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Founding of the Swedish Dental Society, 1860.
Oil painting by Nils Asplund.

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Editorial

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☺ Dear reader,

The Swedish Dental Journal has now been published for forty years by the Swedish Dental Association in collaboration with the Swedish Dental Society. It has played a central role in ensuring that new scientific based knowledge reaches out to dentists practicing in Sweden. For many years my predecessor, Professor Göran Koch, cared for and developed the Journal. Göran has done a great job and we are all in debt of gratitude to him. The Journal is well established in Sweden. Still, the technology of publishing and reading scientific papers have changed and at the same time the number of publications and journals are increasing, making it hard to compete for a national scientific journal.

Right now you are holding the last printed issue of the Swedish Dental Journal in your hands. At least for the moment. At this moment it is not decided whether there will be a continuation or not. This number includes all manuscripts accepted for publication, and it is rather extensive with thirteen articles. It is an ambiguous feeling to write an editorial at this point. However, there are some important issues that should be highlighted.

First of all, Sweden has one of the oldest dental societies still operating. The Swedish Dental Society is proud to celebrate its 156th anniversary this fall. The Society has played an important and central role in developing odontology and dental care in Sweden. Already from the start it recognized the importance of spreading knowledge to dentists throughout the country in order to improve both dental care and dental health in the population. Continuous education courses as well as the annual dental meeting have been important arenas for bringing not only dentists but actually all members of the dental teams together. High quality knowledge based on science has always been the beacon. Also the Swedish Dental Association is extremely important for the development of dental care and oral health in Sweden. The Association, still young, started off roughly 108 years ago. It is now responsible for political work around core issues like education, quality assurance in dental care, and patient safety. Research and development are of course central in this work.

Swedish dentists have two strong bodies representing the dental profession. They share a common history of working together for many years. Publishing the Swedish Dental Journal is an example of this fruitful collaboration. Looking back at the numerous issues and manuscript published it is also very clear that there is strong tradition of dental research in Sweden often manifested by submitting papers to the Journal. The Journal is of course extremely thankful to all colleagues that throughout the years have chosen to share their research through the Swedish Dental Journal. Without knowing what will happen next concerning the Journal, we sincerely hope and believe that true interest in new knowledge and research will remain prominent within the Society, the Association and the dental profession.

Gunilla Klingberg
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Co-editors

Current status on the application of image processing of digital intraoral radiographs amongst general dental practitioners

PARISA TOHIDAST¹, XIE-QI SHI^{1,2}

Abstract

© *Objectives:* The objectives of this study were to present the subjective knowledge level and the use of image processing on digital intraoral radiographs amongst general dental practitioners at Distriktstandvården AB, Stockholm.

Material and Methods: A questionnaire, consisting of 12 questions, was sent to 12 dental practices in Stockholm. Additionally, 200 radiographs were randomly selected from these clinics for evaluation of applied image processing and its effect on image quality. Descriptive and analytical statistical methods were applied to present the current status of the use of image processing alternatives for the dentists' daily clinical work.

Results: 50 out of 53 dentists participated in the survey. The survey showed that most of dentists in this study had received education on image processing at some stage of their career. No correlations were found between application of image processing on one side and education received with regards to image processing, previous working experience, age and gender on the other. Image processing in terms of adjusting brightness and contrast was frequently used. Overall, in this study 24.5% of the 200 images were actually image processed in practice, in which 90% of the images were improved or maintained in image quality.

Conclusions: According to our survey, image processing is experienced to be frequently used by the dentists at Distriktstandvården AB for diagnosing anatomical and pathological changes using intraoral radiographs. 24.5% of the 200 images were actually image processed in terms of adjusting brightness and/or contrast. In the present study we did not find that the dentists' age, gender, previous working experience and education in image processing influence their viewpoint towards the application of image processing.

Key words

Image processing, digital intraoral radiographs, dentistry

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Aktuell status för tillämpning av bildbehandling på digitala intraorala röntgenbilder bland allmäntandläkare

PARISA TOHIDAST, XIE-QI SHI

Sammanfattning

◎ *Mål:* Målet med denna studie var att studera den subjektiva kunskapsnivån hos allmäntandläkare på Distriktstandvården AB i Stockholm när det gällde användning och kännedom av bildbehandling för digitala intraorala röntgenbilder.

Material och metoder: En enkät med 12 frågor skickades till 12 tandläkarmottagningar i Stockholm. Dessutom valdes 200 slumpvisa röntgenbilder från dessa kliniker för enkätevaluering. De applicerade bildbehandlingsalternativen på varje bild registrerades. Beskrivande samt analytiska statistiska metoder applicerades för att kunna analysera användningen av olika bildbehandlingsalternativ under tandläkarnas dagliga arbete.

Resultat: 50 av totalt 53 tandläkare deltog i undersökningen. De flesta av tandläkarna hade fått någon form av utbildning inom bildbehandling under sina karriärer. Inga korrelationer kunde hittas mellan användning av bildbehandling samt faktorer som utbildning, arbetserfarenhet, ålder eller kön. Justering av ljusstyrkan samt kontrasten var de metoderna som användes mest inom bildbehandling. Generellt sett visade studien att 24,5 % av de undersökta bilderna hade bildbehandlats i praktiken.

Slutsats: Enligt vår studie upplevdes bildbehandling användas regelbundet av tandläkarna på Distriktstandvården AB för diagnostisering av anatomiska och patologiska förändringar i intraorala röntgenbilder. Justering av ljusstyrkan samt kontrasten var de metoderna som användes mest frekvent av tandläkarna på Distriktstandvården AB. 24,5 % av de 200 bilderna som undersöktes hade bildbehandlats, varav ljusstyrkan och kontrasten ändrades främst. Tandläkarnas ålder, kön, tidigare arbetserfarenhet eller utbildning inom bildbehandling påverkade inte hur pass frekvent bildbehandling applicerades.

Introduction

Within dentistry, digital imaging has evolved from an emerging technique in the mid-1980s to a reliable technology today (7, 11, 24). Digital intraoral images may be acquired by two different techniques: indirect or direct imaging. Indirect digital technique requires scanning of a phosphor plate after exposure whilst direct digital imaging uses a sensor, where an image is displayed on the screen immediately after exposure (23).

Compared with analogue imaging, digital radiographic techniques eliminates chemical processing and have, in general, resulted in lower radiation doses for patients (4, 7, 11). Another important feature is the increased possibility of image processing (27). Any operation that acts to restore, improve, analyse a digital image is a form of image processing (18, 25, 29, 30). A radiograph without any kind of image processing is defined as a raw image (17). The term "image enhancement" refers to the adjusted radiograph after image processing has improved the original version. Image processing operations may occur at "system level", "viewer level" or a combination of the two. Many radiographic systems have image processing at the systemic level, meaning that image processing algorithms/filters are integrated with image acquisition and applied to every single image automatically after each capture (2, 17). Importantly, this is done since a raw image has a radiographic appearance with low contrast and high brightness level due to low radiation exposure. This step of image processing is usually hidden from the user. After the image has been captured, brightness, contrast and sharpness of an image can be further manipulated by the viewer according to the diagnostic task and viewer preference. For example; caries detection may be improved by adjustment of contrast, whereas a brighter image may be preferred for viewing marginal bone level. Image processing in terms of contrast resolution has been investigated widely (8, 14, 24, 32). Contrast resolution may be improved by applying various mathematical algorithms, for example gamma correction, histogram equalization and colour-coding methods (1, 3, 8, 22). Changing the gamma value of an image enhances selectively image contrast in either the bright or the darker area of an image. Histogram equalization or histogram stretching is a processing operation that changes the range of pixel intensity values in order to increase the contrast of an image. Alpöz et al compared digital radiographs before and after application of different digital image enhancement methods and

found that histogram equalization of Digora images had subjectively improved image quality followed by contrast brightness enhancement (1). On the other hand studies have also reported that image enhancement did not increase diagnostic accuracy, especially enhancement in spatial resolution, the sharpness of an image (5, 18, 21). Only a few studies reported that increasing image sharpness improved the accuracy of image interpretation, for example detection of tooth fracture (6, 28). Studies have shown the use of image processing techniques have also reduced the number of image retakes (20, 26). Most of these studies on image processing were conducted to investigate a specific algorithm/filter, such as to compare image quality or diagnostic accuracy by viewing the same series of images with or without image processing (1, 12, 15, 20).

A previous study on image quality of intraoral radiographs addressed the importance of maintaining image quality of digital radiographs in dentistry. The conclusion in the study suggested that the dentists should be trained to manage problems that could occur when new techniques were introduced in order to fully utilize the potential of new technologies (9).

The aim of this work was to study the current status of the dentists' subjective experience on image processing at viewer level and how general dental practitioners actually apply image processing software for viewing digital intraoral radiographs.

Material and Methods

Subjective Evaluation

A questionnaire was sent to all dentists working at 12 dental practices at Distriktstandvården AB in Stockholm. The questionnaire consisted of 12 questions that covered age, gender, number of years of clinical experience as dentist, subjective experience towards the effect of image processing, as well as, potential factors that could affect the usage of image processing (Appendix A). For those questions that measured either a positive or negative response to a statement a five-point Likert scale was used in this survey. The Likert scale is a psychometric scale commonly used in questionnaire research; it measures either positive or negative response to a statement (16).

Objective Evaluation

The purpose of the objective evaluation was to verify the results from the questionnaire by clinical data on actual use of image processing in daily clinical work amongst the same group of dental practition-

ers. This was achieved by evaluating 200 digital intraoral radiographs. These 200 images captured at these 12 dental clinics were randomly chosen from the company's database. Radiographs were selected at a random date prior to the distribution of the questionnaire. It was possible, with the applied image program (DentalEye, Sweden), to backtrack to the original images and the applied filter on each single image, in terms of manipulation of brightness and contrast, sharpness and noise reduction filters. Across the entire 12 dental practices, the applied X-ray unit was the Planmeca Intra (Planmeca Oy, Finland) and the applied digital sensor was Prosensor (Planmeca Oy, Finland). The software for image viewing was DentalEye. The images were captured directly in DentalEye using Planmeca's driver. The default setting for image processing at the system level was a gamma correction of 0.5 in combination with a noise reduction filter (3x3 mask size) and a sharpening filter (17x17).

One radiologist and one general dentist assessed image quality before and after image processing was applied. For those images that were not image processed the image quality was assessed as well. The subjective criteria for determining whether an image had sufficient quality were visibility and clarity of the following anatomical structures: enamel, dentin, pulp, trabecular bone pattern and the level of marginal bone. By viewing these anatomical structures the general impression on brightness/contrast, noise level and spatial resolution for an image was graded by a five points scale. For an image quality considered to be acceptable, the Likert grade had to be at least three, followed by four ("good") and five ("very good"). Any score below 3 was considered to be of poor quality for clinical use.

Data analysis

The following variables were examined by descriptive analysis in terms of proportions: gender, age, working experience, education on image processing and diagnosis approach for sub-optimal images. Box plot was employed to demonstrate the distribution of the application of image processing for identification of normal anatomy, for various diagnostic tasks for dentists' general experiences with image processing.

Covariance analysis (25) in terms of correlation coefficient between the use of image processing software in recognizing pathological and anatomical structures and the following variables were studied: age, received education on image processing, previ-

ous knowledge/experience with image processing software and working experience. For the use of image processing software in recognizing pathological and anatomical structures, seven different types of structures/diagnoses were studied (Appendix A), which resulted in total 28 different correlation tests.

Results

A total of 50 out of 53 (~94%) dentists responded to the questionnaire. The average age was 44 (± 13 years).

Subjective Evaluation

The result demonstrates that most of the dentists had received some education on image processing software, with only 16% not being trained at all. Slightly more women (28) than men (22) participated in the survey, reflecting the gender distribution of the company. It appeared that female dentists used image processing software more often than the male dentists, however this was not statistically significant (Figure 1).

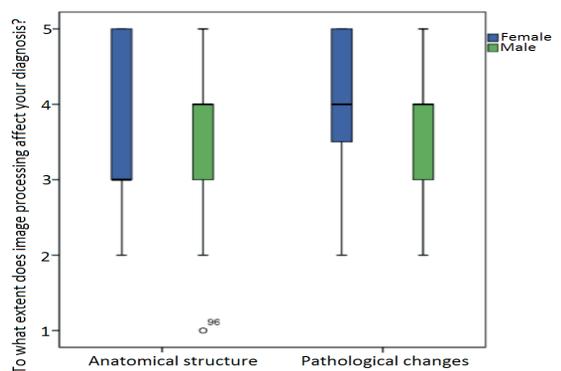


Figure 1. Subjective evaluation on the effect of image processing for viewing anatomical structures and pathological changes amongst female and male dentists.

The use of image processing software was very common for caries diagnostics, apical and marginal periodontitis whereas it was less often employed when viewing anatomical structures (Figure 2). It was common that when an image was sub-optimal in terms of brightness and contrasts the dentists manipulated the current image and waited before the next exposure (Figure 3).

Table 1 shows the correlation coefficient (r) between application of image processing for different diagnostic tasks and the following four variables: age, education on image processing, previous knowledge on image processing and working experience. The

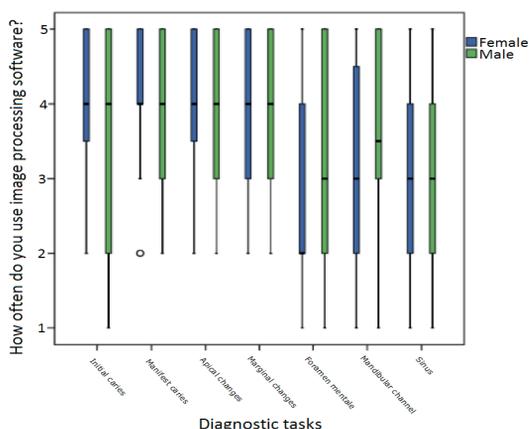


Figure 2. Box plots showing how often dental practitioners apply image processing software for various diagnostic tasks including pathologic changes and anatomical structures.

results showed that all the correlation coefficients were below 0.5, hence no indication of strong linear correlations were found.

Objective Evaluation

The objective evaluation process showed that 24.5% of the 200 radiographs were image processed by the dentists. Amongst the image processed radiographs, 45% improved the image quality, 45% were unchanged and 10% were impaired. The image processing methods for the manipulated images included the adjustment of image contrast and/or brightness. Furthermore, evaluation also showed that 87% of the 200 radiographs initially had acceptable image quality.

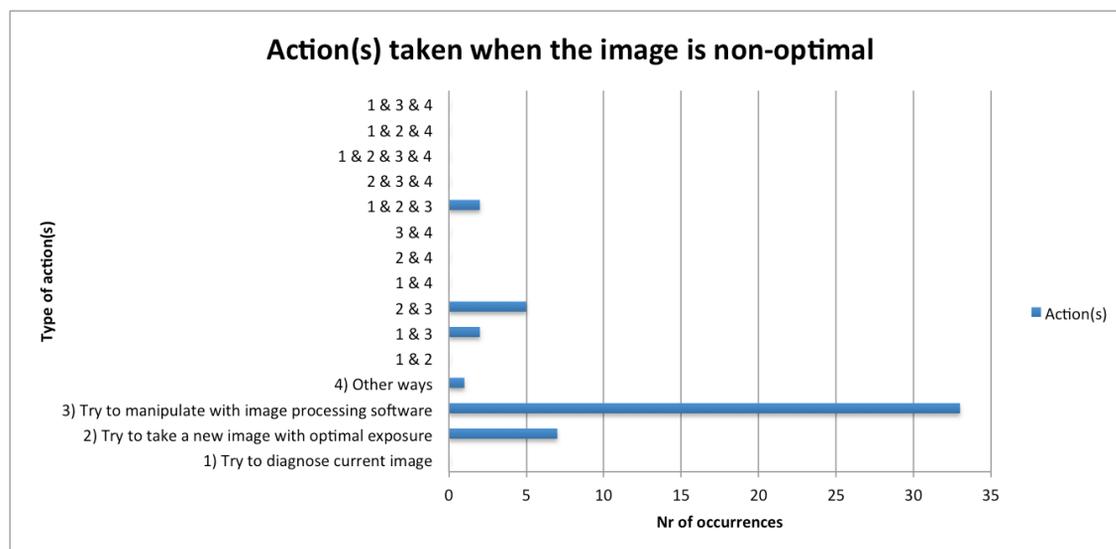


Figure 3. Action(s) taken when the image was non-optimal.

Table 1. Correlation coefficients (r) between different parameters. Parameters a (age), b (education on image processing), c (previous knowledge/experience with image processing software) and d (work experience).

Parameter	Initial caries	Manifest caries	Apical periodontitis	Marginal periodontitis	Sinus	Mandibular channel	Foramen mentale
a	0.05	0.12	0.10	0.21	0.39	0.30	0.44
b	0.18	0.29	0.39	0.48	0.24	0.27	0.21
c	0.13	0.23	0.26	0.32	0.34	0.40	0.28
d	-0.06	0.02	0.20	0.22	0.26	0.12	0.30

Discussion

The results in the study showed that the majority of the dentists had received some education on image processing and the use of image processing was a common action when viewing suboptimal radiographs. Image processing was employed more frequently for viewing pathological structures and less in the case of normal anatomy. A few individuals from each dental clinic did not use image processing software.

From the subjective evaluation we failed to find any statistically significant correlation between the application of image processing and various factors that may influence the use of image processing, such as age, gender, working experience and previous knowledge on image processing. It must be noted that although no strong linear correlation could be found, a non-linear correlation may exist. The limited number of participated general dentists in the present study may also be a confounding factor to reveal the present status on dentists experience towards image processing at viewer level.

With a well-functioned image processing algorithm at system level, it should result in optimal image quality for most of the radiographs. Our results confirmed that 87% of the unprocessed image at operator level had diagnostically acceptable image quality. This may imply that the integrated image processing algorithm in DentalEye generated optimal image quality initially, hence no need for further manipulations were required for most images. The integrated image processing algorithm is essential and it should be developed for a specific type of image according to an ideally projected "standard patient". Theoretically only images of patients who deviates in size from "standard" or images that partially miss the field of view may need further image processing at the operator level.

Results from the objective evaluation showed that 24.5% of the images were further image processed by dental practitioners, in which 90% maintained or had better image quality and 10% were impaired. Image processing was applied not only to make the image diagnostically acceptable, but also to make image visually more appealing. With the present study design it was not possible to trace images that were processed but, of some reason, not saved in the system. Thus caution has to be taken when applying this finding in general.

Of the 24.5% of images that were image processed by the practitioners, it was found that amongst various image processing alternatives, only manipula-

tion of image contrast and brightness was applied to the processed image, which has also been seen in a previous field study (9). It confirms that contrast resolution was the most important characteristic for digital radiographs (13). None of the participants used noise reduction and/or sharpening filter in the present study. This was expected since previous studies have shown these functions made images more visually appealing (19) but did not affect diagnostic accuracy, probably with the exception of diagnosing tooth fractures (6, 28, 29).

Since digital technology and image software is constantly evolving, continuous education on its new features and evidence-based research is of importance for general dental practitioners.

Conclusions

The questionnaire study showed that dentists at Distriktstandvården AB experienced that they frequently use image processing for diagnosing anatomical and pathological changes using intraoral radiographs. The objective study showed that 87% of images had initially diagnostically acceptable image quality. 24.5% of the 200 images were traceable and image processed in terms of contrast and brightness adjustment. The dentists' age, gender, previous working experience and education in image processing do not seem to influence their viewpoint towards the application of image processing.

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Clinical and radiographic outcomes of lateral sinus floor elevation: a retrospective study

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Abstract

© The aim of this retrospective study was to evaluate the clinical and radiographic outcomes of lateral sinus floor elevation (LSFE).

A total of 347 medium rough surface implants were placed in both xenogenic bone and natural bone in 103 patients. A two-stage surgical technique was performed with a lateral window approach followed by a healing period of 9 months prior to implant placement. Patients were analysed with regard to pre- and post-augmentation bone height data (Group A), levels of marginal bone (Group B) and implant survival rates/complications.

A total of 6 implants were lost in the present investigation, of which two were still osseointegrated, albeit mechanically damaged. The implant survival rate was 99.0% considering those engaging BioOss, and the corresponding figure for implants placed in natural bone was 96.2%. The average follow-up time was 2.5 years. The mean preoperative bone height was 3.8 mm and the mean postoperative bone height was 13.7 mm. It may be advocated that preoperative bone heights exceeding 7 mm are not indicative of LSFE treatment and that preoperative bone heights of 4-7 mm may imply alternative treatment options. A group of subjects, corresponding to 16.5% of the patient material, had some sort of postoperative complication.

One may conclude that LSFE is a predictable and safe treatment procedure, with a high implant survival rate. LSFE resulted in gained bone height in the range of 10 mm.

Key words

Lateral sinus floor elevation, bovine hydroxyapatite, jaw bone height, oral implants

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Kliniskt och röntgenologiskt utfall av sinusaugmentation med lateral fönstertechnik: En retrospektiv studie

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Sammanfattning

☉ Syftet med föreliggande retrospektiva studie var att utvärdera det kliniska och röntgenologiska utfallet av sinusaugmentation med lateral fönstertechnik.

Totalt placerades 347 implantat med en förtjockad halvrå titanoxidytta i både bovint benersättningsmedel och maxillärt ben på 103 patienter. Sinus öppnades med en lateral fönstertechnik varefter sinusslemhinnan lyftes och BioOss® placerades för en inläkningsperiod på 9 månader. I ett andra kirurgiskt ingrepp placerades implantat för inläkning 2–4 månader. Patienterna utvärderades med avseende på benhöjd före och efter ingreppet (Grupp A), marginal bennivå (Grupp B), samt implantatöverlevnad/komplikationer.

