postal surveys in two Swedish counties, Örebro and Östergötland.

Materials and Methods:

In 1992 the entire cohort born in 1942 ( $n = 8888$ ) in these two counties were addressed and that has been repeated every fifth year. In 2007 and 2012 also the cohort born in 1932 ( $n = 5295$ ), and in 2002 those born in 1952 ( $n = 8881$ ) were added. In 2012 a random sample ( $n = 1249$ ) of those born in 1962 were also addressed. The same basic questionnaire has been used in all waves and for all age groups. Two reminders were sent at each wave and the census was updated before the last reminder. After each wave all respondents were sent a short folder explaining the major finding, but no other incitements were used.

Results:

The response rates have been consistently high for the 1942 cohort at 71.4%, 74.3%, 75.0%, 73.1% and 72.2%

respectively. Also the 1932 cohort has yielded high response rates at 71.9% and 66.4%. The 1952 cohort response rate was 69.6% while the response rate for the 1962 sample in 2012 was 45.5%.

The panel in the 1942 cohort, those who responded to all five waves were 3585, giving a response rate for the panel of 56.5% according to Ekbäck et al. or 45.4% according to Locker et al.

#### Conclusion:

It has been possible to uphold high response rates in a series of surveys running for 20 years. The last wave also included a sample of those born in 1962, which showed a lower response rate. This, however, was in line with other reports on falling response rates in postal questionnaires.

Contact E-mail: sven.ordell@lio.se



### Fracture strength of porcelain fused to metal crowns made of cast, milled or laser-sintered Co-Cr

S Hama Suleiman, P Vult von Steyern

Department of Materials Science and Technology,  
Faculty of Odontology, Malmö University, Malmö,  
Sweden

#### Aim:

The aim was to compare the fracture strength of porcelain fused to metal crowns with copings fabricated in Co-Cr using different manufacturing techniques (casting, milling and laser-sintering) with crowns manufactured in a high-gold alloy.

#### Materials and Methods:

A total of fifty identical crowns were fabricated and subdivided into five groups; cast Co-Cr, milled Co-Cr, 2 groups of laser-sintered Co-Cr and a control group cast in a high-gold alloy. After thermocycling (5,000 cycles, 5 Co - 55 Co) and pre-load (30-300 Newtons, 10,000 cycles) the crowns were loaded until fracture. Load (N) and fracture mode were recorded.

#### Results:

There was a significant difference ( $P < 0.05$ ) in fracture strength between the control group and one of the laser-sintered groups. The mean values (N)

for the groups were as follows: cast Co-Cr,  $1560 \pm 274$ ; milled Co-Cr,  $1643 \pm 153$ ; laser-sintered Co-Cr 1,  $1448 \pm 168$ ; laser-sintered Co-Cr 2,  $1562 \pm 72$ ; control group,  $1725 \pm 220$ .

#### Conclusion:

There is no difference in strength between Co-Cr crowns produced using the different production technologies: casting, milling or laser-sintering. Metal ceramic crowns made with copings fabricated in a high-gold alloy present numerically higher fracture strength than crowns made with copings fabricated in Co-Cr alloys. The difference is confirmed when analyzing the fracture surfaces but the difference in fracture strength value is limited and is only significant with regard to one of the two laser-sintered groups.

Contact E-mail: sozan80@hotmail.se



### A change of clinical endodontic routines, studied with a qualitative approach

M Koch, M Englander, Å Tegelberg, E Wolf  
Faculty of Odontology, Malmö University, Malmö,  
Sweden.

#### Aim:

The aim of this study was to explicate and describe a successful clinical and organizational change in endodontic practice after a comprehensive implementation program, including the integration of nickel-titanium-rotary technique.

#### Materials and Methods:

Following an educational intervention involving all personnel in the Public Dental Service organisation in a Swedish county, thematic in-depth interviews, covering the participants' experience of the successful clinical and organizational change, were performed. For the purpose of this study, eight interviews with four participants (dentist, dental assistant, receptionist, clinical manager), were purposively selected for a qualitative analysis based on phenomenological philosophy.

#### Results:

Four constituents were identified as necessary for the invariant, general structure of the successful

- ▷ clinical and organisational change: 1) a disclosed motivation among the participants 2) an individual learning process 3) a continuous professional collaboration and 4) a facilitating educator.

**Conclusion:**

The successful clinical and organizational change in endodontic practice required a perceived clinical applicability and an atmosphere allowing for discussions and an individual learning process. An educator being trustworthy regarding scientific knowledge and practical skills as well as familiar with the conditions at the dental clinics was necessary. The results indicate a complex relation of aspects of the successful change process.

Contact E-mail: margaretha.koch@dll.se



**Coping to carry one's fate - health promoting coping strategies in reconstructed patients due to cancer treatment complication**

A Wallström, U Hallberg

Department of oral and maxillofacial surgery, Institute of Odontology, The Sahlgrenska Academy, University of Gothenburg, Göteborg, Sweden; Nordic school of Public Health, Göteborg, Sweden

**Aim:**

To increase and gain a deeper knowledge about coping strategies among mandibular reconstruction patients

**Materials and Methods:**

Classical grounded theory was used to analyze 11 open qualitative interviews with osteoradionecrosis patients. Consecutive and theoretical sampling was performed until saturation. This method seeks to predict and explain the studied phenomena.

**Results:**

Interview analysis revealed a core category "coping to carry one's fate". The informants, treated with mandibular reconstruction due to osteoradionecrosis, used four main active coping strategies. They take the chances they can get; start over again taking one day at the time; gain a new perspective on life; and seek support from other people in all available contexts.

**Conclusion:**

Patients with osteoradionecrosis need increased support. To increase quality of life and contribute to empowerment, health care settings should teach such patients these active health promoting coping strategies.

Contact E-mail: aina@wennewall.se



**Effects of the Antimicrobial Peptide LL-37 in Human Osteoblasts**

J Humlén, M Carlsson, D Jönsson

Department of Periodontology, Faculty of Odontology, Malmö University, Malmö, Sweden.

**Aim:**

The antimicrobial peptide LL-37 has been detected in higher levels in gingival crevicular fluid of patients with chronic periodontitis compared to patients with healthy periodontium, however the underlying mechanisms of LL-37 in periodontal disease are unknown. The aim of this study is to investigate the effects of physiological and pathological levels of LL-37 on human osteoblasts.

**Materials and Methods:**

The human osteoblast cell line MG-63 was cultured in a water jacketed incubator with various concentrations (0-8 µM) of LL-37 corresponding to periodontal health and chronic periodontitis. Cell proliferation was assessed by counting cells in a Bürker chamber and cell viability by TrypanBlue staining. Cell apoptosis was assessed by caspase 3 (Casp 3) ELISA and Annexin V flow cytometry. Alkaline phosphatase (ALP) activity was measured using 4-nitrophenyl phosphate. ALP activity and Casp 3 ELISA was normalized to the total amount of protein. Intracellular calcium was measured by Fluo-4 staining and L-channels were blocked using Nifedipine.

**Results:**

LL-37 had no effect on ALP activity. Concentrations of LL-37 corresponding to periodontal disease reduced the number of osteoblasts in a concentration dependent manner; however levels corresponding to periodontal health had no effect. Similarly, the TrypanBlue staining showed more cell death at 8

$\mu$ M of LL-37 than untreated control cells. Our data further showed that LL-37 increased cellular Casp 3 and the number of Annexin V positive cells, indicating cell apoptosis. Interestingly, LL-37 increased the intracellular Ca-concentration, shown by enhanced Fluo4-AM staining, which was Ca-channel independent.

#### Conclusion:

Our data show that LL-37 in periodontitis associated concentrations exhibit pro-apoptotic activity in human osteoblasts. We also show that LL-37 induced apoptosis is Ca-dependent although Ca-channel independent suggesting that LL-37 acts pro-apoptotic via cell membrane perforation.

Contact E-mail: daniel.jonsson@mah.se



### **The beneficial effects of hormone replacement therapy on periodontal disease are vitamin D dependent**

D Jönsson, B-O Nilsson, RT Demmer

Department of Periodontology, Faculty of Odontology, Malmö University, Malmö, Sweden

#### Aim:

Possible synergism between female sex hormones and vitamin D in periodontitis has not been assessed. Here, we investigate effects of estrogen, progesterone and vitamin D on periodontitis in a population-based sample and use cell studies to explore mechanistic explanations of the population-based findings.