Under studieperioden förlorades sex implantat, vara två var rent mekaniskt skadade med bibehållen osseointegrering. Implantatöverlevnaden varav 99,0 % för dem som placerades i BioOss® och motsvarande siffra för implantat placerade enbart i maxillärt ben var 96,2 %. Patienterna följdes i genomsnitt under 2,5 år. Medelbenhöjden före och efter ingreppet var 3,8 mm respektive 13,7 mm. Preoperativ benhöjd >7 mm torde inte indicera sinusaugmentering med lateral fönstertechnik och preoperativ benhöjd i intervallet 4–7 mm ger möjligheter för alternativa behandlingar till lateral fönstertechnik. Huvuddelen av implantaten förlorade ytterst lite marginalt ben under studietiden. Någon typ av postoperativ komplikation registrerades för 16,5 % av patienterna.

Sammanfattningsvis kan konstateras att lateral fönstertechnik av sinus maxillaris med användande av bovint ben är en säker behandlingsmetod med en hög implantatöverlevnad. Metoden innebar en ökad benhöjd på cirka 10 mm.

Introduction

Titanium oral implants to rehabilitate patients have been in clinical use since the mid-1960s (4). Excellent 10-20 year outcomes have been reported for the single-tooth situation (1), for patients with partial edentulism (7,19), and total edentulism (10,16,28).

Regarding implant rehabilitation of the posterior maxilla specific difficulties are frequently at hand. Tooth loss leads to bone resorption of the alveolar crest beneath the maxillary sinus. In addition, maxillary sinus cavities often expand downwards after extraction to fill out the edentulous alveolar process (27), and rehabilitation of the posterior maxilla may thus be challenging due to the limited bone volume. Further, the posterior maxilla presents in general a bone texture with sparse trabeculation and poor density.

There are several treatment options for the rehabilitation of the posterior maxilla, i.e. the use of lateral sinus floor elevation with or without bone grafts, and the use of the trans-alveolar sinus floor augmentation. Alternative procedures may include the use of short implants, tilted implants, zygoma implants, and implant-tooth splinted constructions (12).

Lateral Sinus Floor Elevation (LSFE)

Handling of autogenous bone grafts in sinus floor elevation was first reported by Boyne & James (3). Today, this is surely an accepted treatment procedure, where different grafting materials have proven to serve their purpose. The use of bovine hydroxyapatite, autogeneous bone or a mixture of these have been described in numerous reports, and in a study by Hallman et al (15), the histomorphometric analyses showed no differences between these groups. The effect of adding autogeneous bone remains unclear but may allow for reduction of the healing time.

There are various techniques of sinus augmentation, of which the lateral window technique with placement of bone or a bone substitute is the most common procedure. Bone is thus allowed to heal for 6-9 months prior to implant placement. However, it has been shown that bone formation may occur by just lifting the membrane, without placing any graft material (6,20).

Further, one may sometimes open a lateral window, lift the sinus membrane and allow for an immediate implant placement. The implant apex protrudes into the sinus and bone/bone substitute is placed and condensed around it. The decision to apply delayed or immediate implant placement is in

praxis based on the amount of residual bone available and the possibility to achieve primary stability for the inserted implants. A residual bone height of at least 5-6 mm seems to be a prerequisite for immediate implant placement, when conducting either the LSFE or the trans-alveolar sinus floor augmentation techniques (9,21,25). The latter technique implies a crestal approach, utilizing drills for bone site preparation. This is followed by the use of osteotomes to fracture the sinus floor upwards, thus allowing for placement of longer implants (8,22).

In a systematic review on LSFE with bovine hydroxyapatite, it was recently shown a 93.7% implant survival at 3 years of follow-up (9). Similar results at 3 years were found by Pjetursson et al (21), who conducted a more extensive systematic review. They concluded, though, that the survival rate was improved when implants with moderately rough surfaces and collagen membrane coverage of the lateral window were used. The latter statement was confirmed in a more recent review, presented by Wallace et al (26). A frequently reported complication in relation to LSFE is the intra-operative sinus membrane perforation and, but more rarely, bone graft loss due to postoperative infection (24).

The aim of this retrospective study was to evaluate the clinical and radiographic outcomes of lateral sinus floor elevation (LSFE) by measuring available jaw bone heights pre- and postoperatively, by evaluating the inserted implants in terms of survival/success criteria, marginal bone resorption, and registered complications.

Materials and methods

Patient and Implant Data

The inclusion criteria for the current study were as follows:

1. LSFE should have been conducted between the years 2004 and 2010 at the Brånemark Clinic, Göteborg, Sweden
2. Bovine hydroxyapatite, BioOss (Geistlich Pharma AG, Wolhusen, Switzerland), should have been the augmentation material used

A search in the clinical ledgers at the Brånemark Clinic resulted in a list of 139 patients that presumably underwent a lateral sinus floor elevation (LSFE) with BioOss as grafting material. Of these, 25 records were not accessible for analysis. Main reasons for exclusion were that treatment was executed in the vicinity of the sinus, albeit actually not involving it, and that 39 patients were referred from clinics that wanted to perform the prosthetic treatment on their

patients, and some of these presented with scarce radiographic data. A conservative approach was taken in the filtering of data, to include as much statistical material as possible. Thus, 114 patients (52 males; mean age: 65 years, 62 females; mean age: 63 years) were included in this retrospective study and a total of 389 implants were placed in both natural bone and BioOss graft (Fig.1). Apart from gender and age, extracted data on patients in general included health condition, medication and smoking habits (Table 1).

To analyze the results of the LSF procedure the

© **Table 1.** Distribution of number of patients recorded with general health disorders. Total number of patients is given within brackets.

Diagnosis	Study group (n-114)
Cancer/history of cancer	16
Cardiac and vascular diseases	29
Deep depression	2
Diabetes	7
Rheumatoid arthritis/arthritis	10
Tuberculosis/lung disease	3
Warfarin medication	0
Irradiation head & neck	0
Cytotoxic drugs	1
Smokers	20
Healthy patients, no diagnoses	35
No drugs or medications	47

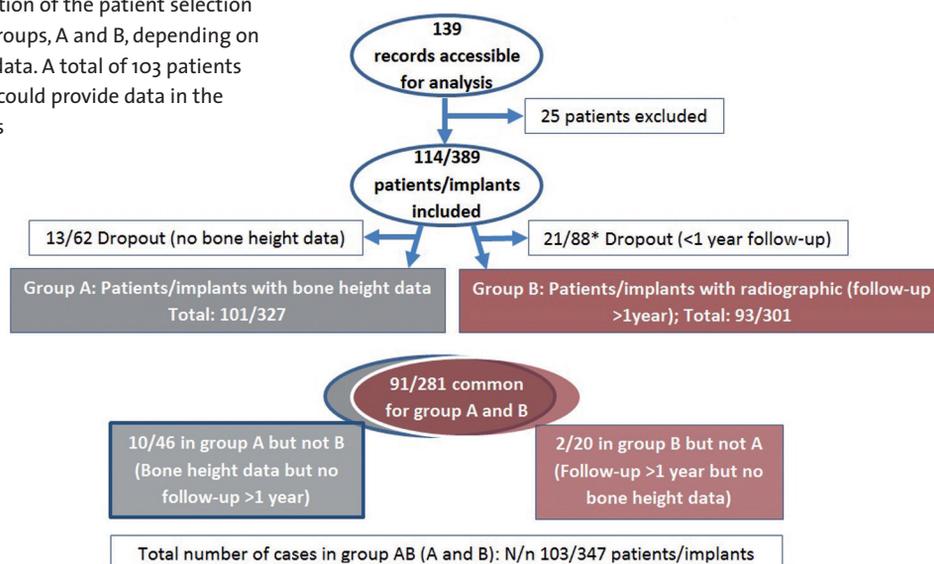
criteria were that each implant had complete data with bone type (implant classification, as described below) and pre- and post-surgical bone heights. Having at least one BioOss-engaging implant with subsequent data, a number of 101 patients with 327 implants met these criteria in Group A. The remaining 13 patients together with 62 implants were dropouts in Group A (Fig. 1).

To analyze marginal bone levels, bone loss and survival rates, at least baseline radiographs (obtained at placement of prostheses) and images obtained at the 1-year follow-up were required. A total of 301 implants in 93 patients met these criteria in Group B, and 21 patients with 88 implants were dropouts in Group B. Four implants in Group B were lost before the 1-year control, and therefore the survival rate on implant level was based on a total of 305 (301+4) implants (Fig. 1).

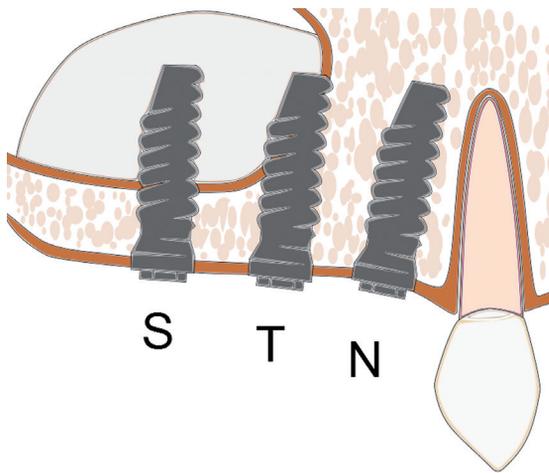
Postsurgical complication analysis was based on the material of 114 patients, and as may be seen in Fig.1, a total of 103 out of 114 patients with 347 out of 389 implants fulfilled the criteria for either Groups A or B.

Of the 347 implants used, 340 (98%) were Tiunite, Brånemark System implants (Nobel Biocare AB, Gothenburg, Sweden) and 7 (2%) were Osseospeed TX implants (Dentsply Implants, Mölndal, Sweden). The most frequently used implant was the MK III TiUnite regular platform (74%).

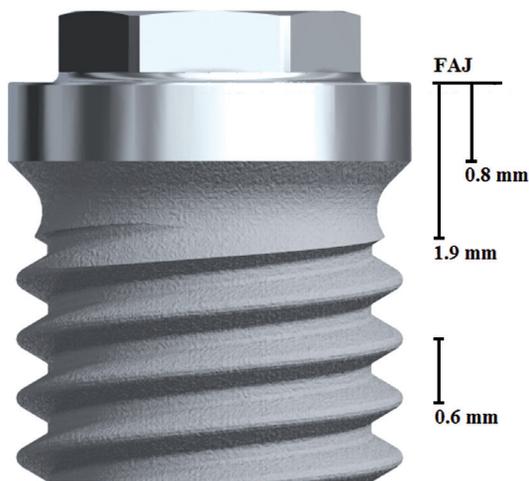
© **Figure 1.** Illustration of the patient selection process into two groups, A and B, depending on the availability of data. A total of 103 patients with 347 implants could provide data in the upcoming analyses



*4 N-implants lost before 1-year follow-up



© Figure 2. Illustration of S-, T- and N-implants



© Figure 3. Illustration of implant head with various reference points used for bone level and bone resorption measurements. Fixture/abutment junction (FAJ) to the radiographic reference point (0.8 mm). Distance from radiographic reference point to the first thread 0.8-1.3 mm (mean 1.1 mm). Distance to the first thread from FAJ is thus 1.9 mm, and the distance between threads is 0.6 mm

Pre- and Post-Surgical Bone Heights

Bone type in which the implants were installed constituted the implant classification (Fig. 2):

S-implants; sinus graft material was visible on both sides of the implant or one side of the implant engaged the graft material with more than half of its length. This group comprised 190 implants (54.8%).

T-implants; one side of the implant engaged the graft material with less than half of its length. This group comprised 34 implants (9.8%).

N-implants; did not engage the graft material, but they may have been in contact with a buccal bone graft or a grafted post-extraction alveolus. This group comprised 123 implants (35.4%).

As per routine at the Brånemark Clinic, the patients were referred to the Clinic of Oral and Maxillofacial Radiology, Public Dental Health Service, Gothenburg, Sweden for a CBCT (Cone Beam Computed Tomography) examination prior to treatment and 6 months after LSFE. Preoperative and postoperative bone heights were consecutively measured by specialists in radiology on mainly CBCT images (>80%), some CT images, and very few OPGs (Orthopantomograms) of good quality. The OPG magnification of 1.7 was accounted for. All images were digital. A postoperative CBCT image was in general sufficient to assess both pre- and post-operative heights due to the clear difference in contrast between the BioOss material and natural bone.

Preoperative bone heights were measured from the crestal bone level, where the bucco-palatal thickness was sufficient to accommodate implants (>3,75 mm), to the bottom floor of the sinus cavity. The postoperative bone heights were measured from the crestal bone level to the top of the BioOss graft (Fig.2). Both mesial and distal bone heights were measured by two observers on the nominated implant sites and mean values were calculated pre and post sinus lift, respectively. The mean bone gain height was the difference between these two measurements. Implant angulation in the bucco-palatal plane could not be taken into consideration; however this would most likely not have had any major effect on the results.

Three clinicians conducted all sinus elevation and implant placement procedures. In all patients a two-stage technique with a lateral window approach was performed, followed by implant placement after a healing period of 9 months on average. Complications such as sinus membrane perforation, leakage of BioOss particles through the oral mucosa or through the nose, and infections were noted during

the interim healing periods. At the time of implant surgery the bone quantity and quality were assessed radiographically according to the classification by Lekholm and Zarb (18). Bone Quantity was thereby classified into type A-E and bone Quality into type 1-4.

Implants were allowed to heal for 2-3 months prior to abutment connection with subsequent fabrication of fixed prostheses.

Clinical and Radiographic Follow-Up

Clinical examinations were performed annually, evaluating intraoral conditions in relation to the implant treatment. Soft tissue swelling, profuse bleeding/pus on probing, deep pockets, were regarded as complications and thus registered. Radiographs were obtained at baseline (prosthesis placement) and at the various check-ups (1-year, 3-year and 5-year). Marginal bone measurements were consecutively made by specialists in radiology, defining the distance from fixture/abutment junction (FAJ) to the present bone level at the mesial and distal aspect of each implant (Fig. 3). Change in marginal bone level was calculated as the difference between two measurements.

Due to the retrospective nature of this study, it was granted an exemption in writing by the Faculty of Odontology, University of Göteborg, Sweden, IRB.

Statistics

Conventional descriptive statistics was used in the present study. Differences between groups were tested with regard to distributions by means of Chi-square tests and differences between group mean values were tested by means of Student's t-test. Overall statistical significance was set to 5%.

Results

The results in this study are based on group A: 103 patients (327 implants) and group B: 93 patients (301 implants). The follow-up period ranged from 8-60 months with an average of 2.5 years.

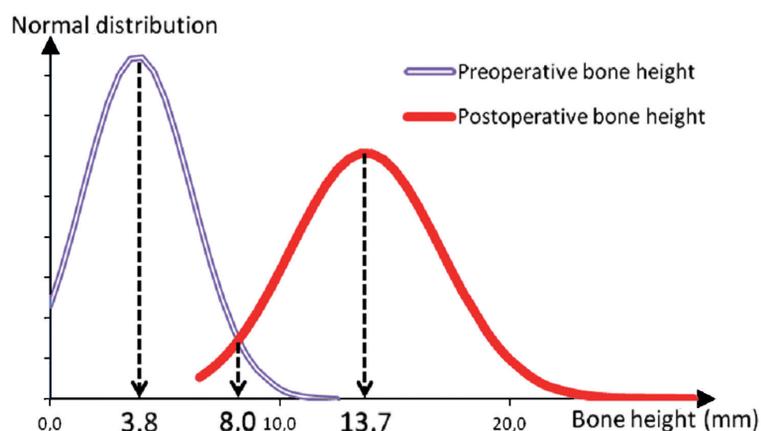
The analysis of the effects of LSFE with regard to bone heights was based on group A. All patients and implants in group B were followed for at least 1 year after loading. Implant survival and success rates were based on group B.

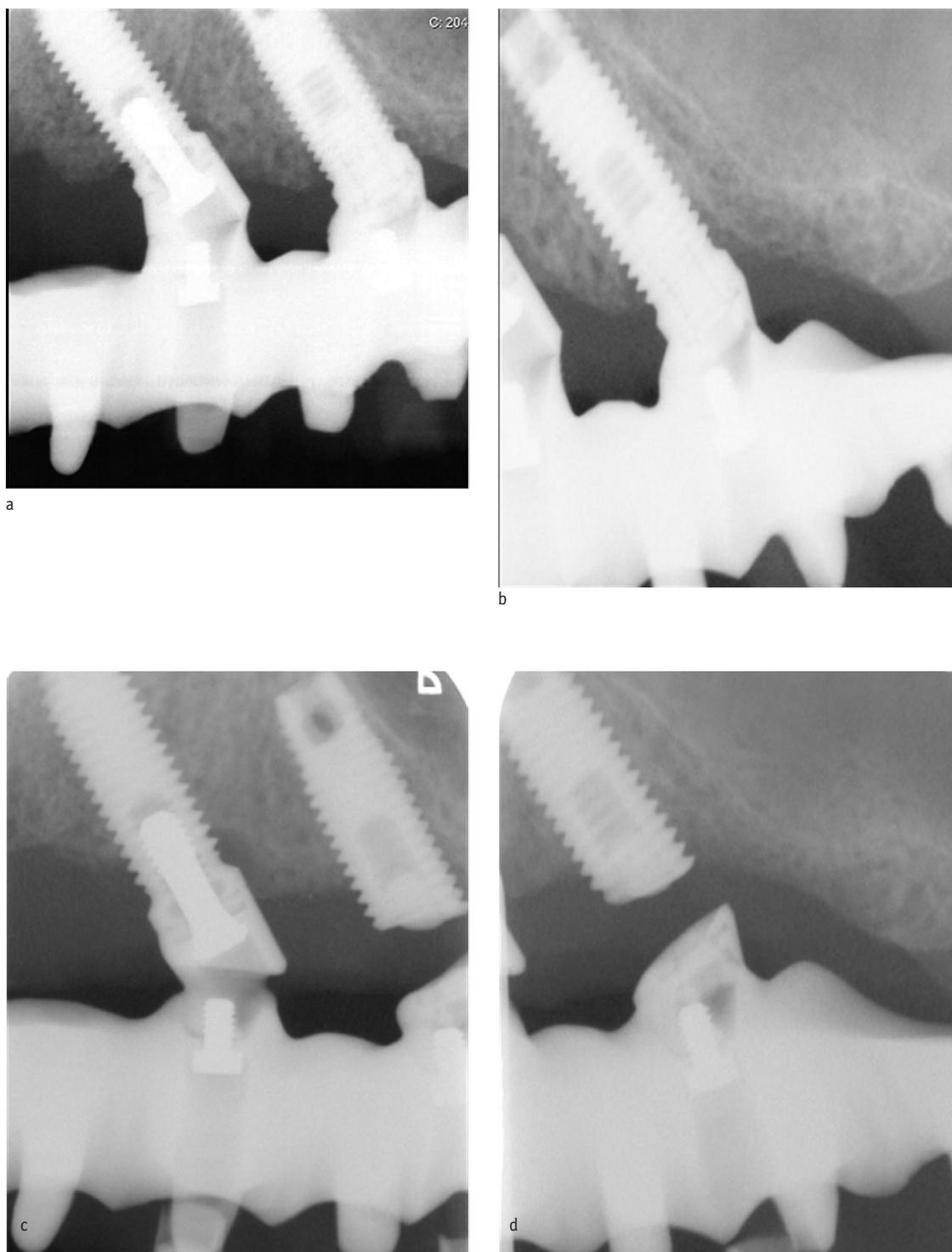
Bone Height and Bone Gain

Two normal distributions superimposed in one chart of residual bone height and bone height after the LSFE procedure for S-implants, are shown in Fig. 4. The diagram reflects well the approach at the Brånemark Clinic where cases with very small residual bone, on average 3.8 mm and less than 8mm, are subjected to the LSFE treatment. The diagram also shows that in some cases the LSFE only resulted in relatively small bone heights between 6 and 8 mm, where other cases already had that much bone prior to surgery. The overall mean values of residual height, height after LSFE and gained height for S- and T-implants separately, are shown in Table 2. It is clear that the augmentation procedure was successful in most cases with an average bone gain of 9.9 mm for S-implants and 6.3 mm for T-implants.

A majority (80%) of the treated sites engaging the sinus represented qualities 3 or 4, and quantities B and C. There was an overall matching between the postsurgical heights and implant lengths, indicating that the additional bone was used to the maximum extent. Most frequently used implant lengths for S- and T-implants were 15 mm and for N-implants 13 mm, respectively.

© Figure 4. Normal distributions of pre- and postoperative bone heights for S-implants





© Figure 5 (a,b,c,d). Baseline radiographs after fixed bridge insertion (a, b). Radiographic appearance after one year in function with abnormal use of interdental brushes with metal wire handles (c, d)

© **Table 2.** Preoperative, postoperative and gained bone height for S- and T-implants.

Implant type	Number of implants (n)	Preoperative bone height (mm)	SD	Postoperative bone height (mm)	SD	Gained height (mm)	SD
S-implants	184	3,8	2,4	13,7	3,3	9,9	3,6
T-implants	25	8,0	2,0	14,3	3,3	6,3	3,5

© **Table 3.** Mean patient marginal bone level (SD) in relation to FAJ (Fixture-Abutment-Junction) for implants placed in "Natural" and "Bovine" bone from "baseline" to annual check-up after 5 years of follow-up

Numbers of patients/implants	Natural bone				Bovine bone (BioOss)			
	Baseline	1 st year	3 rd year	5 th year	baseline	1 st year	3 rd year	5 th year
Patients	48	50	29	9	77	82	44	16
Implants	87	82	54	18	167	170	94	33
Mean bone level to FAJ on patient level (mm)								
Mean	0,7	1,2	1,4	1,4	0,6	1,0	1,3	1,3
SD	0,7	0,8	0,9	1,0	0,6	0,6	0,9	0,7

Implant and Marginal Bone Conditions

A total of 301 implants in 93 patients were followed up for at least one year of time (Group B, Fig. 1), of whom 56 patients had both S- and N-implants. For the sake of simplicity, S- and T-implants are referred to as S-implants from here on, unless specified otherwise. Two S-implants in two patients and four N-implants in another two patients failed. Two of the failed N-implants maintained osseointegration but were removed due to rough brushing where the implant heads literally disappeared (Fig. 5a-d). The survival rate on implant and patient levels were 99.0% and 97.8%, respectively considering S-implants and

96.2% and 96.4% considering N-implants.

Successful implants imply verified clinical stability, lack of clinical and radiographic signs of pathology, and that marginal bone levels remain stable over years to come. In the present investigation, no prosthetic constructions were removed and no statements can be made on stability of individual implants. It was still tempting to present success rates of implants, although only based on the clinical appearance and radiographic analysis.

A total of 29 S-implants and 22 N-implants showed a marginal bone loss that disqualified them from being successful, of which 3 S-implants and 3

© **Table 4.** Mean patient marginal bone loss (SD) in relation to FAJ (Fixture-Abutment-Junction) for implants placed in “Natural bone” for different time intervals of follow-up.

Numbers of patients/implants	Period of follow-up				
	Baseline to 1 st year	Baseline to 3 rd year	Baseline to 5 th year	1st year to 3 rd year	1st year to 5 th year
Patients	43	25	6	20	7
Implants	71	45	11	36	16
	Mean patient bone loss (mm)				
Mean	-0,5	-1,0	-1,1	-0,2	-0,5
SD	0,7	0,8	1,3	0,5	0,8

© **Table 5.** Mean patient marginal bone loss (SD) in relation to FAJ (Fixture-Abutment-Junction) for implants placed in “Bovine bone” for different time intervals of follow-up.

Numbers of patients/implants	Period of follow-up				
	Baseline to 1 st year	Baseline to 3 rd year	Baseline to 5 th year	1st year to 3 rd year	1st year to 5 th year
Patients	69	33	12	31	13
Implants	145	72	27	66	26
	Mean patient bone loss (mm)				
Mean	-0,4	-0,8	-0,8	-0,3	-0,2
SD	0,6	1,0	0,9	0,7	0,5

N-implants showed pus and profuse bleeding together with excessive bone loss, i.e. bone levels below the 3rd thread (>3 mm below FAJ). Adding the 6 implants that were lost, the figures for successful implants were thus 84.6% for S-implants and 75.0% for N-implants. The corresponding figures on patient level were 76.3% and 67.9%, respectively. There was no statistically significance difference between the two success rates.

Marginal bone levels were registered for S- and N-implants, being evaluated on obtained radiographs for the various follow-up periods. The overall majority of implants showed a bone level in close rela-

tion to the first marginal thread (~1.9 mm from FAJ) at baseline and at 1-, 3-, and 5-years of follow-up, respectively. No significant difference in bone level was seen between the implants placed in “Natural” or “Bovine” bone ($P>0.05$; Table 3). Marginal bone loss was calculated for the S- and N-implants. Based on patient level, the obtained radiographs revealed a mean bone loss of 0.5 mm between baseline and the 1-year follow up for the S-implants and 0.4 mm for the N-implants (Tables 4,5). The majority of implants lost only minor marginal bone during the study period. No significant difference in marginal bone loss was seen between the implants placed

in "Natural" and "Bovine" bone during follow-up ($P > 0.05$; Tables 4,5).

Postoperative Complications

The postsurgical complication data is based on a total of 114 patients with 387 implants. There was no significant correlation between the occurrence of complications and the preoperative bone height and bone gain. In 16.5% of the patient records, registration of some sort of postoperative complication was at hand. Perforation of the Schneiderian membrane accounted for 4.9%, leakage of BioOss particles was found in 6.8% and other complications (mainly infection of the sinus) accounted for 5.8%. As already stated, 6 implants showed pus and profuse bleeding at probing and suffered from excessive bone loss.

Discussion

Study Design

In the frame of this study there was an effort to include as much patient material as possible, thus defining two dropout groups depending on the availability of necessary data. The dropout criteria were designed on implant level which led to the exclusion of implants within patients but not the whole patient, unless all S or T implants were lost in the filtering process.

As with any retrospective study one may find shortcomings. The surgical protocol is more or less standardized at the Brånemark Clinic and all cases were operated in a similar fashion. The immediate postsurgical controls were also performed by the same respective surgeons. However, all the upcoming controls, especially after prosthesis insertion, were performed by different dentists. Referred patients continued their prosthetic treatment at home clinics, following their specific routines. Hence, there was no calibration between clinicians and collected data were thus subjected to potential errors in terms of diagnosing postsurgical complications and peri-implantitis.

Bone Height and Bone Gain

For each implant site mesial and distal bone gain measurements were performed, and for S-implants the majority of the two values were similar. For T-sites, however, the distal measurement would naturally be smaller than the mesial due to the inclined anterior sinus wall. As expected the bone gain for S-implants (9.9 mm) was greater than for T-implants (6.8 mm). Similar gain in bone height, i.e. in the range of 6-7 mm, has been presented in other reports (2,5).

Bone height measurements were only obtained where the bone was estimated to be wide enough in the bucco-palatal dimension, allowing for placement of 3.75 mm diameter standard implants. Frequently there would be a surplus of buccopalatal bone volume in the region of interest, but this was disregarded. In general, the clinical situation offered more advantageous opportunities than the bone volume would allow for as assessed on radiographs. During surgery implants may be angulated in various dimensions, resulting in the use of longer implants.

The bone gain decreased with increasing preoperative bone height, and in some cases a preoperative height of 7-10 mm was equal to the achieved bone height after LSFE in other cases. Thus, preoperative bone heights exceeding 6-7 mm may imply that the LSFE procedure would not be worthwhile or not even justified, and instead other treatment options as previously presented in the introduction part of this report should be utilized. Such a statement may be in accordance with a previous review, claiming that a lateral approach of sinus lifting is generally indicated in cases with less than 4 to 5 mm of residual bone height (11). However, many performing dentists would still go for LSFE, since they refrain from placing short implants.

There was a unanimous opinion by the performing surgeons, as based on the hand-felt perception during implant placement, that the jaw bone quality was similar in augmented and pristine bone sites, i.e. class 3 to 4 (18). Various attempts have been made to speed up bone regeneration and increase bone density using Platelet Rich Plasma (PRP), Platelet Rich Fibrin (PRF), or various bone growth factors together with autogenous and xenogenic bone in sinus augmentation procedures, but with no or little clinical impact (13,14,17).

Implant Outcome

There was no significant correlation between implant survival rate and residual bone height in the present investigation. A total of 6 implants were lost, of which two were still osseointegrated, but had to be out-trephined due to mechanical damage by the patient. The S- and N-implant survival rates of 99.0% and 96.2% are most encouraging and in accordance with similar studies. Pjetursson et al (21) presented a 3-year survival rate for rough surface implants of 96.5%, and the additional use of a membrane over the lateral osteotomy site further improved the survival rate to 98.3%. Whether the presence of a covering collagen membrane on the lateral osteotomy site

improved the outcome was also tested by Tawil & Mawla (23). Best implant survival rates were found with a covering membrane (93.1% vs 78.1%) and when using prolonged healing (>9 months). In the present retrospective study the use of covering collagen membranes was not always registered, however one may with careful conclusion state that most sinus lifts were performed with such a membrane.

The success rate was 76.3% for S-implants on a patient level. Here, 31 implants showed a marginal bone loss, presented with clinical infections, or were lost, and thus disqualified from being successful. The rate of success was based solely on the clinical examination and on the radiographic images showing marginal bone conditions. Clinical test of individual implant stability, implying removal of the prosthetic construction, was not executed why the presented success rate should be interpreted with caution.

The marginal bone levels remained stable during the study period for the overall majority of implants. Implants with signs of infection and excessive bone loss were subjected to maintenance care and even explorative surgery. This was unfortunately not always successful and the two lost S-implants belonged to this group.

Registered complications in 16.5% of the 114 patients compare well with the outcome presented by Testori et al (24), who reported various complications in 41 out of 106 patients (38.7%). In a review article (21), it was found that perforation of the sinus membrane occurred in 19.5% of the procedures and that it was the most frequently reported complication. The corresponding figure in the present study was 4.9%. The mean incidence of post-operative graft infection was 2.9%, as compared to 5.8% in the current investigation. Graft loss resulting in inability of implant placement was reported in 1.9% of cases, as compared to 1% in the current investigation.

Conclusions

LSFE is one proper therapy for the edentulous atrophic posterior maxilla. The postoperative outcomes are generally positive and the survival rate on implants is high. It may be advocated that preoperative bone heights exceeding 7 mm are not indicative of LSFE treatment. It was not possible to set a new lower limit for the minimum necessary bone height where LSFE becomes obsolete. The cost-benefit is still subject for further discussions for bone heights in the range of 4-7 mm, where one may consider alternative treatment options.

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The association between root canal filling and treatment outcome

RAHAF ALMOHAREB¹, MICHAEL AHLQUIST², GUNILLA SANDBORGH ENGLUND²

Abstract

© The aim of the study was to evaluate the technical quality of endodontic treatment performed by postgraduate students in Karolinska Institutet, Stockholm, Sweden during the years (2008-2011) and to evaluate the treatment outcome. In addition, possible influencing factors to treatment outcome were analyzed. All maxillary first molars that received endodontic treatment between 2008 and 2011 were included in the study. Pre, post and follow up radiographs were collected. The apical status (PAI-score), the quality of the root canal treatment (RCT) and the treatment outcome were assessed. Analysis of the treatment outcome in relation to the quality of root canal treatment and other possible influencing variables was performed by Chi² or Fisher's Exact test, and the statistical significance was set at $P < 0.05$. A total of 73 teeth were included in the study. Out of these, sixty-three teeth (86,3 %) had periapical lesions at the time for RCT. An initial root canal treatment was performed in 46 teeth (63 %) and 27 teeth (37 %) were retreated. There was no significant association between the outcome and the type of treatment. The majority of the RCT's (58 %) had good seal and correct length. In total, the treatment outcome was successful in 59 (81 %) of the cases. The success rate was 88 % in cases with high quality root fillings, compared to 71% in cases with less good quality. There was a non-significant trend ($P = 0.066$) of an association between RCT quality and treatment outcome. In conclusion the association between the quality of the root filling and the treatment outcome was not verified with statistical significance, but the results indicate a trend that satisfactory root fillings are associated with a favorable outcome. This study was limited by its retrospective nature and a relatively small sample size.

Key words

Root canal filling, root canal treatment, technical quality.

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Samband mellan rotfyllningars tekniska kvalitet och behandlingsresultat

RAHAF ALMOHAREB, MICHAEL AHLQUIST, GUNILLA SANDBORGH ENGLUND

Sammanfattning

☉ Syftet med studien var att utvärdera teknisk kvalitet och behandlingsresultat på endodontisk behandling utförda av ST-tandläkare i endodonti vid Karolinska Institutet under åren 2008–2011. Vidare analyserades faktorer som kan ha betydelse för behandlingsresultatet. Alla första molare i överkäken som rotbehandlats mellan 2008 och 2011 ingick i studien. Röntgenbilder före och efter behandling samlades in. Apikalstatus (PAI-score), rotfyllningens kvalitet och behandlingsresultat bedömdes. Behandlingsresultat i förhållande till kvaliteten på rotbehandling och andra möjliga variabler analyserades med hjälp av Chi2 eller Fishers exakta test, och statistisk signifikans sattes till $p < 0,05$. Totalt inkluderades 73 tänder i studien. Av dessa hade 63 tänder (86,3 %) apikal parodontit vid tidpunkten för rotbehandlingen. Konserverande rotbehandling utfördes på 46 tänder (63 %) och en konserverande revisionsbehandling på 27 tänder (37 %). Det fanns inget signifikant samband mellan typen av behandling och behandlingsutfallet. Majoriteten av de rotbehandlade tänderna (58 %) hade en till synes homogen fyllnadsgrad och rätt längd. Behandlingsresultatet bedömdes som lyckat i 59 (81 %) av fallen. I fall med hög kvalitet var resultatet lyckat i 88 %, jämfört med 71 % i fall med mindre god kvalitet. Det fanns en icke-signifikant trend ($P = 0,066$) för ett samband mellan rotbehandlingens kvalitet och behandlingsresultatet. Sambandet mellan kvaliteten på rotfyllning och behandlingsresultat kunde inte verifieras med statistisk signifikans, men resultaten visar en trend att högkvalitativa rotfyllningar är associerade med ett positivt behandlingsresultat. Denna studie begränsades av sin retrospektiva natur och ett relativt litet antal utvärderade endodontiska behandlingar.

Introduction

Endodontic treatment is performed to prevent or cure apical periodontitis and to retain the treated tooth in function. The success rate of endodontic treatment is dependent upon a variety of factors. In addition to pulpal and periapical status, root canal anatomy and quality of root canal shaping and filling procedures significantly influence the final result of the therapy [19]. Because the treatment is technically evaluated from periapical radiographs (PA), the quality of the filling is mainly judged by its apical extent and the presence or absence of voids. Periapical health is associated with root fillings that terminate within 2 mm of the radiographic apex and are of adequate density [6, 25, 27]. Follow-up clinical studies have shown that root canal treatment (RCT) can result in healing rates from 84% [32] to more than 90% [30]. A strong correlation was found between apical periodontitis and the quality of the root filling [4, 16]. However, other studies could not verify such an association [1, 8, 11, 14, 15, 23, 31]. It has been shown that canal transportation is associated with leakage along root fillings [34]. Perforations, another treatment complication, are also followed by inflammation of the periodontal ligament and the alveolar bone and consequently impair healing [29]. Finally, correlation between instrument separation and negative clinical outcome has been discussed in detail [3].

A well-recognized methodology used in the evaluation of periapical lesions is the scoring system developed by Ørstavik et al. in 1986. This system classi-

fies periapical lesions within an index, the Periapical Index Scoring system (PAI) (Table 1; Figure 1). Today, this system is used as a means of evaluating the outcome of endodontic treatment in cross sectional epidemiological studies as well as in clinical trials. PAI provides an ordinal scale of five scores ranging from 'healthy' to 'severe periodontitis with exacerbating features'. The PAI is based on reference radiographs with verified histological diagnoses published originally by Brynolf (1967) [21, 22]. Friedman defines the endodontic treatment outcomes in reference to 'healing' [7] (Table 1). When follow-up reveals a combined clinical and radiographic normalcy, the tooth and surrounding tissues are classified as having healed. When the radiolucency has persisted without change, it is an expression of disease even when there is clinical normalcy. To accommodate the fact that healing processes may require considerable time, reduced radiolucency combined with clinical normalcy can be interpreted as a suggestion of healing in progress. A scoring system to judge the quality of root filling was constructed by Molander et al. [17]. Four aspects of root filling quality are included in the assessment: apical distance, quality of seal, presence of taper, and canal transportation (Table 1). The aim of this study was to evaluate the technical quality of endodontic treatment performed by postgraduate students in Karolinska Institutet during the years (2008-2011) and to evaluate the treatment outcome. In addition, possible influencing factors to treatment outcome were analyzed.

© **Table 1.** Definitions of periapical index score, quality score and treatment outcome.

Periapical index score (Ørstavik, et al. 1986)	
1	Normal periapical structure
2	Small changes in the bone structure
3	Changes in bone structure with small mineral loss
4	Periodontitis with well-defined radiolucent area
5	Severe periodontitis with exacerbating features
Quality score (Molander, et al. 2007)	
1	Correct length, good seal, tapered canal, no transportation
2	Correct length, good seal, taper lacking and/or transportation
3	Incorrect length, good seal (taper and transportation not evaluated)
4	Correct length, poor seal (taper and transportation not evaluated)
5	Incorrect length, poor seal (taper and transportation not evaluated)
Treatment outcome (Friedman, 2002)	
(A) Healed	The width and the contour of the periodontal ligament is normal, or there is a slight radiolucent zone around excess filling material
(B) Healing	The radiolucent is clearly decreased but still need further follow-up
(C) Disease	There is an unchanged, increased or new periradicular radiolucency

Materials and Methods

This retrospective cohort study evaluated the outcome of endodontic treatments carried out between September 2008 and June 2011 by the postgraduate students in Karolinska Institutet, Stockholm, Sweden. All maxillary first molars were included in the study. The patients were identified in the database of dental records (Effic). Inclusion criteria were root canal treatment (RCT) of maxillary first molar performed by postgraduate students, existing pre-operative radiographs and follow-up radiographs ≥ 11 months after treatment. The standard routines at the clinic involved a follow-up visit about one year after RCT. Exclusion criteria were: Recall less than eleven months or unreadable radiographs (such as superimposed anatomical structures and radiographs that did not show at least 2mm around the apical area). Because of a lack of post-operative radiographs in a number of the patient records, we sent a letter with an empty CD to their ordinary (referring) dentist, asking for the latest periapical radiographs of the specific tooth.

Root Canal Treatment

The standard procedure was as follows: During preparation, a crown-down technique with Profile (Dentsply Maillefer, Ballaigues, Switzerland) instruments was performed. Each canal was irrigated with 0.5% sodium hypochlorite (NaOCl) solution. The working length (WL) was established with the aid of an apex locator, Root ZX (J. Morita Corp., Kyoto, Japan), and a WL of 0–2 mm from the apex was confirmed with periapical radiograph. A calcium hydroxide dressing was used as an inter-appointment dressing. The canals were filled with gutta-percha cones (Dentsply Maillefer, Ballaigues, Switzerland) and epoxy resin-based sealer Topseal (Dentsply-

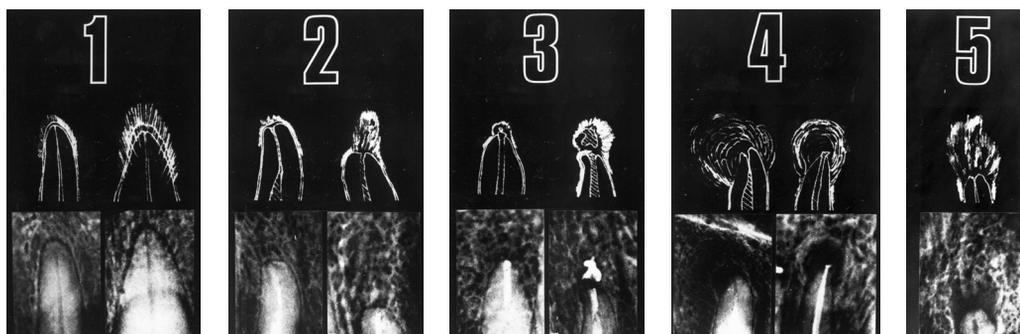
Maillefer, Ballaigues, Switzerland), using cold lateral compaction or thermoplastic obturation techniques. A temporary filling; Intermediate Restorative Material (IRM, Dentsply DeTrey, Konstanz, Germany) was placed in the treated tooth, before sending the patient back to the referring dentist who will place the permanent restoration. Pre-operative and post-operative periapical radiographs were taken during treatment and follow-up apical radiographs about 1 year later. Radiographs were taken using the paralleling technique with the aid of the digital radiographic device, Planmeca Prostyle intra (Planmeca OY, Helsinki, Finland) and Unident apical sensor holder (UNIDENT AB, Falkenberg, Sweden). The radiographs should have adequate quality (i.e., contrast and clarity), and show the entire length of the root and the periapical region.

Data collection

All treatment data were obtained from the original records. Information related to potential prognostic factors, patient related (gender, age, medical history, use of antibiotics), pre-operative status (number of canals, clinical signs and symptoms, type of treatment; primary or retreatment, pulp vitality, radiolucency, periodontal defects), intraoperative variables (number of treatment sessions, apical enlargement, complications), and postoperative variables (coronal restoration either temporary, composite or crown) were recorded. A structured protocol was used to extract data on each treated tooth. A full set of radiographs was attached to each form.

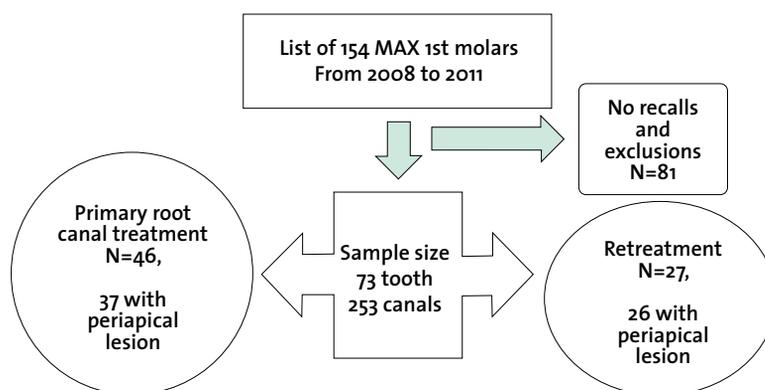
PAI scores and treatment outcome

Two examiners, who are postgraduate students at KI, were assigned to assess PAI scores for



© Figure 1. The visual references of the periapical index (PAI) (Fig 8.2, Ørstavik D, Pitt Ford T eds. Essential Endodontology: Prevention and treatment of apical periodontitis. Oxford, UK: Blackwell Science, 1998).

© Figure 2. Flow chart of the study.



the periapical radiographs. Before assessment of the pre- and post-operative periapical radiographs, the examiners had been calibrated for radiographic interpretation using the periapical index (PAI) calibration kit of 100 periapical radiographs. The radiographic findings were evaluated by the calibrated examiners using a structured form for each tooth. The radiographs were scored according to the PAI system (Table 1; Figure 1). The tooth as a whole was the evaluated unit, and was classified according to the root with the highest PAI-score. Endodontic treatment outcome was determined according to Friedman [7]. The tooth is categorized as healed when follow-up revealed radiographic normalcy (PAI 1&2). A tooth with an initial PAI score >2 that persisted without change at follow-up, is categorized as disease. A tooth with an initial PAI score >2 that at follow-up showed a reduced radiolucency combined with clinical normalcy is categorized as healing (Table 1).