#### Materials and Methods:

The epidemiological analysis utilizes cross-sectional data from the continuous NHANES 2001-2004. The cross sections include  $n=1,230$  women aged 40-85 who received a periodontal examination, responded to questions regarding hormone replacement therapy (HRT) and had a record of serum vitamin D levels. For mechanistic cell culture studies, human monocytes were cultured with or without LPS, estradiol, progesterone and/or 1.25-dihydroxyvitamin D<sub>3</sub> and transcriptional activity of IL-6, IL-1 $\beta$ , BLC and RANTES was assessed.

#### Results:

Subjects on HRT had, on average, higher attachment and more teeth than non-HRT users among vitamin D sufficient subjects, but not among vitamin D deficient. Odds ratio for moderate/severe periodontitis among HRT vs. non-HRT users was 0.69 in vitamin D sufficient and 1.19 in vitamin D deficient subjects. LPS-induced IL-6, IL-1 and BLC expression was attenuated in human monocytes treated with estrogen and progesterone and, in fact IL-6 expression was further attenuated when vitamin D was included. LPS-induced IL-6, BLC and RANTES expression was decreased by vitamin D, especially BLC expression was totally reversed by vitamin D.

#### Conclusion:

Maximal beneficial effects of female sex hormones in respect to periodontitis are associated with high vitamin D levels. This effect is plausibly mediated via an anti-inflammatory transcriptional mechanism.

Contact E-mail: daniel.jonsson@mah.se



### **Implant fracture - finite element and SEM analysis of clinical case**

A Zampelis

Department of Periodontology, Specialist Dental Clinic, Karlstad, Sweden

#### Aim:

To evaluate the cause for implant fracture of an implant after 5 years in function

#### Materials and Methods:

The fixture was splinted to two natural teeth which, the the time of fracture, also exhibited caries. A FE model representing the clinical case was constructed. Various loading scenarios were applied to simulate either initial implant fracture or initial caries. The fractured implant was then scanned in SEM.

#### Results:

The FE analysis suggested that a bending/torsion load was probably responsible for the implant fracture, as modeled in the initial caries-bruxism loading scenario. This was validated by the SEM analysis.





▷ Conclusion:

The implant most probably fractured after being subjected to a bending/torsional load induced by carious decay of the natural teeth splinted to the implant. The FE analysis was able to identify the exact point of initiation of the fracture.

Contact E-mail: antonios.zampelis@yahoo.gr



### The benefits of quality assurance in periodontology

M Haag

Centre for clinical research, County of Västmanland, Sweden

Aim:

Individuals referred to the Department of Periodontology in Västerås have been enrolled in an epidemiological program since 2006, in order to follow the outcome of treatment for periodontal and peri-implant disease. Between 2007 and 2010 a radical change in the information provided to patients was made. Here we analyze the effect of the change through a quality assurance plan instituted from the start of the program to measure defined parameters for all patients.

Materials and Methods:

Group I (226 individuals enrolled in 2007) and group II (228 individuals enrolled in 2010) are compared using the following parameters: number of teeth and implants, number of pockets (5-6mm and deeper), bleeding on probing (BOP), plaque index (PLI) and a Swedish national dental insurance index (SNDI) based on clinical data and radiographs where every tooth is assigned a rating between 0-4. On enrolment all patients received information about the importance of one's own participation in the treatment. However, information was more detailed and extensive in group II. Group II but not group I had the same information repeated during follow-up treatment.

Results:

Age, sex, smoking (pack years), systemic diseases, number of healthy individuals and different periodontal diagnoses did not differ between the groups. At the first evaluation point SNDI was higher in group I ( $p < 0.000$ ). However, the number of implants

± teeth was higher ( $p < 0.004$ ) as were the number of pockets 5-6mm ( $p < 0.014$ ) and BOP ( $p < 0.000$ ) in group II.

The number of individuals needing further treatments and evaluations after initial treatment decreased faster in group II ( $p < 0.001$ ).

The therapy code of scaling only or scaling+surgery were compared in all participants. More pockets >6mm ( $p < 0.003$ ) and higher BOP ( $p < 0.005$ ) were found at the first evaluation point, because individuals registered for scaling+surgery had not yet had surgery. However, BOP was higher after 6 months ( $p < 0.021$ ) and 9 months ( $p < 0.009$ ) in the scaling only group.

Conclusion:

Giving more detailed and extensive information resulted in accelerated healing of periodontitis and peri-implantitis. Scaling+surgery was superior to scaling only, for pockets deeper than 6 mm as judged by bleeding index at 6 and 9 months evaluation. Use of a quality assurance program that defined a systematic method for evaluation of treatment outcomes ensured that no data from individuals in the program were lost to analysis. Complete data permits accurate analysis, leading to improved therapy.

Contact E-mail: marghaag@gmail.com



### Antibacterial activities and composition of essential oil of medicinal plants used for oral care in Uganda

F Ocheng

Department of Dental Medicine, Karolinska Institute, Stockholm, Sweden

Aim:

To investigate the antibacterial activities of the essential oils (E.O) from *Cymbopogon citratus* (Poaceae), and *Ocimum gratissimum* (Lamiaceae), on laboratory strains of the bacteria *E.coli* MC400 (gram positive) and *Bacillus megaterium* (gram negative) and the chemical composition

Materials and Methods:

Essential oils from the plants were obtained from fresh leaves using steam distillation process. Antibacterial activity was investigated by exposing *E.coli* (MC400) and *B. megaterium* to pure E.O, 1/10 and

1/100 dilutions of E.O in dimethylsulfoxide (DMSO). The bacteria were incubated at 37 C for 90 minutes in Luria broth in the presence of 1%, 0.1%, 0.01% (v/v) final concentration of E.O and 1% (v/v) DMSO (solvent control). Following incubation, the bacteria were plated on Luria broth agar for determination of live bacteria by counting the number of colony forming units (CFU). The chemical composition was investigated by Gas Chromatography-Mass Spectrometry (GC/MS).

#### Results:

The E.O from *C.citratus* was bactericidal against *B. megaterium* and *E.coli* at 1% and 0.1% final concentration. The E.O from *O.gratissimum* was bactericidal against *B. megaterium* and *E.coli* at 1% final concentration. GC/MS analysis of the oils revealed the major compounds in *C.citratus* as  $\alpha$ -citral (35.7%),  $\beta$ -citral (28.6%), myrcene (10.2%), and the major compounds in *O. gratissimum* as Eugenol (55.4%), Germacrene D (10.6%) and E-Ocimene (7.5%).

#### Conclusion:

The strong antibacterial effect of the oils against *B. megaterium* and *E.coli* indicates a possible effect against oral pathogens. There is therefore a need to test the oil against oral pathogens. The high content of eugenol in *O. gratissimum*, which is a known compound with analgesic and local anesthetic activity, may give credence to the ethno-pharmacological use of the plant in treatment of toothache.

Contact E-mail: francis.ocheng@ki.se



### **A retrospective 4-year follow-up of Activator treatment in general practice**

H Löthgren, S Jacobson, A Fransson

Department of Orthodontics, Postgraduate Dental Education Centre, Örebro, Sweden

#### Aim:

A retrospective long-term follow-up of combined headgear Activator treatment in general practice, to evaluate Class II division I malocclusion treatment success and to assess the need of later treatment with fixed appliance.

#### Materials and Methods:

All combined headgear Activator treatments in Öre-

bro County Council during 2006-2007, initiated by consulting orthodontists, were retrospectively analyzed. Out of 214 patients 24 were excluded due to missing data. Dental records of 190 patients (95 boys, 95 girls; median age 11 yrs; range 8-16) were included. The records contained Angle classification, overjet, overbite, lip incompetence and traumatic overbite and co-operation. The outcome "success" was defined as treatment completion, evaluated by a consulting orthodontist. Later treatment with fixed appliance was registered.

#### Results:

All 190 patients had been diagnosed as Class II division 1 malocclusion, of these patients 127 (67%) also had lip incompetence and/or traumatic overbite before treatment. Treatment completion was recorded for 117 patients (62%) and of these 25 patients (21%) received later fixed appliance. Treatment discontinuation was registered for 73 patients (38%) and with a significant higher proportion (40 patients; 55%;  $P<0.001$ ) of later treatment with fixed appliance. It was a significant higher proportion of co-operating patients that completed the treatment and also did not receive an additional treatment with fixed appliance ( $P<0.001$ ).

#### Conclusion:

Treatment with combined headgear Activator in Class II division I malocclusion can be effective and may reduce the need of additional treatment with fixed appliance. Co-operation is important for the treatment outcome.

Contact E-mail: hanna.lothgren@orebroll.se



### **Pharmacological orthodontic retention - a systematic review**

E DeGeer, J Subraian, S Petrén, M Sonesson  
Department of Orthodontics, Faculty of Odontology, Malmö University, Malmö, Sweden

#### Aim:

The objective of this study was to create a systematic literature review of methods and substances used as "pharmacological retention" following orthodontic treatment as well as to analyze the reported effects of pharmacological retention by topical or systemic administration on orthodontic relapse. ▶

▷ **Materials and Methods:**

The literature was systematically reviewed using PubMed/Medline and Cochrane databases. Two different reviewers independently selected articles based on established inclusion and exclusion criteria. The search strategy identified 22 studies on animals. After inclusion and exclusion procedure seven articles were selected and divided into groups of topical or systemic administration. The substances used in the studies were bisfosfonat, relaxin, simvastatin, anti vascular endothelial growth factor (Anti-VEGF) and bone morphogenic protein (BMP). No studies were on humans.

**Results:**

Local or systemic injection of pharmacological substances as bisfosfonat, relaxin, simvastatin, anti vascular endothelial growth factor (Anti-VEGF) and bone morphogenic protein (BMP) reduces relapse after tooth movement on laboratory animals.

**Conclusion:**

This systematic review suggests that local or systemic injection of pharmacological substances as reduce relapse after tooth movement on laboratory animals. The scientific evidence is limited and additional research is required. Further long-term studies are needed as well as studies on possible systemic effects.

Contact E-mail: Mikael.Sonesson@mah.se



**Evaluation of visual inspection of a soft tissue profile as a diagnostic instrument for skeletal jaw relationships in orthodontics**

J Ausmann, E Claesson, E Lilja-Karlander, L Paulsson-Björnsson

Department of Orthodontics, Faculty of Odontology, Malmö University, Malmö, Sweden

**Aim:**

It is currently not clarified whether a soft tissue profile, without the support of a cephalometric radiograph, can be used to diagnose the skeletal jaw relationships in orthodontics. Previous studies have shown conflicting evidence in this matter. The aim of the study was to evaluate the possibility to diagnose the skeletal jaw relationships and the incisor

inclination by visual inspection of a soft tissue profile and dental casts.

**Materials and Methods:**

The study was approved by the Ethics Committee of the University of Lund, Sweden. Nine patients, six boys and three girls, 12 to 16 years old, who had been orthodontically treated, were selected for the study. The patients and their guardians were provided with oral and written information about the study and signed a consent form. The patient records formed the basis of a protocol that was sent to 217 orthodontists in Sweden. The protocol included facial photographs, photographs of dental casts and panoramic but no cephalometric radiographs. The orthodontists were asked to diagnose the skeletal jaw relationships (sagittal and vertical) and the incisor inclination. They were also asked to assess the frequency of taking a cephalometric radiograph and answer free-writing questions. The answers were collected and analyzed in SPSS.

**Results:**

The preliminary results are based on the analysis of the first incoming answers from 107 out of 217 orthodontists. More than two thirds of the orthodontists assessed that they used a cephalometric radiograph on half of their patients while a third of the orthodontists used a radiograph in almost every case (91-100 %). A skeletal Class II relationship was the easiest sagittal diagnose to detect compared to a skeletal Class III which was the most difficult to detect. Every second orthodontist was able to detect a skeletal Class I. A skeletal open relationship was the easiest vertical diagnose to detect closely followed by a deep skeletal relationship. A skeletal normal vertical relationship was the most difficult to detect. Answers regarding the incisor inclination are in the process of being analyzed.

**Conclusion:**

Sagittal aberrations with a great variation from the normal ANB value were easier to identify than those close to the normal value. The deep and open skeletal vertical relationships were easier to identify than the normal vertical relationship. There seems to be a great interest in the status of the cephalometric radiograph in orthodontic diagnostics and treatment planning.

Contact E-mail: claesson.emma@gmail.com

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**Patient perception and time required when producing digital study models with intraoral scanning technology - a pilot study**

D Konakovic, L Paulsson-Björnsson

Department of Orthodontics, Faculty of Odontology, Malmö University, Malmö, Sweden

**Aim:**

Digital impressions have become a popular option because of its advantages regarding storage, instant retrieval of models and opportunity for simulation of treatment outcome. The purpose of this study was to evaluate patient perception and the clinical time required for conventional impression and intraoral scanning.

**Materials and Methods:**

Twenty consecutive subjects between 22 and 56 years of age (7 men, 13 women) were selected at the Faculty of Odontology, Malmö University, Sweden. The clinical registration included determination of sagittal, vertical and transversal relationships and measuring of overjet and overbite. Conventional impressions and intraoral scanning with the TRIOS® (3Shape, Copenhagen, Denmark) of the entire dentition were performed. The time required was measured in minutes and a questionnaire was used to evaluate patient perception.

**Results:**

Thirteen of the 20 participants preferred the conventional impressions while 7 the intraoral scanning technology. The perception of each method seems to be age-dependent, with younger individuals more positive to the intraoral scanning technology. The mean clinical time required for conventional impressions was 10.4 minutes compared to 17.7 minutes for the intraoral scanning. Gender or kind of malocclusion did not affect patient perception or time spent.

**Conclusion:**

The preliminary results indicates that digital scanning is more time consuming, however, it does not necessarily mean that the cost of the digital procedure will be higher compared to conventional impressions, since the production of conventional study models also requires laboratory costs. In future a cost-effectiveness

analysis will be carried out as well as analysis regarding the validity of using digital models as a diagnostic tool.

Contact E-mail: damir\_k@hotmail.com

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**Orthodontic treatment efficiency with self-ligating and conventional edgewise twin brackets: A prospective randomized clinical trial.**

K Johansson, F Lundström

Department of Orthodontics, Östersund, Sweden;  
Department of Orthodontics and Pediatric Dentistry, Linköping, Sweden

**Aim:**

To conduct a prospective and randomized study of the efficiency of orthodontic treatment with self-ligating edgewise brackets (SL) (Time2 brand, American Orthodontics) and conventional edgewise twin brackets (CE) (Gemini, 3M).

**Materials and Methods:**

One-hundred consecutive patients were randomized to treatment with either SL or CE brackets. After drop outs, the analyzed material consisted of 44 patients treated with SL (mean age 15.3 years, mean ICON 60.7, 70.4% female) and 46 patients treated with CE (mean age 15.0 years, mean ICON 56.5, 71.7% female). The participants were treated by 3 specialists in orthodontics and after continuous instructions alternately by 5 orthodontic assistants according to our normal treatment routine i.e. modified 0.022" MBT preadjusted edgewise technique. Treatment duration, total number of appointments including emergencies, extractions and number of archwires were noted. Study casts were taken before and after active treatment to assess ICON scores, overjet and relative space.

**Results:**

There were no statistically significant difference between the SL and CE groups in terms of mean treatment time in months (20.4 vs.18.2), mean number of visits (15.5 vs.14.1), mean ICON scores after treatment (13.2 vs. 11.9) or mean ICON improvement grade (7.9 vs. 9.1).

**Conclusion:**

Orthodontic treatment with self-ligating (SL) ▷

▷brackets does not reduce treatment time or number of appointments, and does not affect post treatment ICON scores or ICON improvement grade compared with conventional (CE) brackets.

Contact E-mail: kristina.b.johansson@jll.se

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### **The prevalence of dental erosion in a cohort of fifteen and seventeen year-olds in Stockholm**

M Skalsky Jarkander, K Carlstedt, M Grindefjord

Department of Paediatric Dentistry, Eastman Institute, Folk tandvården Stockholms län AB, Sweden

#### **Aim:**

The main objectives of the present study was to investigate the prevalence and severity of dental erosion in a group of adolescents in Stockholm, and also the correlation to certain habits and lifestyle factors. Another aim is to find out if tooth erosion is more common in seventeen than in fifteen year-olds and if there is a socio-economic influence.