Assessment of root filling quality

All canals were evaluated regarding the root filling quality. Four aspects were judged: apical distance, quality of seal, presence of taper, and canal transportation. Based on these four factors, a quality score by Molander [17] was determined (Table 1). Assessment criteria: The length of the root filling was evaluated as correct if it terminated within 2 mm short of the apex of the root. Cases with surplus of sealer material were judged as having correct length if the apical stop preparation was placed within the accepted distance from the apex. In the quality score, the ideal root canal preparation should

be tapered (roughly corresponding to 0.06) and without signs of canal transportation (zipping or stripping). In roots with two canals only the highest score was used in the analyses. In addition, fractured instruments, perforations, and ledges were identified.

Statistics

Intra- and inter-examiner reliability was assessed using Cohen's Kappa statistics. Analysis of PAI scores and treatment outcome in relation to the RCT quality scores and other possible influencing variables was performed by Chi² or Fisher's Exact test, and the statistical significance was set at $P < 0.05$.

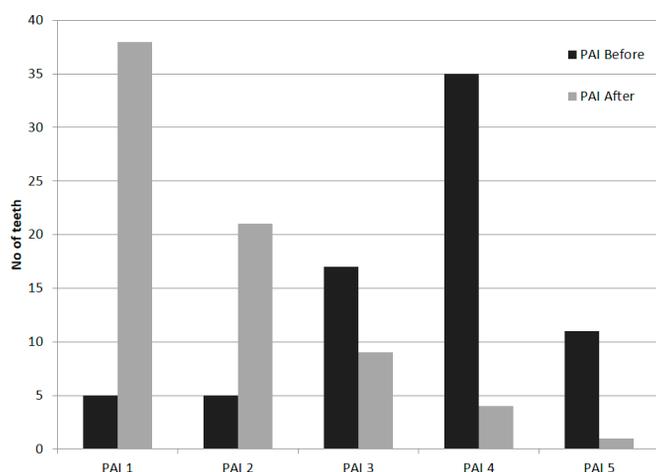
Results

Thirty-three patients from the total of 154 patients attended the routinely annual follow up, resulting in a recall rate of 21.4%. In forty additional patients, appropriate radiographs were received from their dentist, resulting in a total recall rate of 47% (Figure 2). Females (44) comprised 60.3% of the population and males (29) were 39.7%. The age of the patients ranged between 14 and 77 (median age 51 years and a mean age 49 years). The time for follow up ranged between 11 months and 4.5 years (mean \pm SD: 20 \pm 11 months). A total of 73 teeth (253 canals) were included in the study (33 PA radiographs from the records in our clinic in KI and 40 from the referring dentists). Forty-one teeth (56%) had 3 canals, whereas thirty-two teeth (44%) had 4 canals. Out of 253 canals, 190 were judged as straight and 67 curved, the latter mainly found in the mesiobuccal roots. In total, sixty-three

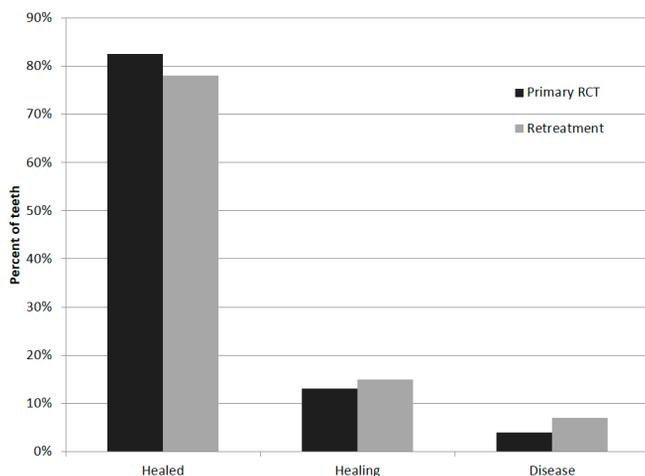
© **Table 2.** The outcome of the RCT in relation to the quality of the root filling*.

Treatment outcome/ Quality score	Healed	Healing	Disease	Total
Score 1-2	37 (88%)	4 (10%)	1 (2%)	42 (100%)
Score 3-5	22 (71%)	6 (19%)	3 (10%)	31 (100%)
Total	59 (81%)	10 (14%)	4 (5%)	73 (100%)

*Treatment outcome according Friedman (2002) and Quality score according to Molander et al. (2007). See table 1 for details



© **Figure 3.** Periapical score (PAI) score before and after RCT of 73 maxillary molars. Follow up time ranged from 11 months to 4.5 years.



© **Figure 4.** The treatment outcome (Friedman, 2002) in relation to the type of RCT (primary treatment vs. retreatment).

teeth (86.3%) had periapical lesion at the time for RCT. Initial root canal treatment was performed in 46 teeth (63%) and 27 teeth (36.9%) were retreated (Figure 2). From the total sample size, eighteen patients (25%) were complaining of pain before the treatment, and there was no significant association between the presence of pain and treatment outcome ($p = 0.53$). Eleven teeth (15%) had fistula before the treatment, and no significant association was found between fistula and treatment outcome ($p = 0.13$). The numbers of visits to complete RCT treatment for each tooth were calculated, twenty-four teeth (33%) were treated within 2 visits, forty-two teeth (57%) in 3 visits, only seven teeth (10%) were treated in 4 visits. There was no significant association between the number of visits for root canal treatment and the treatment outcome ($p = 0.43$). Twenty-one teeth were restored with temporary restoration, whereas 52 teeth were restored with permanent restoration (composite, crown, or post and crown) at the time of follow-up.

Root filling quality

Table 2 shows that 58% of the RCT's had good seal and correct length (score 1-2; 42 teeth), while 42% showed inadequate seal or/and length with/without transportation (score 3-5; 31 teeth). There were six cases of ledges (4 in straight canals, 2 in curved canals), four cases of fractured files during treatment (2 in straight canals, 2 in curved canals), one case of transportation and one case of perforation, both located in straight canals.

PAI scores and treatment outcome

The Cohen's Kappa statistics for intra- and inter examiner reliability of PAI scores were 0.98 and 0.95, respectively. Figure 3 shows the PAI scores before and after the treatment. The score with highest incidence before treatment was PAI 4

© **Table 3.** The outcome of the root canal filling in relation to restoration.

Final restoration	Healed	Healing	Disease	Total
Temporary	16 (76%)	4 (19%)	1 (5%)	21 (100%)
Composite	18 (78%)	3 (13%)	2 (9%)	23 (100%)
Crown/crown and post	25 (86%)	3 (10%)	1 (4%)	29 (100%)
Total	59 (81%)	10 (14%)	4 (5%)	73 (100%)

(periodontitis with well-defined radiolucent area), whereas the most common score after treatment was PAI 1 (normal periapical structure). Periapical periodontitis, i.e. PAI scores 3-5, were found in 63 teeth before treatment and decreased to 14 teeth at follow-up. Complete periapical healing was obtained in 49 teeth. Figure 4 shows the outcome of RCT in relation to the type of treatment (primary treatment or retreatment). There was no significant association between the outcome and the type of treatment ($p = 0.6$).

Coronal filling and treatment outcome

Table 3 shows the relationship between the outcome of the RCT in relation to the final restoration. In all, 76% with temporary restoration had healed, compared to 83% in teeth with permanent restorations ($P=0.52$).

The outcome of root canal treatment in relation to follow up time

Table 4 shows the relationship between the outcome of RCT and the follow up time. The sample was divided in two groups in regard to follow-up period: short follow-up (11-16 months) and long follow-up (>16 months). The healing rates were

76% in the short follow-up group and 86% in the long follow-up group. There was no significant association between the treatment outcomes in relation to follow up time ($p = 0.31$).

The quality of root canal filling and treatment outcome

Table 2 shows the relation between the RCT quality according to the Molander score and the treatment outcome (Friedman score). In total, the treatment outcome was successful in 59 (81%) of the cases. The success rate was 88% in cases with high quality root fillings (score 1-2), compared to 71% in cases with unsatisfactory quality (score 3-5). There was a non-significant trend ($P=0.066$) of an association between RCT quality and treatment outcome.

Discussion

Methodology

Although randomized, controlled trials are regarded as the gold standard in clinical research, the majority of studies on root canal treatment outcome are retrospective surveys and this can be considered a weakness in this study. Numerous studies have analyzed collected data retrospective-

© **Table 4.** The outcome of the RCT in relation to follow up time.

Treatment outcome/ Follow up time	Healed	Healing	Disease	Total
Short follow up (11-16 months)	29 (76%)	8 (21%)	1 (3%)	38 (100%)
Long follow up (>16 months)	30 (86%)	2 (6%)	3 (8%)	35 (100%)
Total	59 (81%)	10 (14%)	4 (5%)	73 (100%)

ly to determine the influence of various factors on the outcome of root canal treatment [13, 30, 32].

PAI scores and treatment outcome:

The Periapical Scoring System was used in the evaluation of periapical status and the detection of periapical pathology. Although the PAI system is used in many studies aiming to investigate the periapical health of teeth, it has been further stated that the PAI system may not be suitable for all tooth positions because thickness of cortical bone and the position of the root tip vary with tooth position [35]. Although these points may raise some concerns regarding the reliability of the PAI system, it was preferred as the method of assessment in the present study because it provides a categorized description of periapical pathologies. Also, considering that apical periodontitis lesions limited to the cancellous bone might pass unnoticed in radiographic examination, more sensitive techniques can be used in further studies. One of these methodologies is cone-beam computed tomography [33]. Although more precise and sensitive, these systems carry the disadvantage of exposing patients to a higher radiation dose.

The follow up rate in our study was low because of high cancellation of recall visits, patients preferred to be seen by their general dentist, some of the patients had moved to other parts of the country or did not answer the recall request. The wide geographical distribution probably prevents patients without symptoms from attending the follow-up examination. When patients do not respond to recall (a low recall rate), the reported success rate could be under- or overestimated; therefore, the teeth that are followed-up may not truly represent the study population. This may be considered as one of the drawbacks and limitations of the present study. However, the high proportion of patients lost to follow-up was similar to other studies [15, 30].

When comparing the results of the present study with various other studies, there are some difficulties because of variations in criteria for the evaluation of the periapical healing, the length of the postoperative observation period, and the type of teeth treated. The teeth in the present study were maxillary first molars, which is a tooth with complex anatomy. It has been reported that the second mesiobuccal canal can sometimes be missed during treatment. In ad-

dition, the high rate of curved buccal canals and poor accessibility can lead to incomplete instrumentation and obturation. Multi-rooted teeth with curved root canals present more of a challenge in all stages of root canal treatment and their higher failure rates may be the result of factors other than filling technique alone, e.g., lack of access, poorer cleaning and presence of accessory canals [24].

Root filling quality:

In the present study, the majority of the RCT's showed good seal and correct length (58%). This result is in agreement with a study done in Sweden [9], which found that adequate quality in root canal treatment in molars was 51%.

We evaluated RCT quality in all canals regarding length, density and tapering, and we found no significant association between the RCT quality and the canal anatomy (palatal, mesiobuccal, and distobuccal). However, short fillings were slightly more common in the mesiobuccal canals, whereas over fillings, voids, and irregular tapering were slightly more common in the palatal canals. This can be explained by the fact that most mesiobuccal canals are curved and achieving a full working length is difficult. Also, palatal canals have wide canal anatomy that makes it more difficult to fill the canal completely without voids and wide apical foramen that will predispose to overextended filling. Our findings were in agreement with another study [11], which found that the mesiobuccal roots of upper molars had a lower frequency of overfilling than palatal roots. The rate of complications, i.e., ledges, fractured files, transportation, and perforation, was low, which may be the result of the high standard quality of treatment that is served by the postgraduate clinic in Karolinska Institutet. In a study on RCT performed by undergraduate students, higher rates of ledges and root perforation were revealed [5]. On the other hand, the frequency of fractured instruments was found to be lower in another study [26]. This can be explained by the usage of hand files. In the present study rotary instruments were used, which is associated with a higher frequency of breakage. In addition, the cases treated by postgraduate students are presumably more complicated compared with cases treated by undergraduate students.

The finding of this study presented a relatively

low frequency of second mesiobuccal canals compared to a study from 2006 [2]. However, the frequency is considered to be high when compared to older studies [12, 28]. The incidence of finding second mesiobuccal canals appears to be increasing with the routine use of the surgical operating microscope and other aids during endodontic access opening procedure.

In the present study, we found that the success rate for the primary root canal treatment was slightly higher than for the retreatment, although not statistically significant. This is in accordance with previously published results [8], showing 82.4% success for primary root canal treatment and 70.3% success in cases of retreatment. Another study by Sjogren et al. [30], found a higher success rate for primary treatment (94%) than for retreatment (62%).

Coronal filling and treatment outcome:

Although the association between the coronal restoration and treatment outcome was not significant, we found high success rate (83%) related to teeth restored with permanent restoration compared to those restored with temporary restoration (76%). The quality of the coronal restoration has been reported to be important for the outcome of RCT, even as important as the quality of root canal filling [10].

The outcome of root canal treatment in relation to follow-up time:

Although there was no significant association between treatment outcome and follow up time, we found longer follow-up time will slightly increase the success rate. This is in accordance with the study by Murphy et al. [18] that emphasized the importance of the length of follow-up. When recall occurred at least 12 months after nonsurgical endodontic treatment, 70.6% of the lesions demonstrated complete healing. However, if the recall period was 6 months or less, only 17.6% showed complete resolution. It has been suggested that follow-up of at least 1 year is required to reveal meaningful changes [6, 20].

The quality of root canal filling and treatment outcome:

In the present study, the treatment outcome was successful in 81% of the cases. This is considered a notable finding since the present sample only included maxillary molars, in comparison to

other studies where all types of teeth have been included [30, 32]. The results of this study are in agreement with the study by Smith et al. [32] that reported an overall success rate of 84% in RCTs performed by postgraduate students and staff in a dental hospital. In the present study, complete resolution of the periapical lesion was slightly more common in cases with satisfactory root fillings compared to unsatisfactory root fillings. This supports the opinion that satisfactory quality of root fillings are associated with a better outcome.

In the present study, the association between RCT quality and treatment outcome was not statistically significant. This is presumably due to the low number of cases and relatively short follow-up time.

Conclusion

The association between the quality of the root filling and the treatment outcome was not verified with statistical significance, but the results indicate a trend that satisfactory root fillings are associated with a favorable outcome. This study was limited by its retrospective nature and a relatively small sample size.

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A randomized controlled cross-over study of the effect of alcohol-free chlorhexidine and essential oils on interleukin-1 levels in crevicular fluid

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Abstract

⊙ Aim of the study was to determine the effect of an alcohol-free chlorhexidine mouth rinse and an essential oils containing mouth rinse on pro-inflammatory cytokine levels in gingival crevicular fluid in participants who continue to perform their regular mechanical oral hygiene regimes and normal dietary practice.

Twenty adult volunteers (mean age: 59 years) participated in the double-blind randomised controlled cross-over study. Three mouth rinses were used during 16-day periods as an adjunctive to regular mechanical oral hygiene: a solution with alcohol-free chlorhexidine (CHX; Paroex[®]), a solution with essential oils (EO; Listerine[®]), and water (negative control). The mouth rinse periods were separated by 3-month washout periods.

At days 0 (baseline) and 17 (end) of each mouth rinse period, gingival crevicular fluid (GCF) was collected at different tooth sites and analyzed with ELISA technique for IL-1 α , IL-1 β and IL-1ra levels.

No significant correlations between clinical parameters (QHI and GI) and cytokine concentrations were observed, regardless of mouth rinse regimen. The generalized linear models revealed that none of the mouth rinses had a statistically significant impact on IL-1 concentrations in GCF. Large inter-individual variations were observed for the levels of IL-1 α , IL-1 β and IL-1ra. Also the changes in concentrations between day 0 and day 17 for the mouthrinses showed large intra-individual variations.

It can be concluded that neither the alcohol-free chlorhexidine nor the mouth rinse containing essential oils reduced the levels of IL-1 α , IL-1 β and IL-1ra in GCF.

Key words

Clinical, chlorhexidine, crevicular fluid, cytokines, essential oils, mouth rinse

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Effekten av daglig sköljning med munsköljningsvätskor innehållande alkoholfri klorhexidin eller essensolja på interleukin-1 nivåer i crevikulär vätska: En randomiserad kontrollerad cross-over studie.

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Sammanfattning

🕒 I studien utvärderades effekten av olika munskölj på pro-inflammatoriska cytokinnivåer i fickexudat. Tjugo frivilliga vuxna (medelålder: 59 år) deltog i en dubbelblind randomiserad cross over-studie. Tre munsköljningar användes under en 16-dagarsperiod som ett komplement till mekanisk rengöring. En alkoholfri klorhexidin (CHX; Paroex®), en munsköljning med essentiella oljor (EO; Listerine®), och vatten (negativ kontroll). De tre munsköljningsperioderna separerades av 3-månaders wash out-perioder.

På dag 0 (baseline) och dag 17 (slutet) av varje munsköljperiod, samlades fickexudat (GCF) vid olika tandytor som analyserades med ELISA-teknik för IL-1 α , IL-1 β och IL-1ra förekomst.

Inga korrelationer mellan kliniska parametrar (plack, gingivit) och cytokinkoncentrationer observerades för de tre munsköljningarna. De tre munsköljningarna hade ej statistisk signifikant effekt på IL-1 koncentrationer i fickexudat. Stora inter-individuella variationer observerades för IL-1 α , IL-1 β och IL-1ra. Även intra-individuella förändringar i koncentration mellan dag 0 och dag 17 visade stora variationer.

Det konkluderades att munsköljning med alkoholfri klorhexidin och essentiella oljor inte minskade IL-1 α , IL-1 β och IL-1ra koncentrationer i fickexudat.

Introduction

Chemical plaque control is based on the potential deficiencies of mechanical cleaning. Several clinical studies have shown the effectiveness of the most widely used antimicrobial mouth rinses, chlorhexidine (CHX) and essential oils (EO), in reducing supragingival plaque and gingivitis, especially in absence of mechanical oral hygiene procedures (5,13,19,40).

Alcohol, especially ethanol, serving in most mouth rinses in relative high concentrations (6-29%) as a vehicle to dissolve and/or stabilize other substances, shows a slight antibacterial efficacy against oral bacteria and improves the shelf-life of the agent (44). However, here is a concern that alcohol can cause oral dryness and pain, epithelial desquamation and deteriorate the surface of dental resin-based restorations (8,12,17). Ethanol may increase the risk of oral cancer although several studies failed to identify such a relationship (26,27,31). Alcohol-free CHX mouth rinses can be used especially in patients where the alcohol content may raise problems. There is limited evidence that the omission of ethanol does not reduce the efficacy of CHX on the development of plaque and gingivitis or its effect on cariogenic microorganisms (4,28,44,46). The present study is part of an ongoing clinical project evaluating the effect of alcoholic-free CHX and essential oils containing mouthrinses on different oral health parameters like plaque acidinogenicity, cariogenic microorganisms, plaque and gingivitis occurrence and several salivary and crevicular fluid parameters (3,46).

Plaque-induced gingival inflammation develops within a couple of days of undisturbed plaque accumulation. An increased vascular permeability occurs and higher leakage of a serum-like exudate with plasma proteins and inflammatory cells is observed. The exudate takes up locally produced molecules during the passage of the gingival tissues to the gingival crevice. The content of the gingival crevicular fluid (GCF) reflects inflammatory reactions taking place in the gingival tissues (10,37). Cytokines, low-molecular-weight proteins, are synthesized in response to bacteria and their products, inducing and maintaining the inflammatory response in the periodontal tissues. Interleukin 1 (IL-1) are a group of pro-inflammatory cytokines, which play an important role in the initiation and regulation of the gingival inflammatory response to dental plaque (6,36). IL-1 cytokines are produced by a large range of cells including macrophages, B-cells, neutrophils,

epithelial and endothelial cells as well as fibroblasts (12,18). They have been observed in gingival crevicular fluid at clinically healthy sites (7) and in experimental gingivitis models, where gingival inflammation is deliberately induced by cessation of oral hygiene measures. Inflamed gingival tissues contain elevated numbers of IL-1-secreting cells, neutrophils as well as macrophages, and concentrations of IL-1 increased sharply within the first week of undisturbed plaque accumulation (18,34,48). IL-1 consists of two protein isoforms, IL-1 α and IL-1 β of which IL-1 β appears to be the more potent agent. The interleukin-1 receptor antagonist (IL-1ra) protein acts by binding with high affinity to the same receptors as IL-1 without inducing any of the biological effects set off by IL-1 receptor binding to control IL-1 activity (14,36). IL-1 β levels can increase in GCF during the initial phase of gingival inflammation before the onset of clinical signs of gingivitis (20,48). Increased levels of IL-1 have also been reported in the crevicular fluid of orthodontic patients during force application (43).