#### **Material and Methods:**

A total of 1200 adolescents, two hundred aged fifteen and two hundred seventeen years, from three dental clinics at the Public Dental Health Service in Stockholm, living in areas with different socio-economic status, were invited to participate. The baseline examination was performed of a dentist or a dental hygienist assessing the presence of tooth erosion. "Marker teeth" of dental erosion were photographed and a questionnaire of each individual's tooth sensitivity, lifestyle factors as food, drinking and oral hygiene habits, in addition to the clinical examination, was performed.

Examination of the photographs recording presence and severity of tooth erosion and analysis of collected data of the patients is ongoing at the department of paediatric dentistry at the Eastman institute, Stockholm. During 2013 a re-examination of a cohort is planned to get a longitudinal follow-up of dental erosion in this group of adolescents.

#### **Results:**

Primary results show a prevalence of dental erosion that varies between 21-44 % with a trend towards higher prevalence in seventeen than in fifteen year-olds. A correlation between dental erosion and soft

drink consumption was established. Further, tooth erosion was more frequently observed in adolescents with acid eructation or reflux.

#### **Conclusion:**

Dental erosion seems to be common in many adolescents in Stockholm making it important for the clinician to be alert and able to diagnose tooth erosion in order to find out the causative factors and to start preventive strategies.

Contact E-mail: Maria.Skalsky-Jarkander@ftv.sll.se

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### **Oral health-related quality of life in children before and after dental treatment under general anesthesia.**

K Ridell<sup>1</sup>, M Borgström<sup>2</sup>, S Brogårdh-Roth<sup>1</sup>, E Lager<sup>2</sup>, G Magnusson<sup>2</sup>

<sup>1</sup>Dep of Pediatric Dentistry, Faculty of Odontology, Malmö University, Malmö, Sweden

<sup>2</sup>Specialist clinics in pediatric dentistry, Region Skåne, Sweden

#### **Aim:**

To determine whether or not dental treatment under general anesthesia (GA) improved the oral health-related quality of life (OHRQoL) in children treated for severe caries or mineralization disturbances (MIH) and to investigate the impact on family life. The hypothesis was that OHRQoL, as measured by P-CPQ and FIS scores (Parental Child perception Questionnaire, Family Impact Scale), is improved in children and families after dental treatment under general anesthesia.

#### **Material and Method:**

All children and adolescents aged 3-14 years old who were treated under GA from September 2010 to June 2011 due to caries or MIH were included. Before the treatment the parents and children were asked to participate in the study. A questionnaire was filled in before the GA and 2-3 months after. The questionnaire composed of 49 questions, which combined P-CPQ and FIS components of the Child OHQOL. The questions concerned the domains Oral symptoms, Functional limitations, Emotional well-being, Social well-being and Family Impact. Information

on age, gender, health/medication, caries data and treatment was collected from the dental records.

#### Results:

Of the 99 individuals in group A (3-6 years old) invited to the study, 88 agreed to participate. Based on a predetermined number of missing/don't know answers seven individuals were excluded and finally, 75 individuals were in analysis. The corresponding numbers in Group B (7-14 years) was 74/61/57.

There was a significant difference in mean Overall P-CPQ scores before and after treatment in both groups (Group A: 19,9 (SD 16,5)-9,5 (SD 9,7), (Group B: 21,1 (SD 17,5)11,6 (SD 14,3). The differences were statistically significant in all domains except in Group A, Social well-being.

#### Conclusions:

According to the parents the children's OHRQoL improved significantly after treatment under GA.

Contact E-mail: karin.ridell@mah.se



### **RCT of prosthetic therapy in young patients with Amelogenesis imperfecta - one year results**

G Pousette Lundgren, M Trulsson, G Dahllöf  
Department of Dental Medicine, Division of Paediatric Dentistry, Karolinska Institute, Stockholm, Sweden.

#### Aim:

Compare treatment outcome in patients with AI treated with ceramic crowns of IPS E-max compared to Procera with Zirconia inner cupping.

#### Materials and Methods:

Prosthetic crown therapy was performed in 21 patients with AI aged 13-22 years. The number of crowns in different patients varies between 1 and 17. After random selection 160 porcelain crowns Procera with Zirconia inner copings (77) or IPS E-max (83), was made both cemented with RelyX ARC cement. Split mouth method was used in lateral segments and the same type of crowns was made in front segments in each jaw. AI type was recorded to hypoplastic type (119) or hypomineralized/hypomatured type (41). Follow-up clinical and radiographic examinations were made one year after cementation by a blinded external examiner.

#### Results:

151 of 160 crowns were recorded with excellent quality, 8 with acceptable quality and 1 with non-acceptable quality. 39 of 41 crowns in the hypomineralized/hypomatured group and 117 of 119 in the hypoplastic group were diagnosed with excellent quality (a non-significant difference). None of the teeth in the hypomineralized group showed complications, while in the hypoplastic group two teeth were diagnosed with periapical periodontitis, one with chipping of porcelain and one crown with deficient marginal integrity. The two cases of apical periodontitis affected patients aged 18 and 19 when cementation was performed. One case with a traumatic injury and one with extensive caries prior to the prosthetic therapy.

#### Conclusion:

There are few complications one year after crown therapy in young patients with AI. No differences were found between the two types of AI or between the two types of crowns.

Contact E-mail: gunilla.pousette-lundgren@ltdalarna.se



### **Child abuse and health problems - associations with self-perceived oral health**

T Kvist, E-M Annerbäck, L Sahlqvist, O Flodmark, G Dahllöf

Department of Paediatric Dentistry, Karolinska Institute, Stockholm, Sweden,

#### Aim:

To study self-perceived oral health (SPOH) in adolescents with regard to health problems, risk-taking behaviors and experience of abuse, to investigate if SPOH can be assessed as a measure to recognize abuse in a dental setting.

#### Materials and Methods:

All grade-9 compulsory school and second-year high school pupils in Södermanland County, Sweden, (n = 7,262) were invited to participate in a population-based survey; 5940 (82%) adolescents responded. Survey items on health, behaviors, exposure to different types of abuse and SPOH were collected. Data was analyzed with Fisher's exact test and multivariate logistic regression analyses.

▷ Results:

Poor self-perceived oral health was associated with health problems and risk-taking behaviors such as use of tobacco and drugs, violent behavior and exhibiting sexual risk (adjusted odds ratio [aOR] 1.9–7.6). Poor SPOH was strongly associated with self reported experience of physical abuse, intimate partner violence, bullying and to have been forced to sex (aOR 2.3–14.7). The likelihood of poor SPOH increased from aOR = 2.1 for a single incident of abuse to aOR = 23.3 for multiple abuses.

Conclusion:

The strong associations of poor SPOH with health problems, risk-taking behaviors and exposure to abuse indicate that dental professionals can have an important role in recognizing child abuse.

Contact E-mail: [therese.kvist@ki.se](mailto:therese.kvist@ki.se)



**Swedish and French children with special needs in oral health - an ICF-CY study**

J Norderyd, D Faulks

The Institute for Postgraduate Dental Education, Jönköping, Sweden

Aim:

Child specialist dental care varies and comparisons are difficult. WHO's International Classification of Functioning, Disability and Health - Child and Youth version (ICF-CY) provides a common language within the biopsychosocial model, but has not been widely used in dentistry. The aim was to compare ICF-CY data between two specialist dental centres in France and Sweden respectively.

Materials and Methods:

A developed ICF-CY checklist for oral health was used and data concerning 82 French and 56 Swedish patients 0-16 years of age with special dental needs was collected and analysed.

Results:

All children at the Swedish and the majority of the children at the French centre had a significant medical diagnosis and at both centres over 50% reported impairment in the ICF-CY domain body function regarding 'mental functions'. More children in the

French group had caries while the Swedish group showed more disorders of tooth development/eruption and malocclusions. At both centres a majority had restriction in the Activities and Participation domain items 'Acquiring skills', 'Carrying out daily routine', and 'Handling stress', but with significantly more children in the Swedish group. In the Environment domain statistically more Swedish children noted 'social norms' whereof 80% reported it as a facilitating factor, while 'Individual attitudes of health-related professionals' and 'Other professionals' was reported by more French children and most of them regarded both items as facilitators.

Conclusion:

Despite great differences between the Swedish and the French health care systems, and despite a heterogeneous patient population in terms of medical diagnoses, the similarities between patients outweighed the differences in terms of function, activities and participation.

Contact E-mail: [johanna.norderyd@lj.se](mailto:johanna.norderyd@lj.se)



**A 2 year retrospective evaluation of titanium and cobalt-chromium metal-ceramic fixed partial dentures**

J Drazic, M Drazic

Faculty of Odontology, Malmö University, Malmö, Sweden

Aim:

The aim of this retrospective study was to evaluate the clinical performance of titanium (Ti) metal-ceramic and cobalt-chromium (Co-Cr) metal-ceramic fixed partial dentures (FPDs) with a follow up period of 2 years.

Materials and Methods:

In 2012, 48 patients treated with FPDs during 2007-2010 at the Department of Prosthetic Dentistry at the Faculty of Odontology, Malmö University, Sweden, were contacted after auditing dental technician bills. Twenty-one patients with a mean age of 59.2 years with 25 FPDs (13 Ti and 12 Co-Cr FPDs) agreed to participate in the study (10 men and 11 women). Evaluation of the metal-ceramic FPDs was made by two independent examiners, using a modified version of

the California Dental Association (CDA) criteria. Success and survival rates were assessed. Statistical analysis was performed using Fisher's exact test for differences between groups and for inter-examiner reliability the kappa value was calculated.

#### Results:

The two groups did not differ significantly concerning the CDA evaluation. Seven out of 13 FPDs in the Ti group were evaluated as acceptable while there were 8 out of 12 in the Co-Cr group. Six Ti and 3 Co-Cr FPDs were evaluated as correct/replace. The survival rate for the Ti FPDs was 81,3 % and for the Co-Cr FPDs 92,3 %. One Co-Cr FPD showed a deep carious lesion contiguous with the margin of the restoration in one of the supporting teeth. Three Ti FPDs showed chip-off fractures while two were recorded in the Co-Cr group. The kappa value was 0,271.

#### Conclusion:

The use of base-metal alloys for metal-ceramic reconstructions has increased worldwide due to the increasing prices of high-noble alloys, and as a result the clinician is often faced with the choice between titanium and cobalt-chromium for metal-ceramic restorations. Within the limitations of this study the clinical performance of the fixed partial dentures was high in both groups.

Contact E-mail: jovan\_d01@hotmail.com



### **Incidence of first implant failure in relation to implant surface - a preliminary report on early failure**

M Olsson, V Stenport, T Jemt

The Brånemark Clinic, Public Dental Health Care Västra Götaland and Department of Prosthodontics and Material Science, Institute of Odontology, The Sahlgrenska Academy, University of Gothenburg, Göteborg, Sweden

#### Aim:

Background: Originally, the turned surface implant was the standard protocol of implant treatment. Surface alterations have improved the early results, when shifting from turned to medium rough implant surface. Although successful, still a few per cent

of all implants fail to integrate, or are found loose after short period of loading.

Aim: To study the incidence rate of early implant failure with respect to the first failure per jaw/patient, and to relate implant surface to these failures in a large population of totally and partially edentulous jaws.

#### Materials and Methods:

Data on jaws/patients treated with oral implants at the Brånemark Clinic, Gothenburg, Sweden, was compiled from 1986 to 2010. Information was collected regarding number of treated jaws and implants with either turned or medium rough surface. All implants had been inserted according to the manufacturer and the clinic's standard protocol. Furthermore, information was collected regarding implant failures up to the first annual examination. First recorded failure per patient was analysed with respect to implant surface and year of insertion. The local EPN approved the ethical application.

#### Results:

Between 1986 and 2010, a total of 35 444 implants were inserted in 8 793 jaws at the Brånemark Clinic. Altogether 5 668 and 3 125 jaws were treated with turned or medium rough implant surfaces during the inclusion period, respectively. A majority of treated jaws (98.6%) were provided with Brånemark System (Nobel Biocare AB) implants with turned or TiUnite® surfaces. The mean incidence rate of early first implant failure during the years 1986-2002 was 8.95% and 1.84% in the maxilla and mandible, respectively. The corresponding mean incidence rate during 2003-2010 was 2.65% and 1.53% for the maxilla and mandible, respectively. The preliminary number of patients identified with implant failure was 743. The incidence rate of early first implant failure per patient during 1986-2002 was higher compared to 2003-2010. Early first implant failure rate was higher in the maxilla than in the mandible, however, the tendency was more pronounced 1986-2002. A decrease in the incidence rate of early failures was observed at the time of transition from turned to TiUnite surfaces.

#### Conclusion:

The results of the present study demonstrated a decrease of early implant failure for TiUnite-implants compared to turned implants. These large-scale results confirm results from previous small-scale studies.

Contact E-mail: malin.olsson@odontologi.gu.se



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**Contact allergies to potential allergens in patients with oral lichen lesions**

C Ahlgren, M Bruze, H Möller, M Isaksson, R Liedholm, T Axéll

Department of Prosthetic Dentistry, Faculty of Odontology, Malmö University, Malmö, Sweden

**Aim:**

The aim of the present controlled study was to investigate a possible relationship between contact allergies to potential allergens, used in dentistry or locally in the oral cavity, and oral lichen lesions.

**Materials and Methods:**

Eighty-three patients with oral lichen lesions (OLL) and control groups of age and gender-matched dermatitis patients (DP, n=83) and patch-tested dermatitis patients randomly selected from files (PSFF, n=319), were included in the study. OLL and DP groups were examined intraorally. OLL patients were tested with the newly developed lichen series containing 66 substances, and control patients were patch-tested with a supplemented European baseline series and depending on reasons for referral with other substances. In addition the dermatitis patients (DP) were tested with 34 of the 66 substances in the lichen series.

**Results:**

The frequencies of contact allergy to mercury and carvone were statistically higher in the OLL group than in the DP group. Surfaces of amalgam and composite restorations were statistically more frequent in the OLL group compared to the DP group. Contact allergy to nickel and colophony, the latter with a statistically significant difference, was more common in the DP group. The numerical difference found for nickel allergy was however not significant comparing OLL and PSFF groups.

**Conclusion:**

Contact allergy to mercury was overrepresented in patients with OLL and has been reported in previous studies, but the present finding of an overrepresentation of contact allergy to carvone (a constituent of spearmint oil) in patients with oral lichen lesions has not been reported previously. Carvone, in addition to mercury and gold as previously suggested, can be one of the maintenance or causative factors

for oral lichen lesions. Patients with oral lichen lesions and hypersensitivity to carvone should therefore avoid carvone-containing products for oral use.

Contact E-mail: camilla.ahlgren@mah.se

◎ ◎ ◎ 27

**Gold in oral mucosa in patients with oral lichen lesions**

A Mörée, C Ahlgren

Department of Prosthetic Dentistry, Faculty of Odontology, Malmö University, Malmö, Sweden

**Aim:**

The aim of this controlled study was to evaluate the presence of gold and mercury in oral mucosa in patients with oral lichen lesions.

**Materials and Methods:**

Seventy-two patients with oral lichen lesions were biopsied. Two biopsies were taken from each patient, one from the oral lichen lesion and one from the healthy oral mucosa. In the control group of 14 dermatitis patients, biopsies were taken from healthy oral mucosa. Two sections of each biopsy were prepared. Sections with autometallographic silver amplification revealed presence of gold and mercury, and sections in addition exposed to ultraviolet light revealed only mercury. The sections were analysed and compared in light microscope to evaluate the amount of gold and mercury.

**Results:**

Gold in oral mucosa was found both in patients with oral lichen lesions (33/72, 46%), and controls (6/14, 43%). Oral lichen lesions and healthy oral mucosa did not differ significantly regarding the presence of gold and mercury. In patients with 11-50 surfaces of dental gold and oral lichen lesions, oral mucosal gold was found more frequently than in control patients (p=0.039; Fisher's exact test).

**Conclusion:**

Although gold and mercury can be detected in both clinically healthy oral mucosa and in areas with oral lichen lesions, surfaces of dental gold restorations seem to be of importance for the pre-

sence of gold in oral mucosa in patients with oral lichen lesions.