Two studies investigated the effect of antimicrobial mouth rinses on pro-inflammatory tissue response in the absence of oral hygiene. Türkoglu et al. (42) showed unchanged IL-1 levels in GCF in subjects with untreated plaque-associated gingivitis after a 4-week rinse period with an undefined CHX mouth rinse. Zhang et al. (48) observed that CHX rinse in the absence of mechanical plaque control prevented the elevation of GCF IL-1 β release in healthy adults. It is not known if the alcoholic-free CHX and/or essential oils containing mouthrinses, besides an antimicrobial effect, also can influence the initiation of the inflammation process by reducing the frequency of pro-inflammatory cytokines in patients who use their regular mechanical oral care. No clinical study has been published evaluating if these mouthrinses do influence pro-inflammatory cytokines, especially those who are present in the early stage of the inflammation process like interleukin-1, if regular mechanical oral hygiene procedures are used. The specific aim of this clinical randomized cross-over study was to evaluate changes of IL-1 α , IL-1 β and IL-1ra in gingival crevicular fluid during 16-day rinsing periods with an essential oils-containing and an alcohol-free chlorhexidine mouth rinse in participants using their regular mechanical oral hygiene. The hypothesis tested was that rinsing with the antimicrobial solutions does not affect the levels of IL-1 α , IL-1 β and IL-1ra in GCF.

Material and methods

Test subjects

Twenty adult volunteers (12 males and 8 females) with a mean age of 58.9 years (range 42-90 years), regularly attending the dental clinic for control of their dental status were recruited at the Public Dental Health Clinic at the Dental School of Umeå, Sweden. Inclusion criteria were 1) good general health reported in anamnesis, 2) minimum of 24 teeth, six teeth in each quadrant and 3) no current active caries lesions and a history of moderate or no caries activity. Exclusion criteria were 1) destructive periodontitis, 2) antibiotic therapy during the previous six months, 2) use of oral antiseptics and 3) use of tobacco, food or lipstick 2h prior the examination, 4) did not wear removable partial dentures, orthodontic appliances or dental implants (3).

No power calculation was done because a missing knowledge of the to be expected difference in IL levels between the groups. The sample size was based on, and slightly higher than, previous sample sizes used in similar designed cross-sectional evaluations, which allowed determination of significant differences between groups in the intra-individual comparison design (3,33,23-25,46). Oral and written information was given to the subjects at the first visit. All subjects gave their informed consent prior to the start of the study. The study was approved by the Regional Ethical Review Board at the medical faculty, Umeå University, Sweden (Dnr 08-072M) and we followed recent CONSORT recommendations writing the manuscript.

Study design

The study was designed as a double-blind randomized controlled cross-over study enabling an intra-individual comparison of three mouth rinses (1,2,11): 1) a solution with 0.12% alcohol-free chlorhexidine (Paroex®; Sunstar Butler Mölndal, Sweden; CHX; without CPC); 10ml, for 60s rinsing, 2) a solution containing essential oils (Listerine fluoride®, McNeil, Stockholm, Sweden; EO; 0.225ml 95% ethanol ml, 0.06% thymol, 0.04% menthol, 0.09% eucalyptol, 0.05% methylsalicylate and 0.22% fluoride); 20 ml for 30s rinsing, and 3) water (negative control), 10ml for 60s rinsing. Each subject participated in each rinse regimen in a randomized order. Randomization was performed at the start of the study by using sealed random numbers. Each product was used during a test period lasting 16 days as an adjunctive to the subjects' regular mechanical oral hygiene procedures and normal dietary habits.

The participants continued to perform their regular mechanical oral hygiene regimes and normal dietary practice throughout the study. To induce formation of gingival crevicular fluid, subjects refrained from brushing during three days before each mouth rinse period started and during the last three days of each rinsing period as described by Wikén Albertsson et al. (3,46). The different mouth rinse periods were separated by 3-month wash-out periods. The unsupervised rinsings were initiated after a baseline oral examination (Day 0). The mouth rinses were used according to the manufacturers' recommendations. After the baseline registrations professional tooth cleaning (PTC) was performed. The subjects used the mouth rinses once on Day 0 and twice a day during Days 1-16. In order to assure compliance, they maintained a written diary to document the rinsing as well as the performance of the daily mechanical oral hygiene procedures. None of the participants was familiar with the commercial mouth rinses. The mouth rinses were distributed to the participants in unmarked, plastic bottles. In addition, the persons performing the clinical examinations were not aware of which treatment each individual participant was subjected to.

Gingival crevicular fluid sampling

Sampling of GCF was performed at the Public Dental Health Clinic at the Dental School of Umeå, Sweden. Each subject attended six sessions; at baseline (Day 0) and at the end of each mouth rinse period (Day 17). On Days 0 and 17, the subjects were not allowed to eat, drink or use tobacco for 2 h prior to sampling. GCF samples were taken at each session contiguous to the mesio-buccal surfaces of 11, 14 and 16. If any of these teeth was missing or in case of presence of restorations in one of the teeth a suitable neighbouring tooth was chosen. The sites were isolated with cotton rolls and then carefully sprayed with water to remove saliva in order to reduce the possibility of contamination. A saliva ejector was used. Each site was then gently dried for ten seconds using an air syringe. A standard paper strip (Perio-paper®, ProFlow, Amityville, NY, USA) was inserted carefully at the orifice of the gingival sulcus and left in situ for 30 s. Strips contaminated by blood were excluded. Fluid volume on the strip was immediately measured with a Periotron 8000® (ProFlow, Amityville, NY, USA). A second strip was then inserted at the same site for another 20 s and fluid volume was again measured. Immediately after sampling the GCF, the absorbing part of both strips were transferred to a coded plastic

tube (Eppendorf) and stored at -70°C until performance of cytokine analyses. Absolute fluid volumes were determined from performed standard curves by using standardized volumes of distilled water with the Periotron 8000[®], adding the volumes of both strips and expressed as $\mu\text{l}/\text{sample}$. After GCF assessments, Plaque Index (QHI) (35,40) and Gingival Index (GI) (29) were scored at the test sites. Each subject then received a PTC by the author who performed all the clinical measurements and sampling (KWA). The assessments and index scores evaluated were registered during the evaluation by another author (AP).

ELISA analysis of IL-1 α , IL-1 β and IL-1ra

GCF samples were eluted in phosphate-buffered saline (PBS pH 7.4) for 1 h at 4°C and then centrifuged ($400 \times g$ and 5°C for 10 min). The supernatant was stored at -70°C . The concentrations of IL-1 α , IL-1 β and IL-1ra were quantified with enzyme-linked immunosorbent assays (ELISAs) according to the protocol provided by the supplier (duo-set, R&D Systems, Abingdon, UK). All wells were filled with $50 \mu\text{l}$ of the respective substances. After washing, $50 \mu\text{l}/\text{well}$ of K-Blue[®] Aqueous TMB Substrate (Neogen Corporation, Lexington, KY, USA) was added, and the plates were incubated in the dark for 20 min at room temperature. The reaction was terminated with $25 \mu\text{l}/\text{well}$ of $1\text{M H}_2\text{SO}_4$ solution. Plates were read at 450 nm in a spectro-photometer (EMax, Molecular Devices, Mississauga, Ontario, Canada). All samples were assayed in triplicate. The detection levels of the assays were 1 pg/ml for IL-1 α , 1.25 pg/ml for IL-1 β and 39 pg/ml for IL-1ra. Calculation of the cytokine concentration in each GCF sample was

performed by dividing the total amount of IL-1 α , IL-1 β or IL-1ra by the volume of the sample. Results were expressed as picograms of cytokine ($\pm \text{SD}$) per microliter of GCF.

Statistical analysis

The data were processed in SPSS (Statistical Package for the Social Sciences, version 22, Chicago, IL, USA). Cytokine concentrations were tested with Kolmogorov-Smirnow for normal distribution. Gingival index (GI;29) and Quigley-Hein plaque index (QHI;35) modified by Turesky et al were assessed on the buccal, mesio-buccal and distobuccal surfaces of teeth 11, 14, 16, 31, 34, 36 without fillings. Analysis of these variables are presented in another ongoing publication. Correlations between cytokine concentrations and QHI and GI were assessed by Spearman's rho. Changes in concentration of the different IL-1 cytokines ($\text{pg}/\mu\text{l}$), differences between respective individuals baseline value (day 0) and end (day 17), were analyzed by a generalized linear model. The repeated measures of cytokine concentrations were chosen as within-subject variables. Mouth rinse regimens were set as the between-subjects factor.

p-values < 0.05 were considered statistically significant.

Results

No adverse effects were reported by any of the subjects during or after the rinsing regimens. Eighteen of the originally twenty subjects successfully completed all three series of rinses. One participant attended two sessions and received than antibiotics to treat a non-oral inflammation, while the second drop out did not want to continue the rinsings. Data

© **Table 1.** Gingival crevicular fluid volumes for the three mouth rinse groups at baseline and end of rinsing periods given as mean (standard deviation).

GCF Volume (μl)	baseline	17 days	Change	p-value
CHX	0.84 ± 0.38	1.17 ± 0.46	0.34 ± 0.52	0.014
EO	1.17 ± 0.58	1.06 ± 0.51	-0.11 ± 0.63	0.477
Water	1.03 ± 0.52	0.95 ± 0.34	-0.08 ± 0.62	0.610

© **Table 2.** Concentrations of IL-1 cytokines in gingival crevicular fluid for the three mouth rinse groups at baseline and end of the rinsing period given as mean (standard deviation).

Concentration in GCF (pg/μl)	CHX		EO		Water	
	baseline	17 days	baseline	17 days	baseline	17 days
IL-1α	60.8 ±31.7	62.9 ±36.8	47.8 ±31.2	70.9 ±64.8	87.6 ±66.3	71.1 ±55.7
IL-1β	20.0 ±14.8	18.7 ±16.3	13.9 ±10.4	22.1 ±20.4	25.3 ±20.1	23.2 ±21.2
IL-1ra	30343.7 ±19648.0	25137.8 ±13725.9	24422.4 ±18391.3	30455.2 ±23983.1	33250.7 ±21278.5	29630.3 ±15872.2

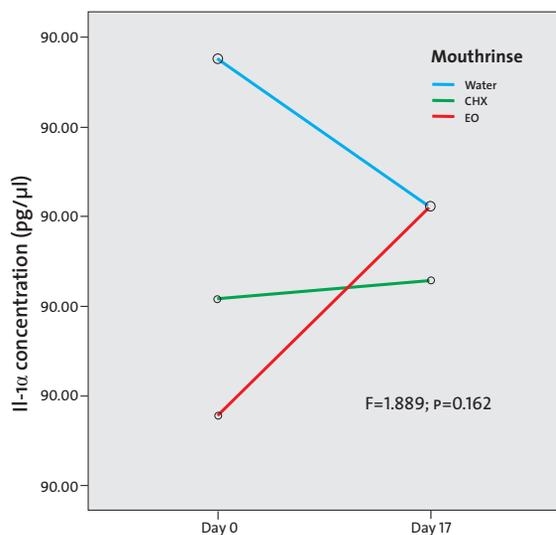
© **Table 3.** Changes in concentrations of IL-1 cytokines in gingival crevicular fluid for the three mouth rinse groups given as mean (standard deviation). Positive values indicate increase.

Changes in concentration in GCF (pg/μl)	CHX	EO	Water
IL-1α	2.1 ±35.9	23.1 ±74.0	-16.4 ±66.5
IL-1β	-1.3 ±13.4	8.2 ±23.1	-2.1 ±22.6
IL-1ra	-5205.9 ±25690.3	6032.8 ±29358.6	-3620.5 ±29289.8

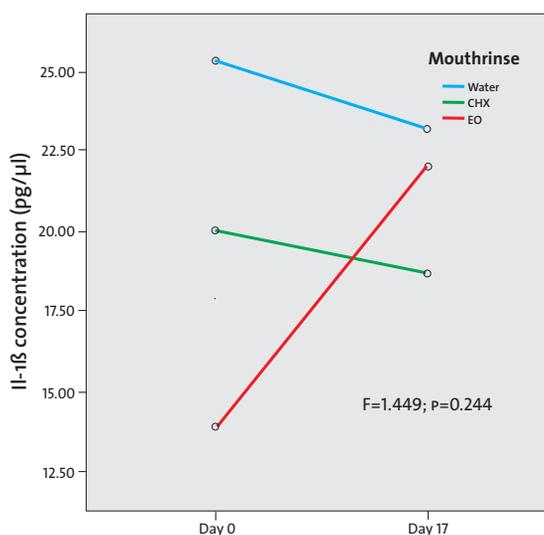
© **Table 4.** Baseline values of Gingival index (GI; Löe 1967) and Quigley-Hein plaque index (QHI) modified by Turesky et al assessed on the buccal, mesio-buccal and distobuccal surfaces of teeth 11, 14, 16, 31, 34, 36.

Mouthrinse	mean	medium	SD	SEM
GI				
EO	1.13	1.14	0.53	0.12
CHX	1.23	1.25	0.68	0.16
Water	1.02	1.00	0.66	0.16
QHI				
EO	2.31	2.41	0.59	0.14
CHX	2.33	2.19	0.75	0.17
Water	2.12	2.10	0.70	0.16

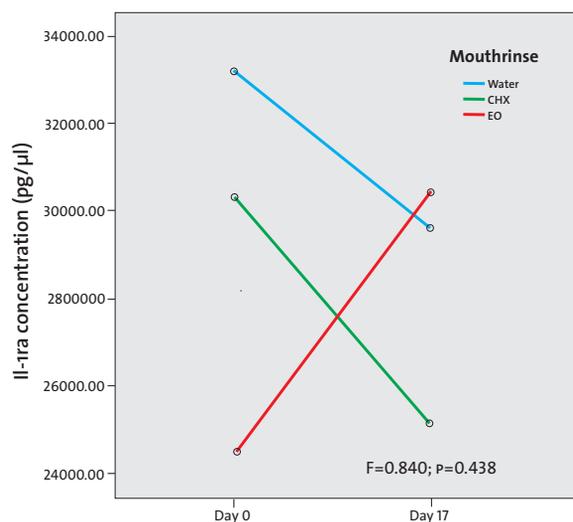
© **Figure 1.** Generalized linear model (repeated measures). Within-subject variables: IL-1 α concentrations. Between-subject factor: mouth rinse.



© **Figure 2.** Generalized linear model (repeated measures). Within-subject variables: IL-1 β concentrations. Between-subject factor: mouth rinse.



© **Figure 3.** Generalized linear model (repeated measures). Within-subject variables: IL-1 γ concentrations. Between-subject factor: mouth rinse.



from both subjects were removed from all analyses. The three IL-1 cytokines were detected at all sites.

The GCF volumes at baseline and at 17 days for each of the three mouth rinses are presented in Table 1. The results of the Spearman's rho analyses showed

no significant correlations between clinical parameters (QHI and GI) and cytokine concentrations, regardless of mouth rinse regimen. Large inter-individual variations were observed for the levels of IL-1 α , IL-1 β and IL-1 γ in GCF. Mean values at baseline and at the end of each mouth rinse period are shown in Table 2. Changes in concentrations of IL-1 cytokines in gingival crevicular fluid for the three mouth rinse groups given as mean (standard deviation)(Table 3). Positive values indicate increase. Table 4 gives the baseline plaque (QHI) and gingivitis (GI) levels for the three mouthrinses shown as mean, medium, SD and SEM. Figures 1-3 illustrate changes in cytokine concentrations during the three different mouth rinse regimens. The generalized linear models revealed that none of the mouth rinses had a statistically significant impact on IL-1 concentrations in GCF.

Discussion

The present randomized cross-over study assessed the effect of 0.12% alcohol-free CHX and an EO mouth rinse compared to a control water mouth rinse. The results showed that 16 days of rinsing with the 0.12% alcohol-free CHX or the EO mouth rinse, in addition to regular daily oral hygiene measures, did not result in significant changes of

IL-1 α , IL-1 β and IL-1ra levels in GCF. The hypothesis was therefore accepted. The present findings confirm results by Türkoğlu et al. (42), who tested an alcohol-containing CHX mouth rinse and observed no impact on GCF cytokine levels. The intra-individual comparison design reduces highly variable individual-confounding influences like oral health and oral hygiene habits, diet and salivary quality/quantity, caries experience, socioeconomic status and genetic differences. These parameters may vary dramatically between subjects and thereby mask the effect of tested chemical agents in a parallel design study (11). The cross-over design requires fewer subjects than a parallel design and has considerable power to detect statistical differences between agents (1,2).

Short and long term clinical studies have shown that daily use of EO and CHX mouth rinses may retard plaque build-up and thereby reduce gingivitis (19,40). Wikén Albertsson et al. (46) showed recently that 16 days of EO and CHX mouth rinsing had little effect on the number of cariogenic microorganisms in patients who used their own oral care measures during the rinsing periods. An advantage of assessing GCF is the simple, non-invasive technique and repeatability (18). The local production of IL-1 α , IL-1 β and IL-1ra levels in GCF have been found to be increased with increasing inflammation (32,36). Several investigations have shown that IL-1 β is a reliable marker associated with the presence and severity of plaque-induced gingival inflammation (7,15,41). Previous studies demonstrated that IL-1 β and IL-1ra are present in crevicular fluid in the vast majority of patients (9,18,34). All GCF samples in the present study contained IL-1 but with a wide range of concentrations. This high variability was also observed by other authors (7,18,41). No significant correlation was found between clinical gingivitis status, and the level of gingival crevicular fluid and inflammatory cytokines as have been reported in many other studies (16,18,21,30,36).

Cytokines are objective biological markers of inflammation but they have been investigated only in few studies on chemical antibacterial treatment (39,42). The effects of mouthrinses on cytokines may vary and depend on the frequency of application, the concentrations used and whether or not subjects continued their regular oral hygiene measures. Significantly reduced IL-1 β and prostaglandin E₂ levels in GCF were observed after two applications with a 1% CHX/ 1% thymol-containing dental varnish (47). The CHX/thymol varnish had a ten times

higher CHX concentration, than the CHX mouth rinse used in this study, and is combined with an additional antibacterial substance, thymol. Sharma et al. (39) observed significant lower IL-2 and IFN- γ levels in gingival biopsies after 2 weeks of rinsing with 0.2% alcohol-containing CHX and EO in children with severe chronic gingivitis continuing with their regular tooth cleaning habits. In experimental gingivitis studies, increased levels of IL-1 β preceded clinical signs (18,20,48), while a CHX rinse prevented the elevation of IL-1 β in healthy adults. Sekino & Ramberg (38) evaluated in an intra-individual model the effect of regular mouthrinsing with EO and alcohol-containing CHX during a 2-week period of no mechanical oral hygiene on the GCF content of lactoferrin an antibacterial produced by PMN cells. The lactoferrin/ albumin ratio in the EO group was significantly smaller compared to the negative saline rinse group but significantly larger when compared to the CHX group. Zhang et al. (48) showed that rinsing with 0.12% CHX during a 3-day no brushing period in healthy adults prevented elevations in GCF flow rates and IL-1 β release. In non-rinsing subjects with no oral hygiene, IL-1 β levels were increased after 3 days. In these studies which observed an increase of IL-1 levels in GCF, participants refrained from their regular mechanical oral hygiene procedures or an experimental gingivitis model was used.

Few studies have investigated the additional effect of these antibacterial mouth rinses on GCF cytokine levels in subjects with regular daily mechanical oral hygiene habits. Türkoğlu et al (42) reported that neither an alcohol-containing CHX nor a placebo mouth rinse, without the active chlorhexidine digluconate, in addition to daily mechanical plaque control, resulted in significant reductions of GCF IL-1 α , IL-1 β and IL-1ra levels. Significant reductions in plaque index and papillary bleeding index in the CHX, but also in the placebo subjects were observed. The authors explained this with the Hawthorne effect due to a high awareness of oral health care as well as the effect of control visits. The present study focused on the additional effect of mouth rinses in healthy subjects, who continued their regularly oral hygiene measures during the whole rinsing period. The experimental study design was thought to resemble clinical where there the mouth rinses will be used in cases of low to mild gingivitis. A high inter-individual variability of IL-1 concentrations was observed, which can be used as an explanation for the non-significant differences between the control group and the active mouth rinses. In contrast to a

parallel study design, differences in baseline levels of the three groups are not important because the statistical testing of the effect of the mouthrinses is based on the intraindividual differences between the baseline and end values for each of the participants (1,2,11). Therefore large variations at baseline, participants with both low and high values, are accepted. However, very large intraindividual variations of IL-1 values were also found for the change of concentrations within the participants during the rinse periods. This explains that significance differences between the mouthrinses were difficult to obtain. It was not possible to observe that the mouthrinses influence the formation of IL-1 cytokines in patients who used their own regular oral care measures during rinsing. GCF IL-1 variability has earlier been associated to daytime variation, gender and psychological stress (7,41,45). A disadvantage of the present cross-over study can be the time length each participant participated. It is very well possible, considering that there are daytime variations in IL-1 production observed, the biological variations of IL-1 concentrations over a more than one year period can be even larger. Waschull et al. (45) reported gender differences in IL-1 β response in an experimental gingivitis study. Males showed a strong increase within the first week of plaque accumulation while women showed an IL-1 β increase only after three weeks of continuous plaque accumulation. However, in the present study, an intra-individual comparison model was used for the three mouth rinses, which controlled the gender influence.

It can be concluded that the use of 0.12% alcohol-free CHX and EO mouth rinses in healthy adult subjects with regular daily oral hygiene measures had no additional effect on the levels of IL-1 cytokines in gingival crevicular fluid.

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Oral condition and background factors in Somali immigrant children newly arrived in Sweden

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Abstract

© The aim of the present study was to obtain baseline information about oral health, oral health behaviours and knowledge about prevention of oral diseases in newly arrived Somali children.

All 310 Somali children arriving in four municipalities in Kronoberg County, Sweden, during 2013 participated. We collected interview data (background factors related to oral health) and performed a clinical examination (oral hygiene, marginal bone loss, malocclusion, dental caries) within the first two months after arrival. The children were analysed in three age groups: 3–6 years (n=49), 7–11 years (n=125), and 12–17 years (n=136).