Contact E-mail: camilla.ahlgren@mah.se

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### **Self-reported bruxism is associated with incidence of frequent headaches**

S Marklund, B Häggman-Henrikson, A Wänman

Department of Odontology, Clinical Oral Physiology, Faculty of Medicine, Umeå University, Umeå, Sweden

#### **Aim:**

A relationship between bruxism and tension-type headaches has been found in several cross-sectional studies but these study designs cannot show cause and effect. Pain in one region seems to predict the onset of pain in other regions, but otherwise the knowledge of possible risk factors to incidence of frequent headaches is limited. Prospective, observational studies can contribute to the understanding of cause and effect and provide a basis for preventive measures. The aim of this study was to test the hypothesis if self-reported bruxism (tooth grinding/clenching), local biomechanical factors in the dental occlusion, and female gender predicted the onset of headaches and if these factors also predicted persistence of headaches during a 2-year observation period.

#### **Materials and Methods:**

The study population comprised 280 dental students (98 men, 182 women) at Umeå University, Sweden, examined annually at 1-year intervals (baseline, after 1 year, and after 2 years). Before the clinical examinations, everyone filled out a questionnaire including presence and frequency of headaches (temples and/or forehead), and self-reported bruxism. After the 2-year period all subjects were dichotomized into cases with frequent (once a week or more) or controls with non-frequent symptoms. The 2-year cumulative incidence was based on subjects without reported headaches at baseline. Those who reported frequent headaches at all three examinations were considered having persistent headaches. The clinical examination included registration of signs of temporomandibular disorders, and morphological and functional occlusion. Mandibular stability

in intercuspal position (ICP) was registered if the molar teeth could keep a firm grip on an occlusal foil during moderate clenching. The two examiners were always blinded from the questionnaires. Self-reported bruxism and clinical registrations of local biomechanical factors in the dental occlusion at baseline were used as independent variables in logistic regression analyses.

#### **Results:**

The 2-year cumulative incidence of frequent headaches was 21%. Incidence of frequent headaches was associated with female gender OR 2.6 (95% CI 1.3-5.4), self-reported bruxism, OR 2.3 (95% CI 1.2-4.4), and mandibular instability in ICP, OR 3.2 (95% CI 1.4-7.5). Approximately 4% reported persistent headaches throughout the 2-year period. Persistent headaches were associated with mandibular instability in ICP, OR 6.1 (95% CI 1.6-22.6).

#### **Conclusion:**

The study shows that those with reported bruxism and unstable occlusion have an increased risk of developing frequent headaches. Mandibular instability emerged as a significant factor in persistent headaches, which warrants further studies. In management of frequent headaches a dental assessment may be beneficial.

Contact E-mail: susanna.marklund@vll.se

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### **Prevalence of pain and dysfunction in the temporomandibular region.**

A Lövgren, S Marklund, B Häggman-Henrikson, A Wänman

Department of Odontology, Clinical Oral Physiology, Faculty of Medicine, Umeå University, Umeå, Sweden

#### **Aim:**

Treatment need owing to symptoms of temporomandibular disorders (TMD) is not met in dentistry despite that these symptoms has a negative affect on daily life. One hypothesis is that dentists do not pay attention to TMD symptoms at regular dental check-ups. Mandatory questions included in the health declaration might increase the dental profession's awareness of these patients. The aim of

▷ this study was to analyse the prevalence of frequent pain and dysfunction in the jaw-face-temple region in relation to sex and age. A further aim was to analyse the relationship between affirmative answers to questions related to pain and dysfunction.

#### Materials and Methods:

Three mandatory questions (3Q/TMD) were included in the health declaration of the digital record system in the Public Dental Health care in the county of Västerbotten, Sweden. The three questions were; Q1 = Do you have pain in your temple, face, jaw or jaw joint once a week or more? Q2 = Does it hurt once a week or more when you open your mouth or chew? Q3 = Does your jaw lock or become stuck once a week or more

#### Results:

Over a 12-month period, 74 576 patients (mean age 34 years, SD 22.8) answered the health declaration and underwent a routine dental examination. The prevalence of frequent pain in the temple, face, jaw or jaw joint (Q1) was 5.1 % among women and 1.7 % among men ( $P < 0.0001$ ). The prevalence of frequent pain on jaw movement (Q2) was 2.5 % among women and 0.9 % among men ( $P < 0.0001$ ). The prevalence of frequent locking of the jaw (Q3) was 2.8 % among women and 1.3 % among men ( $P < 0.0001$ ). The reported symptoms increased during adolescence, peaked among women in the 40 to 49 years of age period and then gradually diminished. In a working age (20 to 69 years olds) subsample, 3 004 out of 42 203 individuals responded affirmatively to one or more of the three questions. Of these, 69% gave positive answer to one, 19% to two, and 10% to all three questions.

#### Conclusion:

Frequent symptoms of pain and dysfunction in the jaw-face-temple region, increase during adolescence, peak among women in their middle ages and then gradually diminish. The prevalence of these symptoms is significantly higher among women than among men.

Contact E-mail: anlao058@student.umu.se



### Assessment of proprioceptive allodynia after intense experimental chewing

I Domi, Neziri, T List1, A Dawson1

Department of Stomatognathic Physiology, Malmö University, Malmö, Sweden

#### Aims:

To evaluate if intense chewing leads to proprioceptive allodynia in the masseter muscle, and test if (1) pain and fatigue are increased after intense chewing, (2) pressure pain thresholds are decreased after intense chewing, (3) vibration thresholds are increased after intense chewing, (5) intense vibrations exacerbate pain after intense chewing.

#### Materials and Methods:

16 healthy female volunteers (mean age  $25.8 \pm 5$  years) participated in two 60-minute sessions, each with 24-hour follow-ups. In the first session, the subjects were instructed to chew on a viscous chewing gum (Masticha Chios). In the other session the participant were assigned a control task where no chewing was performed. Perceived intensity of vibration and perceived discomfort were assessed with a Vibrometer® on a 0-50-100 visual analog scale (VAS). Two 0-100 mm visual analog scales measured pain intensity and perceived fatigue. The pain threshold was measured with an electronic algometer. These variables were measured to assess delayed onset muscle soreness. All measurements were made on the masseter muscles. Two-way analysis of variance for repeated measures and Dunnett's post hoc test was used to test for significant alterations in the outcome variables.

#### Results:

Significant differences were observed between chewing and no-activity for vibration threshold ( $P < 0.001$ ); perceived fatigue ( $P < 0.001$ ); pain threshold ( $P < 0.01$ ) and vibration discomfort ( $P < 0.05$ ). No significant differences were seen for perceived pain and perceived intensity of vibration. A significant increase over time could only be observed for vibration threshold ( $P < 0.01$ ) and perceived fatigue ( $P < 0.05$ ).

#### Conclusion:

Our findings suggest that there is no relation bet-

ween intense chewing and delayed onset muscle soreness in the masseter muscles. Intense chewing evoked moderate levels of fatigue and discomfort, and a hypoalgesia to mechanical stimulation, and reduced vibrotactile sensitivity.

Contact E-mail: andreas.dawson@mah.se

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### **Pain and intramuscular release of algescic substances in the masseter muscle after experimental tooth clenching exercises healthy subjects**

A Dawson<sup>1</sup>, B Ghafouri<sup>2,3</sup>, B Gerdle<sup>2,4</sup>, B Larsson<sup>2,4</sup>, T List<sup>1</sup>, P Svensson<sup>5,6</sup>, M Ernberg<sup>7</sup>

<sup>1</sup>Department of Stomatognathic Physiology, Faculty of Odontology, Malmö University, Malmö, Sweden

<sup>2</sup>Department of Clinical and Experimental Medicine, Faculty of Health Sciences, Linköping University, Sweden

<sup>3</sup>Pain and Rehabilitation Centre, County Council of Östergötland, Linköping, Sweden

<sup>4</sup>Occupational and Environmental Medicine, County Council of Östergötland, Linköping, Sweden

<sup>5</sup>Department of Clinical Oral Physiology, School of Dentistry, Aarhus University, Aarhus, Denmark

<sup>6</sup>Center for Functionally Integrative Neuroscience (CFIN), MindLab, Aarhus University Hospital, Denmark

<sup>7</sup>Department of Clinical Oral Physiology, Karolinska Institutet, Department of Dental Medicine, Huddinge, Sweden

#### **Background:**

Tooth clenching is a risk factor for chronic orofacial muscle pain (M-TMD). Previous work have shown that masseter levels of 5-HT and glutamate are increased in M-TMD patients. This study investigated the hypothesis that experimental tooth clenching increases the release of algescic substances in the masseter muscle. **Methods:** 30 healthy subjects (16 females, 14 males) participated. During two sessions, separated by at least one wk, intramuscular microdialysis was performed to collect masseter muscle 5-HT, glutamate, pyruvate, and lactate. Two hours after the start of microdialysis the participants were randomized either to a 20-min repetitive experimental tooth clenching task (50% of maximal voluntary contraction) or con-

trol (no clenching). Pain and fatigue were measured throughout the experiment.