The interview revealed that 78–82% of the children in the three groups had never visited a dental clinic in Somalia. Toothache was reported by 18–28% of the children. In the youngest group, 71% of the parents did not assist with tooth-cleaning and children commonly used a Miswak stick for cleaning. About half the children had poor oral hygiene while 25–33% reported daily intake of sugary snacks. Malocclusion affected 40% of the 7–11-year-olds and 50% of the 12–17-year-olds. Bone loss affected 13% of the 12–17-year-olds. The 3–6-year-olds had a high prevalence (37%) of missing primary, lower cuspids. Their mean number of decayed, extracted and filled primary teeth (deft) was 2.3, and 43% were free from caries. In the 7–11-year-olds, mean decayed and filled permanent teeth (DFT) was 0.8, while in the 12–17-year-olds DFT was 2.2 with 40% caries-free. Comparison with resident children indicates substantially higher caries prevalence among the Somali children.

The study has shown that newly arrived Somali children often present with oral diseases and are in urgent need of treatment and have great need for oral health promotion.

Key words

Children, Somali, oral health, dental caries

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Orala förhållanden och bakgrundsfaktorer hos somaliska invandrabarn nyligen anlända till Sverige

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Sammanfattning

⊙ Sedan reglerna för invandrabarn att få permanent uppehållstillstånd för återförening med sina föräldrar i Sverige ändrades 2012, har antalet barn från Somalia ökat markant. Tandvårdens kunskaper om den orala hälsan, tandvårdsbehovet och vanor relaterade till oral sjukdom hos dessa nyanlända barn är bristfälliga och syftet med studien var att er hålla en kunskapsbas för planering av tandvård och sjukdomsprevension.

Merparten av flyktingar från Somalia i Kronobergs län bor i kommunerna Alvesta, Lessebo, Växjö och Tingsryd. Samtliga 310 somaliska barn som återförenades med sina föräldrar i dessa orter under 2013 deltog i studien. Bakgrundsfaktorer relaterade till oral hälsa samlades in med hjälp av strukturerade intervjufrågor och en klinisk undersökning gjordes, omfattande munhygiennivå samt förekomst av marginal benförlust, malockklusion och manifest karies. Intervju och klinisk undersökning utfördes av fyra kalibrerade undersökare. Deltagarna analyserades i tre åldersgrupper, 3–6 år (n=49), 7–11 år (n=125) och 12–17 år (n=136).

Intervjun visade att 78–82 % av barnen i de tre grupperna aldrig hade besökt en tandklinik i hemlandet, 18–28 % rapporterade att de hade tandvärk och 33–46 % bedömdes genom fråge-formuläret ha otillräckliga kunskaper om orsaker till uppkomsten av karies. Beträffande tandvårdsvanor rapporterade 78–90 % att de rengjorde sina tänder minst två gånger per dag. I den yngsta gruppen fick 71 % av barnen ingen hjälp av förälder med tandrengöring. Användning av Miswakpinne för tandrengöring var vanligt, och i yngsta gruppen användes Miswak av ungefär hälften av barnen. 25–33 % av barnen angav att de åt sötsaker dagligen. Vid den kliniska undersökningen framkom att munhygien var bristfällig hos cirka hälften av barnen. Malockklusion (IOTN grad 4–5) sågs hos 40 % av 7–11-åringarna och 50 % hos 12–17-åringarna. Marginal benförlust registrerades hos 13 % av 12–17-åringarna. Undersökningen av de yngsta barnen visade en hög frekvens (37 %) av saknade primära hörntänder, sannolikt beroende på tidigt avlägsnande av tänderna av traditionsskäl.

Hos de 3-6 år gamla barnen var medelvärdet av karierade, extraherade och fyllda tänder (deft) 2.3 och 43 % av barnen var kariesfria. Medelvärdet karierade och fyllda tänder för permanenta tänder (DFT) hos 7–11-åringarna var 0.8 och hos 12–17-åringarna 2.2 (40 % kariesfria). En jämförelse med övriga jämnåriga barn i Kronobergs län visade betydligt högre kariesprevalens hos de somaliska barnen. De yngsta somaliska barnen hade tre gånger så höga värden på deft som övriga barn i länet.

Studien visar att nyanlända somaliska barn ofta har orala sjukdomar och är i stort behov av behandling. Nästan en fjärdedel av barnen uppger att de har tandvärk. Den kliniska undersökningen och svaren på intervjufrågorna visar på ett stort behov av preventiva insatser. Barnen i studien ingår i ett speciellt anpassat preventionsprogram som kommer att utvärderas efter tre år.

Introduction

The prevalence of dental caries among children has decreased markedly during the last decades in developed as well as in developing countries. However, the caries prevalence varies between different countries and also between different subpopulations in a country. Several studies have demonstrated that in developed countries immigrant children run a greater risk of developing dental caries than other children (24), (8), (20), and in some ethnic minority groups childhood caries is a serious problem.

Sundby and Petersen (21) studied the oral health in children of various non-Danish ethnic backgrounds living in Copenhagen. They found dental caries to be more common in immigrant children than in Danish children, and twice as common in 3-year-old Somali children. The mean number of carious and filled surfaces was six times as high in these children. However, they found no such differences in older Somali children. A later Danish study by Christensen *et al.* (8) found the same pattern, with a higher level of caries in 5-year-old Somali children compared to Danish children and no obvious differences in the older children. These studies, however, did not specify the time period a child had lived in Denmark, and they pooled the caries data of Somali children born in Somalia, those born in a refugee camp, and those born in Denmark. There seems to be a lack of information about the oral health and treatment needs of newly arrived children from Somalia.

Rodd *et al.* (15), studying Somali children living in Sheffield, reported higher caries levels for Somali children born in the UK than for those born abroad. The authors ascribed the lower caries prevalence in children born outside the UK to a possible protective effect of systemic fluoride at an early age, indicated by observations of a high prevalence of dental fluorosis in the permanent dentition in these children. However, as an alternative explanatory factor, they proposed a longer exposure to a Western European cariogenic diet in the UK-born children. The latter view stresses the importance of community health promotion initiatives to help newly arrived immigrant children.

According to the UN Refugee Agency (23), about one million Somalians are registered as refugees, forced to flee their country due to civil war, drought, and famine. More than 50,000 of these Somali refugees live in Sweden, the second largest group in 2013 (after Syrians) to be granted residence permits (19). One reason for this is that, since 2012, it has been

possible for children from Somalia to receive a permanent residence permit if they are joining a parent already living in Sweden.

The majority of the children arriving in Sweden already spent varying periods of time in countries neighbouring Somalia, sometimes under very tough conditions. Information about their general health is scarce, but studies in Scandinavia have reported a high prevalence of tuberculosis (14), (16), vitamin D deficiency (9), and autistic disorder (4).

As a result of changes in the regulations for receiving a permanent residence permit, in 2013 about 350 Somali children were able to reunite with their parents in Kronoberg County in southern Sweden. To introduce these newly arrived children to Swedish dental health care, the Public Dental Service in Kronoberg County launched a program "Integration into Swedish Dental Health Care." The program provided a clinical examination and oral health information within the first two months after a child's arrival in Sweden and free dental care when needed. The children were then invited to enter a specially designed oral health program running over three years. The program was planned and implemented in close collaboration with different public authorities, immigrant organizations, and the Somali community.

There is very little information about the oral health of Somali refugee children in general. Data relating to the initial period after arrival in a Western country seem to be lacking. We therefore decided to systematically collect data relating to oral health and oral health behaviour during the children's first visit to the public dental clinic, within two months after arrival. Thus, the aim of the present study was to obtain base-line information about newly arrived Somali children, and to compare the prevalence of dental caries in these children with reference data from all children of the same age attending the Kronoberg County Public Dental Service.

Material and Methods

Study group

The vast majority of the Somali refugees in Kronoberg County, Sweden, live in the municipalities Alvesta, Lessebo, Växjö, and Tingsryd. In 2013, the Public Dental Service invited all newly arrived Somali children in these municipalities, along with their parents, to participate in a program with the purpose of integrating the children into the Swedish dental health care system. The program provided extramural information to parents and children about

the Swedish dental health system, and also invited the children to receive a dental examination and oral health information. Dental care was provided when needed according to the routines of the Swedish Dental Health Service, which offers free dental care for all individuals aged 0–19 years.

The children were then invited to enter a three-year oral health program, which included a baseline collection of clinical and interview data. Parents were given verbal and written information about the study and provided written consent before data collection for research purposes. The Ethics Review Board at Linköping University approved the study. The parents of all 310 children between 3 and 17 years of age who arrived in the four municipalities during 2013 agreed to participate in the program, as well as in the research study.

Clinical examination, oral health education, and collection of interview data all took place at the Public Dental Health Clinic in the municipality in which the child was living within the first two months after arrival.

Interview

We interviewed the 12–17-year-old children and the parents of the younger children using a structured questionnaire to determine the highest level of parental education, their place of residence and experience with dental care in Somalia, self-perceived general and oral health, and attitudes and knowledge about oral health. The questionnaire also contained questions on oral health behaviours, including use of oral hygiene aids, frequency of tooth-cleaning, and intake of sugary snacks. An interpreter was used when needed.

Clinical examination

Three dentists and one dental hygienist performed the clinical examinations under optimal clinical conditions.

Oral hygiene

The presence of dental plaque was rated according to the visible plaque index (3), and individuals with visible plaque on $\geq 20\%$ of the labial surfaces of the upper incisors were recorded as having poor oral hygiene.

Malocclusion

The team assessed malocclusion in the permanent dentition (7–17-year old children) following the policy of the Public Dental Service, which is based

on the Index of Treatment Needs (IOTN-DHC) (7). The index groups individuals into treatment-need categories: little or no need, borderline need, and definite need for orthodontic treatment. This study defined malocclusion as presenting a definite need for treatment (Grade 4 and 5) according to the IOTN-DHC.

Marginal bone loss

The team assessed the presence of marginal bone loss using bite-wing radiographs in the premolar/molar region of the 12–17-year old children. After an initial calibration and training session, two examiners (IS, JG) analysed the digital images on a 24-inch monitor (HP LP247w, Palo Alto, CA USA) under standardized background lighting conditions. First, each examiner evaluated the bite-wing radiographs of all the children, after which the examiners discussed all disagreements in diagnosis to reach a consensus on the presence or borderline presence of marginal bone loss. After this preliminary survey, the team evaluated all tooth surfaces with a borderline or clear presence of bone loss using the measuring instrument of a digital radiographic system (Arion, Lund, Sweden), defining a distance > 2 mm between the cemento-enamel junction (CEJ) and the marginal bone level (MBL) as bone loss (12).

Dental caries

According to the policy of the Public Dental Service in Kronoberg and based on the recommendations of the Swedish National Board of Health and Welfare, the four examiners were calibrated in the diagnostic criteria for dental caries before the examinations. The study recorded the presence of manifest caries, clinically defined as a cavitated lesion and radiographically defined as caries extending beyond the enamel-dentine junction (24). We exposed digital bite-wing radiographs on a case-by-case basis according to national recommendations. From the data obtained, the team calculated the number of decayed, extracted and filled primary teeth (deft) or surfaces (defs), and/or the number of decayed and filled permanent teeth (DFT) or surfaces (DFS) for each subject, also calculating the number of decayed surfaces (ds and DS). We compared this to caries data from the Public Dental Service collected as a part of the national epidemiologic program by the Swedish National Board of Health and Welfare. Thus, reference data on deft and DFT was extracted from the Kronoberg County database that included all children in the county attending the Public Den-

tal Service (about 70% of all the children living in the county).

Statistical analyses

For presentation and analyses, we divided the 310 participating children into three age groups: 3–6 years, 7–11 years, and 12–17 years. We presented the data using standard descriptive statistics and analysed it using IBM® SPSS® Statistics 22. The analyses of the interview data revealed missing answers in 14 separate instances, which we excluded from presentation and statistical analyses. Differences between genders was tested using the chi-square or Fisher's exact test for interview data and the student's *t*-test for dental caries. We also tested for possible relationships between individual independent variables and the dependent variable "presence of manifest dental caries in permanent teeth" in a multiple logistic regression model with all variables adjusted for age and gender, including all individuals between the ages of 7 and 17 years in this analysis. The level of statistical significance was set to 0.05 in all tests.

Results

Study participants included 49 3–6-year-old children (mean age 4.8 years), 125 7–11-year-old children (8.9 years), and 136 12–17-year-old children (14.4 years). An interpreter participated in 86%, 87%, and 91% of the interviews in the three age groups, respectively.

With one exception (parent-assisted tooth-cleaning in the group of 7–11-year-olds), testing for gender differences found no statistically significant differences in the interview data or in the examination for dental caries. Thus, we present the results below without differentiating between girls and boys.

Interview

Table 1 presents the background characteristics of the children. The parents' highest educational level was primary school in 51–54% of cases in the various age-groups, while 31–41% had no education at all. Regarding living location in Somalia, 82–90% of the families came from an urban area, and 78–82% of the children had never visited a dental clinic in their homeland.

The parents reported none of the 3–6-year-olds as having a general disease or taking medicine. In the two older age groups, 17 children (7%) reported a general disease, the most common being tuberculosis, asthma, and hepatitis. In these two age groups, 14 children (6%) were on medication. One child in

the group of 7-year-olds reported a minor physical disability. Toothache was reported by 18–28 % of the children, the lowest figure representing 3–6-year-olds.

Concerning attitudes towards oral health and dental appearance (Table 2), 67% of the 3–6-year-olds, 83% of the 7-year-olds, and 97% of the 12–17-year-olds considered their teeth and oral health to be important. All parents of the youngest children were satisfied with their child's dental appearance or reported "don't know." Thirteen percent of the 7–11-year-olds and 29% of the 12–17-year olds, however, were dissatisfied.

Regarding knowledge of the etiology of dental caries (Table 2), 54% in the youngest group and 63–67% in the older groups gave a correct or partly correct answer. The remaining parents or children responded incorrectly or "don't know." On the question about adequate frequency of tooth-cleaning, 92–94% responded "twice a day", and 5–7% "once a day." Two individuals stated that cleaning is unnecessary.

Concerning oral health behaviours (Table 3), 78–90% reported that they cleaned their teeth "twice a day or more." Of the parents in the youngest group, 22% reported a tooth-cleaning frequency of "once a day or less." In this youngest group, 29% of the parents assisted with tooth-cleaning, and thus, 71% did not assist. The older children reported parental assistance at 38% and 28%. However, the comparison between genders revealed that, in 7–11-year-olds, 47% of boys compared to 29% of girls received assistance from a parent ($p < 0.05$). When cleaning, 51–78% used a toothbrush only and 15–28% used a toothbrush in combination with a Miswak stick (in Somali: Xidid). In the youngest age group, 27% of the children used a Miswak only. Toothpaste was used by 86–90% of the children. Regarding consumption of sugary snacks, 55–61% of the children reported either daily intake or intake some days a week. None of the mothers in the youngest group of children reported breastfeeding and only one reported bottle feeding at night.

Clinical examination

Examination revealed poor oral hygiene, that is, $\geq 20\%$ of the labial surfaces of the upper incisors with visible plaque, in 45–56% of the children. Malocclusion was recorded in 40% of the 7–11-year-olds and 50% of the 12–17-year-olds.

The examination of the 3–6-year-old children revealed a high frequency of missing lower cuspids,

© **Table 1.** Interview. Background characteristics of Somali children newly arrived in Sweden.

	3–6 years n=49		7–11 years n=125		12–17 years n=136	
	n	%	n	%	n	%
Gender						
Boys	21	42.9	60	48.0	67	49.3
Girls	28	57.1	65	52.0	69	50.7
Parental educational level						
College/University	9	18.4	6	4.8	11	8.1
Primary school	25	51.0	68	54.4	72	52.9
No education	15	30.6	51	40.8	53	39.0
Living location in the homeland						
Urban area	40	81.6	108	86.4	122	89.7
Rural area	9	18.4	17	13.6	14	10.3
Visit dental clinic in the homeland						
Yes	8	16.3	23	18.4	23	16.9
No	38	77.6	101	80.8	112	82.4
Don't know	3	6.1	1	0.8	1	0.7

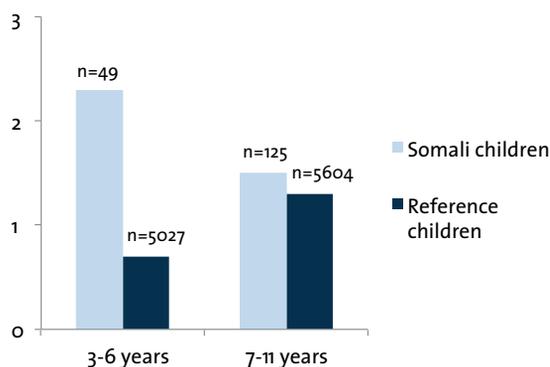
© **Table 2.** Interview. Attitudes towards oral health and dental appearance, and knowledge of oral health and oral health behavior in newly arrived Somali children.

	3–6 years n=49		7–11 years n=125		12–17 years n=136	
	n	%	n	%	n	%
Importance of teeth and oral health						
Important	33	67.4	103	83.1	132	97.1
Not important	0	0	2	1.6	0	0
Don't know	16	32.6	19 ¹	15.3	4	2.9
Self-evaluation of dental appearance						
Satisfied	36	75.0	100	80.6	95	69.9
Not satisfied	0	0	16	12.9	39	28.7
Don't know	12 ¹	25.0	8 ¹	6.5	2	1.4
Knowledge of etiology of dental caries*						
Correct	5	10.4	13	10.5	22	16.2
Partly correct	21	43.8	65	52.4	69	50.7
Incorrect/Don't know	22 ¹	45.8	46 ¹	37.1	45	33.1
Knowledge of adequate tooth-cleaning frequency						
Twice a day	43	91.5	114	91.9	127	94.1
Once a day or less	3	6.4	9	7.3	8	5.9
Not necessary	1 ²	2.1	1 ¹	0.8	0 ¹	0

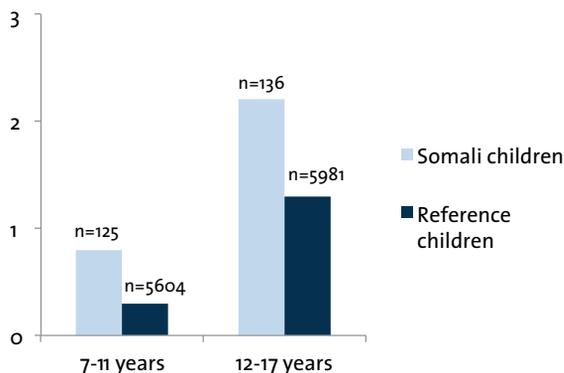
* The item comprised two correct and two incorrect alternatives.

¹ Answer from one individual missing. ² Answer from two individuals missing.

© **Figure 1.** Mean number of decayed, extracted and filled primary teeth (manifest lesions) in 3–6-year-old and 7–11-year-old newly arrived Somali children and reference children living in Kronoberg County.



© **Figure 2.** Mean number of decayed and filled permanent teeth (manifest lesions) in 7–11-year-old and 12–17-year-old newly arrived Somali children and reference children living in Kronoberg County.



with 18 children (37%) missing one or both of these teeth. In one of these children all four cuspids were missing.

Bone loss (CEJ-MBL distance >2 mm) was recorded in 12.6% of the 135 12–17-year-olds who received a full set of bite-wing radiographs. Nine individuals showed 1–2 affected sites, five 3–4 sites, and three 5–13 sites, while 82% of the affected sites measured >2–3 mm, 14% a distance of >3–4 mm, and 4% a distance of > 4–5 mm. All but one affected site were accompanied by proximal calculus.

Table 4 indicates the presence of manifest den-

tal caries in the primary teeth. In the group of 3–6-year-olds, the mean number of deft was 2.3, of defs 3.0, and of ds 2.9. Corresponding figures for the 7–11-year-olds were 1.5, 2.3, and 2.1, while 43% of the 3–6-year-old children and 58% of the 7–11-year-olds were free from manifest caries in primary teeth.

In the permanent teeth of the 7–11-year-old children, the mean number of DFT was 0.8, DFS 1.1, and DS 1.0. Corresponding figures for the 12–17-year-olds were 2.2, 3.3, and 2.7. In this case, 66% of the 7–11-year-olds and 40% of the 12–17-year-olds were free from manifest caries in the permanent teeth.

To compare the Somali children with resident children living in the county, we extracted data on deft and DFT from the database of the Public Dental Service of Kronoberg County. In all age groups, the Somali children displayed higher caries prevalence than the residents (Figs. 1 and 2), with the largest difference seen in the youngest group. The number of children free from manifest caries was 43% in the 3–6-year-old Somali children compared with 82% in residents of the same age. In the 7–11-year-olds the corresponding figures for primary teeth were 58% and 63%, and for permanent teeth 66% and 82%. In the 12–17-year-olds 40% and 54%, respectively, were free from manifest caries.

A multiple logistic regression analysis tested the relationship between various background variables and the dependent variable “presence of manifest dental caries in the permanent dentition” of all 7–17-year-old children (Table 5). It revealed a statistically significant association for the variable “presence of toothache” (OR 5.36; $p < 0.001$). Surprisingly, it also found a negative association for “frequent intake of sugary snacks” (OR 0.53; $p < 0.02$).

Discussion

After liberalization of the permanent resident permit rules for children, there has been a marked increase in the number of Somali children arriving in Sweden, with a peak in 2013. Little is known about the oral health and dental treatment need of these newly arrived children, often coming from tough living conditions. This study was undertaken to obtain baseline information about their oral health status to facilitate planning and implementation of preventive programs and dental care. A high prevalence of dental disease was seen in the Somali children and there is an urgent need of treatment and oral health promotion in this group.

Without exception, all parents of the 310 children arriving in the four municipalities of Kronoberg

© **Table 3.** Interview. Oral health behaviours in newly arrived Somali children.