#### **Results:**

No alterations were observed for 5-HT, glutamate, pyruvate and lactate over time in the clenching or control session, or between-sessions at various time points. The levels of pyruvate increased significantly over time in the clenching session for females, with significantly higher levels after the clenching task and after recovery compared to baseline ( $P$ 's < .05). Pain ( $P$  < .01) and fatigue ( $P$  < .01) increased significantly over time in the clenching session, and were significantly higher after clenching than control ( $P$ 's < .01).

#### **Conclusions:**

Low levels of pain and fatigue were developed after experimental tooth clenching. The increased levels of pyruvate suggest that tooth clenching could be associated with a reduced tissue oxygenation. Further research is required to elucidate the role of algescic substances in the pathogenesis of M-TMD.

Contact E-mail: andreas.dawson@mah.se

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### **Development of a quality assessment tool for experimental bruxism studies: reliability and validity**

A Dawson<sup>1</sup>, K G Raphael<sup>2</sup>, A Glaros<sup>3</sup>, S Axelsson<sup>4</sup>, T Arima<sup>5</sup>, M Ernberg<sup>6</sup>, M Farella<sup>7</sup>, F Lobbezoo<sup>8</sup>, D Manfredini<sup>9</sup>, A Michelotti<sup>10</sup>, P Svensson<sup>11</sup>, T List<sup>2</sup>

<sup>1</sup>Department of Stomatognathic Physiology, Malmö University, Malmö, Sweden

<sup>2</sup>Oral and Maxillofacial Pathology, Radiology and Medicine, College of Dentistry, New York University, New York, USA

<sup>3</sup>Kansas City University of Medicine and Biosciences, Kansas City, MO USA

<sup>4</sup>Swedish Council on Health Technology Assessment, Stockholm, Sweden

<sup>5</sup>Department of Oral Rehabilitation, Graduate School of Dental Medicine, University of Hokkaido, Sapporo, Japan

<sup>6</sup>Section of Orofacial Pain and Jaw Function, Department of Dental Medicine, Karolinska Institutet, Huddinge, Sweden

- ▷<sup>7</sup>Department of Oral Sciences, Faculty of Dentistry, University of Otago, Dunedin, New Zealand
- <sup>8</sup>Department of Oral Kinesiology, Academic Centre for Dentistry Amsterdam (ACTA), University of Amsterdam and VU University Amsterdam, MOVE Research Institute Amsterdam, Amsterdam, The Netherlands
- <sup>9</sup>TMD-Clinic, Department of Maxillofacial Surgery, University of Padova, Italy
- <sup>10</sup>Section of Orthodontics and Clinical Gnathology, School of Dentistry, Oral, Dental and Maxillo-Facial Sciences, University of Naples “Federico II”, Naples, Italy
- <sup>11</sup>Section of Clinical Oral Physiology, Department of Dentistry, Aarhus University, Aarhus, Denmark and MINDLab, Center of Functionally Integrative Neuroscience, Aarhus University Hospital, Aarhus, Denmark
- <sup>12</sup>Department of Stomatognathic Physiology, Malmö University, Malmö, Sweden

#### Objectives:

Human experimental pain models have improved our understanding of how muscle activity like tooth clenching and grinding (bruxism) affect jaw muscle pain. The large variation in the quality of reported study design and methodology of experimental bruxism studies makes findings from a literature review difficult to compare. Currently, systematically developed and evaluated tools for assessing experimental bruxism are lacking. This study combined empirical evidence and expert opinion in a formal consensus method to develop a quality assessment tool for experimental bruxism studies in systematic reviews.

#### Methods:

Tool development comprised 5 steps: (i) preliminary decisions, (ii) item generation, (iii) face-validity assessment, (iv) reliability and construct validity assessments, and (v) instrument refinement.

#### Results:

Following preliminary decisions and a literature review, a list of 52 items to be considered for inclusion in the tool was compiled. Eleven experts were invited to join a Delphi panel and 10 accepted. Four Delphi rounds reduced the preliminary tool—Quality Assessment Tool for Experimental Bruxism Studies (Qu ATEBS)—to 8 items: study aim, study sample, control condition or group, study design, experimental bruxism task, statistics, interpretation of results, and conflict of interest statement. Consensus among the Delphi panelists yielded good face validity.

Inter-observer reliability was acceptable ( $k = 0.77$ ). Discriminative validity was excellent (phi coefficient 1.0;  $P < .01$ ). During refinement, 1 item (no. 8) was removed.

#### Conclusion:

Qu-ATEBS, the 7-item evidence-based quality assessment tool developed here for use in systematic reviews of experimental bruxism studies, exhibits face validity, excellent discriminative validity, and acceptable inter-observer reliability. Development of quality assessment tools for many other topics in the orofacial pain literature is needed and may follow the described procedure.

Contact E-mail: andreas.dawson@mah.se



### Experimental masseter muscle pain alters jaw-neck motor strategy

B Wiesinger<sup>1,2</sup>, B Häggman-Henrikson<sup>1</sup>, F Hellström<sup>3</sup>, A Wänman<sup>1</sup>

<sup>1</sup>Department Odontology, Clinical Oral Physiology, Umeå University, Umeå, Sweden; <sup>2</sup>Dept Research and Development, Västernorrland County Council, Sweden; <sup>3</sup>Centre for Musculoskeletal Research, University of Gävle, Umeå, Sweden

#### Aim:

A functional integration between the trigeminal and cranio-cervical sensory-motor systems has been suggested, with simultaneous jaw and head-neck movements during jaw opening-closing tasks. Experimental pain mostly results in inhibited activation of the painful muscle, and a reorganization of load sharing between agonists, antagonists, and synergists has been suggested. The effect of experimental muscle pain on the jaw-neck sensory-motor system and the integrated jaw-neck movements has not been investigated.

The aim of this study was to investigate the effect of induced masseter muscle pain on integrated jaw-neck movements during a continuous jaw opening-closing task.

#### Materials and Methods:

Sixteen healthy men performed continuous jaw

opening-closing movements to a target position, defined as 75% of the maximum jaw opening. Each subject performed two trials without pain (control) and two trials with masseter muscle pain, induced unilaterally with hypertonic saline injection. Simultaneous movements of the mandible and the head were registered with a wireless 3-D optoelectronic recording system. Data from the two control trials and the two pain induction trials were pooled respectively. Differences in movement amplitudes between control and pain trials were analyzed with Wilcoxon matched pairs test.

#### Results:

The head movement amplitudes were significantly larger during induced pain ( $P = 0.008$ ) compared to control. The ratio between head and jaw movement amplitudes was higher in trials with induced pain, compared to control ( $P = 0.006$ ). The jaw movement amplitudes did not differ between control and induced pain trials ( $P = 0.079$ ).

#### Conclusion:

Experimental masseter muscle pain affects the integrated jaw-neck movements, by increasing the neck component during continuous jaw opening-closing tasks. The findings indicate that pain alters the strategy for jaw-neck motor control. This altered strategy may have consequences for development of musculoskeletal pain in the jaw and neck regions.

Contact E-mail: birgitta.h@wiesinger.se

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### **Achieved competences in temporomandibular disorders/Orofacial pain**

S Dahl, EC Ekberg

Department of Stomatognathic Physiology, Faculty of Odontology, Malmö University, Malmö, Sweden.

#### Aim:

Temporomandibular disorders (TMD) and orofacial pain (OP) are two common problems in public health. In the undergraduate dental education at Malmö University, TMD/OP has received increased attention by incorporating new learning approaches regarding pain and dysfunction. The aims of this study were to assess the achieved competences in

TMD/OP together with the perceived satisfaction of TMD/OP education.