	3–6 years n=49		7–11 years n=125		12–17 years n=136	
	n	%	n	%	n	%
Frequency of tooth-cleaning						
Twice a day or more	38	77.6	111	88.8	121	90.3
Once a day or less	11	22.4	14	11.2	13 ²	9.7
Parent assisted tooth-cleaning						
Yes	14	28.6	48	38.4	38	27.9
No	35	71.4	7 ¹	61.6	98	72.1
Tooth cleaning aids						
Toothbrush only	25	51.0	82	66.1	105	78.4
Miswak stick and toothbrush	11	22.5	35	28.2	20	14.9
Miswak stick only	13	26.5	71	5.7	9 ²	6.7
Toothpaste						
Yes	42	85.7	113	90.4	119	87.5
No	7	14.3	12	9.6	17	12.5
Intake of sugary snacks						
Daily	16	32.7	31	24.8	35	25.7
Some days/week	11	22.4	37	29.6	48	35.3
Once a week or less	22	44.9	57	45.6	53	40.0

¹ Answer from one individual missing. ² Answer from two individuals missing.

© **Table 4.** Clinical examination. Prevalence of dental caries (cavitated lesions) in primary teeth (deft, defs, ds) and permanent teeth (DFT, DFS, DS) in newly arrived Somali children.

	3–6 years (n = 49)	7–11 years (n = 125)	12–17 years (n = 136)
Primary teeth			
deft			
mean	2.3	1.5	
SD	2.8	2.5	
defs			
mean	3.0	2.3	
SD	4.3	4.3	
ds			
mean	2.9	2.1	
SD	3.9	4.0	
Caries-free children (%)	42.9	57.6	
Children with bite-wings exposed (%)	49.0	94.4	
Permanent teeth			
DFT			
mean		0.8	2.2
SD		1.4	2.9
DFS			
mean		1.1	3.3
SD		2.0	5.4
DS			
mean		1.0	2.7
SD		1.9	4.4
Caries-free children (%)		66.4	40.4
Children with bite-wings exposed (%)		94.4	100

© **Table 5.** Multiple logistic regressions for individual independent background variables adjusted for age and gender in 7–17-year-old Somali children. The dependent variable is presence of manifest dental caries in permanent teeth.

	OR	95% CI	p
Parent's education			0.94
No education (reference)			
Primary school	0.99	0.58-1.71	
College/University	1.20	0.41-3.55	
Rural living in homeland	1.38	0.62-3.07	0.44
Presence of general disease	1.76	0.62-5.01	0.28
Daily medication	1.24	0.39-3.92	0.72
Presence of toothache	5.36	2.77-10.38	0.000
Tooth brushing once a day or less*	0.82	0.36-1.88	0.64
No help with tooth brushing	0.92	0.53-1.60	0.77
Use of Miswak	0.86	0.49-1.50	0.59
Presence of dental plaque	1.32	0.79-2.20	0.29
Frequent intake of sugary snacks**	0.53	0.31-0.91	0.019

*Once a day or less vs. twice a day or more; ** Several times week or more frequent vs. once a week or less

County during 2013 accepted the invitation to participate in the study. The 100% compliance was most likely an effect of the active contribution of all parties involved, including the Somali association and the local public authorities. It also reveals a true interest in oral health among Somali parents and children, reflected in a high frequency of children and parents in the interview study reporting teeth and oral health to be important.

All dental examinations and interviews were carried out within the first two months after arrival in Sweden, and thus, the collected information and the oral health status reflects the oral health in Somalia or in a neighbouring transit country. Before reunion with their families in Sweden, the majority of the children had stayed in Ethiopia – although for some it was in Kenya or Uganda – and both the length of time spent as a refugee and the living conditions experienced seem to vary between children. Also the children's family backgrounds varied; the structured interview showed that about one third of the parents had no education at all, while about 10% had a college or university degree. About 80% of the children had grown up in urban areas in Somalia, and about as many had never visited a dental clinic before. Thus, despite a cultural and ethnic homogeneity, there are obvious differences in background within the group, which should be taken into account when interpreting the present results, as well as when planning dental care and oral health promotion.

In the older age groups (7–11 and 12–17 years) 13–29% of the children were not satisfied with their dental appearance. The interview did not explore more precisely the reasons behind this, but tooth discoloration was fairly common among the children, as was the presence of malocclusion. Regarding malocclusion, the clinical examination revealed a definite need for treatment according to the IOTN in almost half of the children.

Previous Scandinavian studies have reported a comparably high prevalence of general disease in Somali refugee children (9), (14), (16). In our study, about 5% of parents reported a general disease in their child, the most common being tuberculosis, asthma, or hepatitis. No systematic information about the medical health of the children was available from the Public Health Service, but the medical teams reported the general health in the group to be good.

The interview revealed a high awareness of the importance of tooth-cleaning, and in fact, the majority reported brushing their teeth twice a day or more. The lowest figure, 78%, was noted in the 3–6-year-olds. This can be compared with the results in a recent Swedish study of 4-year-old immigrant and non-immigrant children in which 60–70% of the children reported tooth-brushing twice a day or more (20). In the present study, 70% of the parents of the youngest children did not assist their child when brushing, as compared with 10–20% in

children of similar age living in Sweden (20), (25), (26). Obviously, oral health information directed towards newly arrived Somali children should stress the importance of parental participation in tooth-brushing from an early age. The frequent findings of dental plaque in all age groups emphasize the need for oral hygiene information and instruction.

Use of a Miswak stick for tooth cleaning was fairly common, especially in the youngest children. Because the interview mainly surveyed the children's time before arriving in Sweden, one can expect the use of Miswak to discontinue when the children adapt to a Swedish lifestyle. However, research has shown that Miswak has a substantial antibacterial effect on a variety of oral bacteria and it has a proven capacity to remove dental plaque (17), (18). Between 85% and 90% of the children used toothpaste, but it was not possible to determine fluoride content.

A substantial number of participants in all age groups reported a frequent intake of sugary snacks. Thus, 33% of the parents of 3–6-year-old children reported that the children consumed sugary snacks on a daily basis, and 55% a few days per week or more. Stecksén-Blicks *et al.* (20) reported consumption of sweets three or more times per week in 10–30% of non-immigrant and immigrant children living in Sweden. The present interview question was limited to intake of sugary snacks such as candy, chocolate bars, ice cream, or cookies. However, the interview sessions revealed a pattern of sugar intake among the Somali families; sugar was used in everyday cooking in far larger amounts than in Swedish cooking. The structured interview did not capture this pattern and more studies are needed to learn more about Somali dietary habits. Still, our results show that oral health promotion should emphasize the risks of a high-sugar diet on the development of dental disease.

Using the IOTN, we estimated the need for orthodontic treatment in all 7–17-year old children with a mixed or complete permanent dentition. We found malocclusion in definite need of treatment (IOTN grade 4 and 5) in 40% of the 7–11-year-olds and 50% of the 12–17-year-olds. Although somewhat higher, these figures compare well with those reported by Josefsson *et al.* (10) in Swedish children and children with an immigrant background. They concluded that the increasing multi-ethnicity in the population has not led to a change in overall orthodontic treatment needs. This seems to be true also when this new group of Somali immigrants is included in the population, although the type of malocclusions

may vary. Possible differences in types of orthodontic problems need further study.

Marginal bone loss, diagnosed on bite-wing radiographs and restricted to the posterior region, appeared in 13% of the 12–17 year olds. Most individuals displayed 1–2 affected sites, but there were those with up to 13 sites with bone loss. All but one affected site were accompanied by proximal calculus, indicating the presence of active periodontal disease and, thus, a need for treatment. Comparable epidemiologic data on bone loss in young individuals is scarce, but studies of 16-year-old Swedish adolescents using the same criteria for radiographic bone loss and including the same tooth areas showed a prevalence of 1% (13). Julihn *et al.* (11), examining incipient alveolar bone loss (CEJ-MBL ≥ 2 mm), reported a prevalence of 5% in Swedish 19-year-olds. Albandar (1) concluded in an overview that localized aggressive periodontitis is most prevalent among Africans, and least common among Caucasians in Europe and North America. Estimates of the aggressive form of the disease indicate a prevalence of 1–5% in African populations. Our results are based on radiologic findings and thus not clinically verified. Therefore, further studies of the periodontal condition in newly arrived Somali children and young adults are needed.

The clinical examination revealed a high prevalence of missing lower cuspids in the primary dentition. In the group of 3–6-year-old children, 37% were missing one or both lower cuspids. One child was missing all four cuspids. Barzangi *et al.* (5) reported a prevalence of missing cuspids of 21% in children with East African ethnicities living in Sweden, and ascribed this phenomenon to a traditional remedial procedure, enucleation, consisting of early removal of the tooth germ. This reason for early tooth germ removal was confirmed by several parents in our study. Enucleation has been reported to be practiced frequently in many African countries (6), however no local studies in Somalia seem to have been conducted. The Swedish findings indicate that enucleation is a common phenomenon in Somalia.

This study reports on manifest (cavitated/dentine) caries only, that is, caries in need of restorative treatment. This follows the policy of the Swedish National Board of Health and Welfare for collecting national statistics on dental caries in young individuals. By excluding initial (enamel) caries in our study, the diagnosis of caries become more reliable, and it also allows comparisons with available official epidemiological data. In the group of 3–6-year-old

children, 43% of the Somali children were free from manifest caries. By comparison, 82% of the Swedish residents in Kronoberg County in the same age group were caries free in 2013, and the 2011 national levels for 3- and 6-year-olds were 96% and 82%, respectively (22). Also, in the older age groups, the Somali children had a higher caries prevalence than the resident children. The difference, however, was most evident in the 3–6-year-old children, who had, on average, three times as many decayed and filled teeth (dft) compared with resident children of the same age (Fig. 1). The 12–17-year-old Somali children had almost twice as many decayed and filled permanent teeth than residents of the same age (Fig. 2).

A majority of the children had never visited a dental clinic, and thus, very few had undergone restorative dental treatment. This was reflected in almost identical mean values of decayed, extracted and filled surfaces (defs/DFS) and decayed surfaces (ds/DS). The criterion for the presence of caries – a cavity/lesion extending into the dentine – means that, on average in all age groups, two teeth per individual needed treatment and that there were children with 10–15 teeth in need of restorative treatment. About half of the children in the three groups had an immediate need for treatment, and 20–30% of all individuals reported current toothache. Together with an unmet need for orthodontic and periodontal treatment, this put pressure on the dental care providers, in this case the Public Dental Health Service. In addition to the first phase, which requires planning of dental care and allocation of healthcare resources, providers must parallel this with health care promotion efforts. The need of active intervention strategies has been stressed by Amin *et al.* (2), who identified a number of barriers for African immigrant families to overcome.

In line with the present results, studies have found higher caries prevalence in Somali preschool children living in Denmark than in Danish children (8), (21). Our study also revealed higher, although less pronounced, caries prevalence in the older children with permanent dentition. The Danish studies, however, did not find a difference in these ages. Possibly the different results are explained by the fact that all children in our study were newly arrived in Europe, while the Danish studies did not differentiate between Somali children who were born and raised in Denmark or children born in Somalia or in a refugee camp. The Somali children in the Danish study might thus have had time to adapt to favourable oral hygiene and dietary habits. However, a study in the

UK (15), showed higher caries prevalence in Somali children born and growing up in the UK compared with children born in Somalia, possibly indicating a negative effect of Western European lifestyle on oral health.

To explore possible explanations for the relatively high caries prevalence in the Somali children, we performed a multiple logistic regression analysis. We found an expected significant positive association between toothache and manifest caries. No other variable showed a statistically significant positive relationship. Surprisingly however, frequent intake of sugary snacks showed a negative association ($p < 0.02$) with caries. Thus, the children reporting a frequent intake of sweets had lower caries levels than children with an intake of once a week or less. This unexpected result might reflect general difficulties in determining dietary habits in an immigrant group, especially when using structured interview questions based on Western European living conditions. This methodological limitation of the interview part of the study should be considered when interpreting the results, not only from questions about diet but from other questions as well. In addition, although the present results may be representative for newly arrived Somali children, the results most likely do not apply to children who have lived in the country for some time.

In conclusion, the study has shown that a high number of Somali children newly arrived in Sweden present with oral diseases in urgent need of treatment, as emphasized by a high prevalence of toothache. Also, the results from the interview study indicate not only the need for oral health promotion, but also the need for deeper knowledge about dietary and oral habits in Somali immigrants for health workers to be able to help these children to achieve better oral health. All children in the present study have entered into an oral health program that will be evaluated after three years.

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Swedish orthodontists' opinions and experiences regarding miniscrew implants

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Abstract

Miniscrew implants (MSI) can be a useful tool when maximal anchorage is desired in orthodontic treatment. The aim of this study was to describe the opinions and experiences of miniscrew implants among orthodontists currently practising in Sweden.

A web-based anonymous questionnaire containing 17 multiple choice questions was sent to 218 listed members of the Swedish Association of Orthodontists during fall 2012. Descriptive statistics were used for analysing the collected data set.

In a total of 147 (67%) respondents 80 were women, 62 were men and five did not specify gender. MSI had been used by 78 (53%) respondents in orthodontic treatment. The majority of the respondents, 53 (70%), had used 1-10 MSI. The majority of MSI placements were made by orthodontists (84%) while 18 (9%) referred the procedure to an oral surgeon.

The most common indications for MSI were space closure, intrusion, and bodily movements. The use of MSI enabled 61 (81%) of the respondents to set higher treatment objectives. The success frequency of the MSI was perceived as satisfactory by 48 (65%) of the respondents.

Key words

miniscrew implants (MSI), temporary anchorage device (TAD), questionnaire, survey, dentist's practice patterns/statistics and numerical data.

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Svenska ortodontisters åsikter och erfarenheter gällande miniskruvimplantat

DANIEL SVENSK, LARS-INGE NOREVALL

Sammanfattning

⊙ Förankring vid ortodontisk behandling kan definieras som motståndet mot oönskad tandförflyttning. Miniskruvimplantat (MSI) kan vara ett användbart verktyg då maximal förankring vid ortodontisk behandling är eftersträvarsvärd. Målet med denna studie var att beskriva åsikter och erfarenheter gällande miniskruvimplantat hos ortodontister yrkesverksamma i Sverige.

En web-baserad anonym enkät innehållande 17 flersvarsfrågor skickades under hösten 2012 till 218 medlemmar av Svenska Ortodontiföreningen. Deskriptiv statistik användes för att analysera svaren.

Av totalt 147 (67 %) respondenter var 80 kvinnor, 62 män och fem uppgav inte könstillhörighet. MSI hade använts av ungefär hälften (53 %) av respondenterna och fler än hälften (55,1 %) av de respondenter som ännu inte använt MSI hade planer på att börja använda denna teknik. Majoriteten av respondenterna (70 %) hade använt mellan en och tio MSI. Applicering av MSI utfördes till största del av respondenten själv (84 %) och ungefär var tionde respondent (9 %) överlät ingreppet till käkkirurg. De vanligast förekommande indikationerna för användning av MSI var luckslutning, intrusion och förflyttning av hela segment. Fyra av fem respondenter (81 %) upplevde att användningen av MSI gjorde det möjligt att uppnå högre behandlingsmål. Lyckandefrekvensen av MSI ansågs som tillfredställande av ungefär två tredjedelar (65 %) av respondenterna.

Resultatet av denna enkät visar att användningen av MSI är utbredd bland ortodontister yrkesverksamma i Sverige och att större delen av dem som använt sig av tekniken upplever sig nöjda med resultatet.

Introduction

Anchorage can be defined as the resistance against unwanted tooth movement in orthodontic treatment. Anchorage control is often crucial in the choice of treatment objectives and the selection of the appropriate method for achieving these objectives. Anchorage can be divided into minimal, moderate, maximal and absolute. Based upon the objectives and selected method there are various appliances such as extraoral traction, intermaxillary traction or transpalatal arch available when minimal, moderate or maximal anchorage is desired. These appliances are not sufficient when absolute anchorage is demanded [1]. Osseointegrated dental implants have previously been used to provide absolute anchorage control. These implants demand a mucoperiosteal flap surgery and an initial healing period before orthodontic force application.

An option is dental implants enabling direct force application. Temporary anchorage devices (TAD), miniscrew implants, miniscrews and mini implants are frequently used literature definitions of these devices. The term miniscrew implant (MSI) is used in this article. The advantages of MSI are the small size, the relatively easy handling and most importantly it enables direct loading of the MSI for anchorage in tooth movement. In addition MSI may enable the practitioner to select more advanced treatment objectives as well as a reduction in treatment duration [2].

Since the first publication [5] regarding MSI, there has been numerous studies concerning different aspects such as indications, success rate, material properties, and implant design. Indications for the use of MSI are orthodontic space closure, intrusion or extrusion of teeth and dentofacial orthopaedic treatment [1].

The success rate varies between different studies. The success rate, expressed as survival of MSI at the end of treatment, for the most common treatment indications are above 80% [9].

There are few studies regarding orthodontists' opinions and experiences of MSI. A search of Medline in 2014 showed that no such study has been conducted among orthodontists practicing in Sweden. The aim of this study is therefore, with help of a questionnaire, to describe the opinions and experiences of miniscrew implants among orthodontists currently practising in Sweden.

Material and methods

A list of 255 registered active members of The Swedish Association of Orthodontists (SOF) was obtained from the secretary of this organisation. An active member was defined as an orthodontist currently practicing in Sweden. Following an update of the personal contact details, 218 members with valid email addresses were selected for the questionnaire. A web-based anonymous questionnaire (Publech® Survey 5.7 provided by Region Östergötland) was sent to 218 subjects in October 2012. Three weeks later the intended respondents who hadn't answered the questionnaire received a reminder. In November 2012, the data collection was ended and in total 147 orthodontists had responded to the questionnaire (Figure 1). The collected data samples were analysed in the survey tool and thereafter descriptive statistics was applied.

Fallout analysis

In order to analyse why some of the orthodontists didn't answer the questionnaire the following procedures were performed. Due to the anonymity, telephone contact in alphabetical order according to the original contact list was necessary until ten non-responders were localized. They were asked to answer a series of complementary questions (Figure 2).

Results

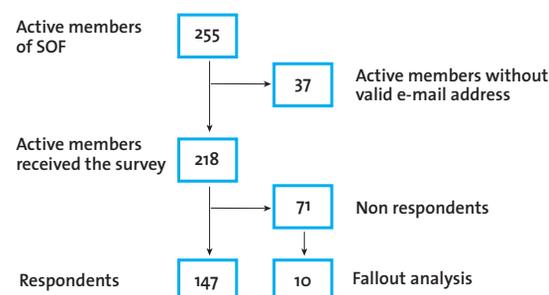
There were 147 respondents (67%). The gender distribution was 80 women and 62 men. Five did not specify gender. The complete sets of responses are presented in Table 1.

Experience

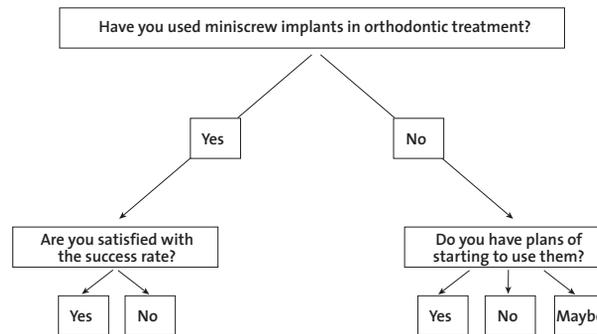
The group of orthodontists with more than 15 years of experience was the largest (45.8%).

Approximately half of the respondents (53.1%) had used MSI in orthodontic treatment and the

© Figure 1. Flow chart of the questionnaire.



© **Figure 2.** The questions asked in the fallout analysis.



group who had used MSI less than three years was the largest (40.8%). More than half of the respondents (55.1%) who hadn't used MSI had plans of starting to use it.

Higher treatment goals could be set when using MSI according to over eighty percent (81.3%) of the respondents and nearly two out of three respondents (64.9%) were satisfied with the success rate. A shorter treatment time, when using MSI, was reported by more than half of the respondents (58.3%).

MSI failure of one to five implants was most common (58.1%) while every third respondent (33.8%) hadn't experienced any early loss of a MSI.

Formal education regarding MSI was absent in approximately every tenth of the respondents (10.8%) while more than half had theoretical (58.1%) and almost every third had theoretical and practical training (31.3%).

Technique

Approximately seventy percent of the respondents had used ten or less MSI and most respondents inserted (60%) and removed (84.4%) the MSI by themselves. Lack of time was the most common cause for not placing the MSI (21.4%). Other respondents had chosen to relinquish the insertion to an oral surgeon, periodontist or a more experienced colleague. The most common radiological methods for determining where to place the MSI were apical radiographs (53.7%) followed by panoramic radiographs (37%).

Indications for MSI usage

The most common indication for MSI usage was orthodontic space closure (54.1%) followed by dental intrusion (13.5%) and movement of a whole dental segment (8.1%). Other indications such as orthodontic expansion aided with a rapid maxillary ex-

pander anchored with MSI, distalization of molars and correction of dental midline discrepancies were mentioned in free text.

Fallout analysis

Three out of ten respondents in the fallout analysis group had used MSI whence two were satisfied with the success rate. Two of the seven respondents who had not used MSI were planning to use them in the future, three were not and two had not yet decided.

Discussion

Sampling

There are 265 certified orthodontists in Sweden by The National Board of Health and Welfare [7], whereas 255 were registered as active members in SOF the year of 2012. Valid email addresses were obtained for 218 orthodontists whereas 147 responses were obtained (67%). Thus the results of this study are representative for the opinions of Swedish orthodontists. More respondents could eventually have been obtained using complementary regular mail questionnaires and additional reminders for the nonresponders with a valid email address.

Survey response rates have declined over the years. Paper format surveys have shown greater response rates compared to electronically administered surveys [10, 11]. There is no scientifically proven minimum response rate but 60% has been used as a threshold of acceptability [4]. A higher response rate than our 67% would have been desirable. However, response rates are in fact a poor indicator of non-response bias while additional responders seem to give the same estimates as the initial responders [8].