#### Materials and Methods:

Dental students responded to a self-report questionnaire regarding their competences in TMD/OP with the main focus on anatomy and physiology, screening and clinical training. This study was a longitudinal follow-up, where the same students responded to the questionnaire at four different times during their education at the department of Stomatognathic Physiology at Malmö University. The first occasion was at the start of the seventh semester, then after the preclinical course, after the final exam at seventh semester, and finally after the clinical course at eighth semester. Competences and satisfaction were estimated using a numeric scale ranging from 0 (none/not satisfied) to 10 (very high/very satisfied). In addition, the students got to choose two out of ten adjectives, which they thought best described their idea of treating patients with pain.

#### Results:

The mean value of responding dental students was 48, and their mean age was 24.5 ( $\pm$ SD 2.4) years. At start the students rated education and competences as low regarding pain (NRS 4.5/5.2), most of the clinical competences (NRS 2.4–4.3) and some of the clinical training (NRS 1.5–5.7). After the clinical course the competences and satisfaction with the education had increased (NRS 8.4–9.3). Occlusal appliances, prognosis and clinical decision making had the highest rating increase between start of the seventh semester and after the clinical course. Occlusal adjustment, pain school and pharmacotherapy showed the lowest rating (NRS 6.3–6.8) among all variables after the clinical course. The students' opinion about treating patients with orofacial pain was described as challenging, interesting and valuable after the clinical course.

#### Conclusion:

In general, the achieved competences, as well as the satisfaction with the education in TMD/OP, increased with the level of education. This was most evident for topics concerning the clinical setting.

Contact E-mail: sara.dahl@mah.se

▷ ◎ ◎ ◎ 35

**Can bite-splints reduce tinnitus in tinnitus patients? A five-year follow up study.**

D Ström<sup>1,3</sup>, E Behrenth<sup>1</sup>, K Ekman<sup>1</sup>, A Johansson<sup>2</sup>, L Unell<sup>1</sup>

<sup>1</sup>Department of Stomatognathic physiology, Post Graduate Dental Education center, Örebro County Council, Örebro, Sweden

<sup>2</sup>Department of Clinical Dentistry- Prosthodontics, Faculty of Medicine and Dentistry, University of Bergen, Bergen, Norway

<sup>3</sup>Department of Prosthetic Dentistry, Institute of Odontology, The Sahlgrenska Academy, University of Gothenburg, Göteborg, Sweden

**Aim:**

Tinnitus is a sound in the ear (s) and/ or head without external origin and is a serious health problem for millions worldwide. A great variety of treatment methods for tinnitus have been tried over the years, often with modest success.

The aim of this present study was to investigate if a treatment protocol frequently used against Temporomandibular Disorders (TMD) such as bite-splint therapy can be effective in reducing tinnitus

**Materials and Methods:**

Standard statistical methods were used; Student's test and Wilcoxon Signed Rank Test, using PASW statistics 17.0.

The study comprised of 33 tinnitus patients (11 men, 22 women; mean age  $51 \pm 12$  years) referred from the audiology department at the university hospital in Örebro, Sweden. A complete audio logical investigation including audio metrical status was performed. Patients with medical causes to tinnitus (otosclerosis, Meniere's disease and tumors) were excluded. No participants were on antidepressive drugs. All patients had a (TMD) clinical examination including palpation of jaw muscles and temporomandibular joints (TMJ). (Research diagnostic criteria, Dworkin & Le Resche 1992). A subjective tinnitus evaluation on a 100 mm scale (VAS) was performed at baseline and after five years. All patients received standard stabilization splints (Michigan splint) at baseline.

**Results:**

Duration of tinnitus at baseline was  $5.2 \pm 3.2$  years. VAS (tinnitus) at baseline was  $76 \pm 18$  mm and after

five years  $41 \pm 28$  mm ( $P < .001$ ). 28 patients were improved after five years and only four patients did not report improvement of their tinnitus.

23 patients reported a decrease in jaw-muscle tenderness and 9 a reduction in TMJ –pain on palpation.

**Conclusion:**

Splint therapy may have a favorable effect on tinnitus in tinnitus patients in the long term.

Contact E-mail: [lennart.unell@comhem.se](mailto:lennart.unell@comhem.se)

◎ ◎ ◎ 36

**Increased thermal thresholds in facial skin in patients with chronic whiplash associated disorders**

E Lampa<sup>1</sup>, B Häggman-Henrikson<sup>1</sup>, E Nordh<sup>2</sup>

<sup>1</sup>Department of Odontology, Clinical Oral Physiology, Umeå University; <sup>2</sup>Department of Clinical Neurosciences, Clinical Neurophysiology, Umeå University, Sweden.

**Aim:**

There is a close anatomical and functional relationship between the jaw and neck regions, and head-neck movements are an intimate part of natural jaw activities. Patients with chronic pain after whiplash injury show impaired jaw and head movements and report that jaw activities and eating are associated with pain and discomfort. In addition, an association has been shown between jaw and neck pain, and it has been suggested that trigeminal sensory impairment can follow whiplash injury. All these observations indicate the presence of an important functional integration between the jaw and neck sensorimotor systems.

The aim of this study was to evaluate possible disturbances in facial thermal detection capacity following whiplash trauma, using two methods; qualitative clinical assessment and Quantitative Sensory Testing (QST).

**Methods:**

Ten women with chronic pain and dysfunction following a whiplash trauma were compared to ten healthy age-matched women. Thermal detection thresholds for warmth and cold were determined by qualitative clinical assessment and by QST according to the 'method-of-levels' (Thermotest®, Some-

dic AB, Sweden). Seven test sites in the facial skin (six bilaterally overlying each trigeminal branch, and one overlying the midpoint of the chin) were examined.

Qualitative assessment was done with the flat tip portion of the handle of a cold (room tempered) and warm (45°C) Miller forceps. For QST a series of 10 cold and 10 warm stimuli was delivered by a computer controlled thermal probe, starting at an adapted skin temperature of 32°C.

#### Result:

In the WAD patients, the qualitative assessment demonstrated both reduced and increased sensitivity, compared to healthy subjects. The QST however, showed significantly higher perception thresholds (i.e. reduced sensitivity) for both warm and cold stimuli for the WAD group. In WAD individuals showing increased sensitivity at the qualitative examination, the QST displayed either normal or increased thresholds, i.e. reduced sensitivity.

#### Conclusion:

The results suggest that QST is more sensitive for detecting thermal sensory disturbances in the face than qualitative clinical assessment. The reduced thermal sensitivity shown by QST in the WAD group indicates interference between the thermal and nociceptive inputs within the evaluating somatosensory structures.

A possible explanation to the sometimes contrasting findings at the qualitative assessment might be that the clinical testing situation expose patients to a less well defined sensory stimulation, in turn resulting in multimodal cross-talk in evaluating higher centra which may cause increased sensitivity in some subjects.

Contact E-mail: ewa.lampa@vll.se



### **Impacted maxillary canines - a comparison of the treatment outcome with two surgical procedures before the orthodontic treatment**

L Börjesson, M Sinclair, K Bjerklin

Faculty of Odontology, Malmö University, Malmö, Sweden

#### Aim:

To compare the treatment outcome after open and closed surgical exposure before the orthodontic treatment

#### Materials and Methods:

The material comprised of 30 subjects treated with closed surgical exposure and 30 subjects with open surgical exposure before the orthodontic treatment. The subjects were collected from two different clinics there all patients were treated with open surgical exposure and closed surgical exposure respectively.

#### Results:

The 60 patients were treated for 73 impacted maxillary canines, 33 in the open group and 33 in the group with closed exposure palatally. Only 7 teeth were impacted buccally. The age at the exposure was mean 15.2 years (sd 2.39) in the open exposure group and mean 12.9 years (sd 1.82) in the closed exposure group. The total treatment time was 1.94 years (sd 0.77) for the open exposure group and 3.07 years (sd 0.96) for the closed exposure group. The patients in the open exposure group had received fixed orthodontic appliances in both jaws in 7 patients and in only the maxilla in 23 patients the corresponding figures for the patients in the group with closed surgical exposure was 12 and 17 respectively.

#### Conclusion:

The mean age at the surgical exposure was significantly higher in the group with open exposure. The mean total treatment time was about one year longer for the patients in the closed exposure group. No comparison could be done between the cases wit buccally and palatally impacted canines as there were very few patients with buccally impacted canines.

Contact E-mail: Krister.bjerklin@mah.se



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