The fallout analysis was conducted among ten orthodontists out of the 71 nonrespondents, corresponding to 14% of the total number of nonrespondents. This constitutes a small sample from which no

© **Table 1.** Distribution of answer alternatives in relation to the number of responses given expressed in percent.

Have you used MSIs in orthodontic treatment? ^{1, 2)}		On what indications do you use MSI? ¹⁾	
Yes	53.1%	Space closure	35.5%
No	46.9%	Intrusion	19.9%
How many years have you been using MSIs? ¹⁾		Extrusion	3.6%
<1	28.9%	Alignment of occlusal plane	4.8%
1–3	40.8%	Segmental movements	15.1%
3–5	22.4%	Molar uprighting	9%
>5	7.9%	Orthopaedic treatment	1.8%
How many MSIs have you used? ¹⁾		Other	10.2%
<10	69.7%	What is your most common indication to use MSI? ¹⁾	
11–20	18.4%	Space closure	54.1%
21–30	3.9%	Intrusion	13.5%
31–40	1.3%	Extrusion	1.4%
>41	6.6%	Segmental movements	8.1%
Who is currently inserting your MSIs? ¹⁾		Molar uprighting	2.7%
Myself	60%	Orthopaedic treatment	2.7%
Periodontist	3.8%	Other	17.6%
Oral surgeon	22.5%	How many of your MSIs have been lost? ¹⁾	
Other orthodontist	7.5%	None	33.8%
Other	6.2%	1–5	58.1%
Who is currently removing your MSIs? ¹⁾		6–10	4.1%
Myself	84.4%	11–15	2.7%
Periodontist	1.3%	16–20	0%
Oral surgeon	9.1%	>20	1.4%
Other orthodontist	1.3%	Are you satisfied with the success rate of your MSIs? ¹⁾	
Other	3.9%	Yes	64.9%
Why don't you place all of your MSIs by yourself? ¹⁾		No	35.1%
Lack of time	21.4%	Do you experience that MSI usage shortens the treatment time? ¹⁾	
Lack of MSI training	17.9%	Yes	58.3%
Risk for root damage	10.7%	No	41.7%
Too invasive	7.1%	Do you experience, that higher treatment goals can be set, when using MSIs? ¹⁾	
Risk of causing pain	3.6%	Yes	81.3%
Other	39.3%	No	18.7%
Have you participated in any training regarding MSI? ¹⁾		Do you consider starting to use MSIs in orthodontic treatment? ²⁾	
Yes, theoretical	58.1%	Yes	55.1%
Yes, theoretical and practical	31.1%	No	10.1%
No	10.8%	Don't know	34.8%
What type of radiograph do you use when deciding MSI placement site? ¹⁾		Gender? ^{1, 2)}	
None	1.9%	Male	43.7%
Panoramic radiograph	37%	Female	56.3%
Apical radiograph	53.7%	How many years have you been practising as an orthodontist? ^{1, 2)}	
Lateral radiograph	1.9%	1–5	9.9%
CT	0.9%	5–10	24.6%
Other	4.6%	10–15	19.7%
		>15	45.8%

¹⁾ Question for MSI users

²⁾ Question for non MSI users

certain conclusions can be drawn. However, seven of the orthodontists in the fallout analysis had not been using MSI which is more than among the web survey respondents. The fallout could be due to invalid email addresses. It is also possible that the orthodontists in the fallout group have been using MSI to a lower extent than the web survey responders group which could explain the lower interest to answer a survey regarding this particular technique. Thus, there is a risk that these two groups are not homogenous.

The questionnaire was tested on experienced orthodontists at The Centre of Orthodontics in Linköping, Sweden. Adjustments were made to clarify the proposed questions and the questionnaire design.

No formal validation of the survey's questions was performed. Similar questions concerning orthodontists' opinions regarding MSI have been used in other studies [2, 3].

The design of this questionnaire allowed the respondents to skip questions. Thus the answer frequency varied between different questions.

Approximately half of the respondents (53.1%) in this study had used MSI in orthodontic treatment. At least three prior studies address the respondents with a similar question. Two of these studies were carried out among members of the AAO (American Association of Orthodontists). MSI had been used by 80% and 60% respectively [2, 6]. The third study was conducted among a smaller group of American orthodontists and showed that approximately 90% out of 47 respondents had used MSI [3]. The reason why Swedish orthodontists have used MSI to a lesser extent than American orthodontists could be due to a lower interest of MSI among these orthodontists and different constructions of the orthodontic insurance system.

The largest group with MSI experience (69.7%) had placed one to ten MSI. This indicates a large variation among these respondents. The design of this question does not show the distribution of the MSI experience within this group. A different design of this question could render the exact number of MSI placements thereby enhancing the interpretation of the result.

On the other hand, the current question design corresponds well to other studies in this field of interest making a comparison of the results easier [2].

The orthodontists who had used MSI were asked whether they had previous theoretical or clinical education in practising the technique. Not surpris-

ingly 89.2% of the respondents had received such an education. There is no information in the questionnaire regarding how many of the respondents with no MSI experience who had participated in MSI education. A better alternative might therefore have been to address this question to all the respondents. There seems to be a strong correlation between education and the usage of MSI. However this could not be verified due to the construction of this specific question.

The success rate of MSI treatment satisfied 64.5% of the respondents in this study. Buschang found 75% of the respondents to be satisfied or very satisfied with MSI treatment. Hyde reported an 82% satisfaction of MSI treatment. The satisfaction among Swedish orthodontists was seemingly lower in comparison with the two previous studies. One reason could be due to differences in indication for MSI treatment. The most common indications among our respondents were in falling order space closure, intrusion and movement of a whole segment. Uprighting of molars was less common among the respondents in our study. On the other hand, movement of a whole segment and uprighting of molars were the most common indications for treatment among Buschangs respondents. Furthermore, Hyde reported that the most common indications for treatment with MSI were mesial movement of molars, space closure and intrusion which corresponds better to our study [2, 3].

Thus we conclude that the indications for MSI treatment vary.

The interpretation of success rate differs among different studies. The success rate in our study is not clearly defined. Some studies count loose and displaced MSIs as successful [9]. The greater part of the dissatisfied MSI users (58.3% of the respondents) did not experience a shortening of the treatment time which might explain the dissatisfaction. An alternative explanation of the dissatisfaction of this method of treatment could also be due to the amount of loosened MSIs. The failure rates of MSIs might vary among different locations of insertion and force application. However this was not addressed in this survey.

Conclusion

More than half of the respondents have used MSI. The most common indications for treatment with MSI were space closure followed by intrusion and movement of whole segments. Two thirds of the respondents who have used MSI were satisfied with

the success rate. Four out of five respondents had the opinion that MSI let them set higher treatment goals.

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Reporting dental caries disease in longitudinal studies – a suggestion

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Abstract

© In general, most infectious and/or lifestyle-related diseases are defined as being present when sufficient signs or symptoms occurs in an individual. The term “sufficient” is a relative concept and a disease can therefore be measured with different degrees of certainty. These symptoms are commonly defined in such a way that it is possible to determine the incidence and prevalence of the disease and also the proportion of individuals that are cured from the disease. If dental caries is an individual disease which can be compared to other diseases regarding incidence and prevalence, it is important to determine for how long an individual must be free from new signs of the disease before being considered cured or free from the disease and to define the “sufficient” signs or symptoms needed for a diagnose. Based on these thoughts, the purpose of this study was to calculate caries incidence and prevalence in a group of adolescents from a definition of dental caries based on ICD-10. This study included all 12 year olds in 1990 who attended a clinical dental examination in 1990-1995 in Örebro County, Örebro, Sweden, yearly during these six years. Dental caries disease at the individual level was defined as Ko2.1 (dental caries) according to ICD-10 while freedom of caries was defined as the absence of Ko2.1 during a three-year period. In this study the yearly prevalence was 12%, the three year cumulative incidence was 18% and the incidence rate 13%. Results of this study highlight the poor outcomes in curing caries disease in this age-group, according to the criteria in this study, as only 17% of the children with caries at the outset of the study were free from the disease three years later. Defining both a practical level to measure signs of dental caries, and the period an individual must be free from them to be classified as cured from the disease create new opportunities to compare and communicate the disease of dental caries with other diseases. This way of registration is also of advantage for planning purposes as there the centre of interest must be the individual patient and not the tooth or surface.

Key words

dental caries, incidence, longitudinal, prevalence, terminology

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Rapportering av kariessjukdom i longitudinella studier – ett förslag

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Sammanfattning

⊙ Sjukdomar och medicinska tillstånd definieras vanligen genom att ett antal kriterier uppfylls och en individ bedöms som frisk från sjukdom när dessa kriterier inte längre föreligger, ofta efter en definierad tidsperiod. Incidens och prevalens mellan olika sjukdomar kan därför ofta jämföras. I longitudinella studier definieras dental karies ofta som förändringar i medeltal av ett index, vanligen DMFT/S. Karies är en livsstilssjukdom som går att bota, men symtomen på kariessjukdom är oftast persisterande vilket innebär att ett sådant index inte redovisar hur många individer som är sjuka under en viss period eller hur många som är botade från själva kariessjukdomen under samma tid utan istället redovisar en livstidsprevalens.

Syftet med denna studie var att beräkna karies incidens och karies prevalens utgående från begreppen årsprevalens, kumulativ incidens och incidenstalet (incidensraten). Definition på karies hämtades från ICD-10 (K02.1) som beskriver diagnosen för karies in i dentin. Som definition på att vara frisk (botad) från kariessjukdom användes en definierad tidsperiod på tre år utan att ny dentinkaries registrerats.

Studiepopulationen var 423 individer och bestod av alla 12-åringar i Örebro län, år 1990, och som under sex år deltog i samtliga årliga recall-undersökningar (1990–1995). Av dessa hade 210 dentinkaries (definierat som ICD K02.1) någon gång under de tre åren 1990–1992 medan 213 inte uppvisade dentinkaries någon gång under samma tidsperiod. Under den efterföljande perioden 1993–1995 blev 17 % av de sjuka barnen friska från karies. Av de friska barnen insjuknade 38 individer vilket ger en årlig prevalens av 12 %. Karies hade en incidens rate av 134 fall per 1000 manår (13 %) och en kumulativ incidens på 15 % för ett år, 17 % för två år och slutligen 18 % för tre år. Vår definition av den tid som krävs (3 år) för att kunna avgöra om en tidigare sjuk individ kan bedömas som frisk från karies kan i framtiden behöva justeras och fler studier i olika åldrar och populationer behövs för att ytterligare belysa problemställningen. Studien visar på relativt dåligt resultat när det gäller att bota kariessjukdom då endast 17 % av de sjuka blev friskförklarade under en period på tre år. Likaledes är resultaten av preventionen nedslående då hela 12 % av individerna i den friska gruppen blev sjuka. Resultatet bör dock tolkas med försiktighet med tanke på det begränsade antal barn som ingick i studien och risker för selektionsbias mellan grupperna. Under dessa år hade dock individuella kallelseintervall utifrån ett riskperspektiv inte införts hos Folk tandvården Örebro utan orsaken till att barn inte kallades årligen berodde vanligtvis på resursbrist hos vårdgivaren.

Denna metod att rapportera karies i longitudinella material och därmed definiera karies på individnivå ersätter inte traditionella metoder för att mäta kariesincidens och kariesprevalens. Metoden ger dock en ökad information avseende det antal individer som faktiskt är sjuka i karies. Ett sådant förfaringsätt medför stora fördelar ur planeringssynpunkt för tandvården då fokus blir individer och inte medeltal av ytor eller tänder, och möjliggör dessutom jämförelser mellan dem som faktiskt är sjuka i karies med dem som diagnostiserats med andra sjukdomar.

Introduction

Historically, the pattern of diseases and their definitions have varied depending on variations in life style, medical knowledge and philosophical beliefs [14]. Today the *International Classification of Diseases and Related Health Problems - Tenth Revision* (ICD10) is the most common tool to describe the different diagnoses classified as diseases or health related problems [29]. In this classification dental caries is defined as; caries limited to enamel (K02.0), caries of dentine (K02.1), caries of cementum (K02.2), arrested dental caries (K02.3), odontoclasia (K02.04), other dental caries (K02.8) and dental caries unspecified (K02.9).

In general, most infectious and/or lifestyle-related diseases are defined as being present when sufficient signs or symptoms occur in a person. This is a relative concept and a disease can therefore be measured with different degrees of certainty. Diagnostic criteria may differ according to the context in which they are used and in some situations very simple criteria can be justified [2]. Thus, for a large variety of diseases incidence and prevalence rates make it possible to calculate and compare different occurrences of diseases [6]. This is valid for many medical conditions such as hip fracture, stroke, acute myocardial infarction, thyroid autoimmunity and different forms of cancers [15, 18, 19]. However, this strict way of calculating incidence and prevalence rates is generally not used in epidemiology of dental caries [1, 11].

Caries prevalence is commonly expressed as the mean of affected teeth or surfaces in a population. There are several indexes in dentistry to describe this and the DMFT/S index is the most used [10]. It is clear that the DMFT/S-index, which report lifetime prevalence of dental caries as symptoms and signs of earlier defects caused by the disease is prevailing. Consequently, the use of DMFT/S-index does not indicate whether the individual is free from the disease of dental caries or not.

In longitudinal studies the most reported outcome measure of dental caries is the caries increment, usually expressed as differences in means of the DMF index [3]. In contrast, medical epidemiology typically relies on two different outcome measures to describe disease rates in longitudinal studies: cumulative incidence and incidence rate [12, 24]. These measures are well known and described in detail in medical literature [2, 5, 6, 8, 21] but rarely used in caries epidemiology.

In the Swedish quality-register for caries and periodontitis (SKaPa) the following definition of dental

caries (actual active disease) has been given: "Someone is free from dental caries or has been cured from dental caries, if there has been no new injuries reported and no existing lesions deepened during a defined period of time" [23]. Thus, the diagnosis "free from caries disease" after an episode of disease demands a time component in between registrations. Therefore, in epidemiological studies a longitudinal follow-up is necessary in order to present the actual number of individuals with actual caries disease. In this regard, it is important to take in consideration that the progression of dental caries in most individuals in general is slow [17]. It may therefore take several years for the disease to be clinically detected by its symptom. As a result of these circumstances it is understandable, but unfortunate, that the restoration of a carious lesion often has been synonymous with a cure for the disease, overshadowing the fact that caries is a lifestyle related disease which cannot be cured by restorations. Unfortunately, it appears that it is still not a universally accepted fact that dental caries is a curable disease. As an example it has recently been stated that "Dental caries is a chronic, progressive and cumulative disease" [3] thus, not curable.

The objective in this paper was to longitudinally assess dental caries on an individual level by using an alternatively measure method i.e. yearly prevalence, cumulative incidence and incidence rate. A secondary objective was to compare the changes between the caries and caries free groups.

Material and methods

Study sample

Swedish dental care provides free, regular and comprehensive care to all children and adolescents up to 20 years of age [22]. Caries data used in this study was retrieved from the electronic dental records in Örebro County Council, Örebro, Sweden. The criterion for inclusion was: all 12 year olds (N=3009), who attended a clinical examination in 1990 (n=2897) and thereafter attended all six yearly recalls during 1991-1995 with complete caries registration in the electronic database (n=423). This subgroup (n=423) constitute the study sample. This subgroup was compared with all those 12-year olds who attended a clinical examination in 1990 (n=2897) and only small differences were found (Table 1). All examinations were conducted in an ordinary clinical setting with standard dental equipment and in accordance with the County Council's procedures. Radiographic examination was performed on individual indications.

© **Table 1.** Non-response analysis. Comparison between the entire group examined in 1990 and the sample.

	n	Proportion of boys	DFTmean	DFT=0
12-year-olds examined in 1990 (base population)	2873	51%	1.84	38.9
12-year-olds examined in all years between 1990 and 1995 (study sample)	423	49%	1.85	40.6

Measures and methods

The study sample was divided into two groups (A and B) according to ICD10 [4, 29]. Group A was defined as having dentinal caries (K02.1; n=210) and group B was defined as not having dentinal caries (K02.1=0; n=213) during a three year period 1990, 1991 and 1992. Thus, a dichotomy variable was used for either having caries disease or not having caries disease in the start of the study 1993.

Between 1993 and 1995, the two groups were followed and dentinal caries recorded from the electronic files. *Caries prevalence* over one year was calculated as the total number of individuals with caries disease (K02.1) divided by the sample population. *Cumulative caries incidence* in the sample was calculated as the proportion of individuals without dentinal caries disease in 1992 (group B) who developed new carious lesions (K02.1) in 1993, 1994 or 1995. The *incidence rate* took into account how many healthy years at risk each person contributed to the study, and at what point in time dental caries was registered. The assumption was made that dental caries was developed at a half-way point between the registrations. Analyses were performed using the Statistical Package for Social Sciences (SPSS, release version 21).

Ethical approval

The study was approved by the Ethics Committee in Uppsala, Sweden, in 2012 (Dnr 2012/203).

Results

At the start of the study in 1993 there were 210 adolescents with dentinal caries experience (Group A) and 213 dentinal caries-free adolescents (Group B) according to the criteria in this study. In Group B, there were 31 new cases of caries after one year (1993), after two years there were five additional cases of caries (1994), and in the last follow-up (1995) there were two new cases (Table 2).

The yearly prevalence of caries during 1990 - 1995 was calculated as the number of individuals with caries at the start of the study (Group A = 210) and adding number of individuals in Group B who established new caries during the period 1990 -1995 (38 individuals) divided by the total sample population (n=423) and the number of recorded years. Thus, yearly prevalence of dental caries in the total sample will be $248/423/5 = 0.117$ which equals 11.7%.

In order to calculate incidence rate and cumulative incidence we have to start with the healthy sample without caries (defined as K02.1=0), Group B (n=213). Out of these, 175 did not develop caries during the three years period (1993-1995) and they contributed with 525 healthy man-years, (175 x 3). Thirty-one individuals acquired caries during the first year and they therefore contributed with (31 x 0.5) 15.5 healthy man-years. Five more were diagnosed with dental caries between year one and two and those contributed with 7.5 man-years (5 x 1.5). Finally, two cases were found between the second and the third year, which contributed with five healthy man-years (2 x 2.5). The whole healthy subsample (Group B), thus had 553 healthy man-years (525+15.5+7.5+5). The total number of man-years at risk was 639 (213 x 3). The dental caries incidence rate for this population was $[(639-553) / 639] = 0.134$ (13.4%) or 134 cases per 1000 man-years at risk.

Cumulative incidence of dental caries for the healthy subsample, (group B, n=213), was calculated on those who developed new dental caries during a defined number of years. Therefore, one year cumulative incidence was calculated to be $31/213=0.15$ (15%) and two years to $36/213=0.17$ (17%) and finally three years to 0.18 (38/213, 18%).

Among those with dental caries disease during 1990-1992 (Group A), 17% (n=36) changed status from having caries to be caries-free (defined as K02.1=0) during three following consecutive years.

© **Table 2.** Number of individuals regaining dental health and number of individuals with new dental caries disease.

Year of examination	1990–1992	1993	1994	1995
Total population	423	423	423	423
Group A. Individuals with dental caries sometime during 1990–1992)	210			
Regained health K02.1=0 during a three year period		10	12	14
Individuals with dental caries	210	200	188	174
Group B. Individuals without any dental caries during 1990–1992	213			
New cases with dental caries		31	5	2
Individuals without dental caries	213	182	177	175

Among those without dental caries disease during 1990–1992 (Group B) 82% (n=175) maintained caries-free status during three following consecutive years.

Discussion

If dental caries is an individual disease that can be compared with other diseases it is important to determine both the level of measurable signs and how long an individual must be free of new signs, before being considered cured from the disease. In the case of dental caries it is unfortunate, and confusing, that the same term is used both for the actual disease and its symptoms (the caries lesions). It is also misleading as the disease is curable but the symptoms in many cases are irreversible. Similar problems with irreversible symptoms can also be seen in other organs such as persistent post-occupational dermatitis, where the dermatitis persist even if the causative agent has been removed [9].

Traditionally studies have approached the prevalence of dental caries from a life time perspective [25, 26, 27, 28]. As far as the authors can find, there is a lack of studies with the purpose to define and diagnose dental caries disease similar to other diseases at an individual level, and on that basis calculate the incidence and prevalence rates. The objective in this paper was to consider additional methods eg yearly prevalence, cumulative incidence and incidence rate to report on dental caries in longitudinal studies. In this study, we used K02.1 from the ICD-10 system as a measure of dental caries and we decided that duration of three years was long enough for observation. The chosen period for freedom from disease without some new “destruction” was chosen

with respect taken to the relatively long period that in general is needed for symptoms of dental caries to be clinically visible [16]. The chosen period could be either shorter or longer. This method is also similar to what is used in other common medical diseases and conditions [18].

The results showed that dental caries among adolescents is still a disease with both high prevalence and high incidence. The results also highlights the poor results in terms of curing the caries disease in this age group, since only 17% of children with caries from baseline became free from active disease. The study also highlights the poor preventive results as in the initially caries-free group about 18% developed caries during the study period.

This study was limited to 423 adolescents while the total population of Örebro County was at the time for the study (1990–1995) about 270 000. Using many dentists and only K02.1 as a measure of dental caries limits the collected information. There is also some risk for a diagnostic drift during this period which all together means that the data must be interpreted with some caution. The dentists worked according to a written protocol but were not systematically calibrated, however, the large number of patients and dentists (>150) involved should provide a common standard and the study group was very similar to the base population (Table 1). Finally, the main purpose of this study was to longitudinally assess dental caries on an individual level by using yearly prevalence, cumulative incidence and incidence rate similar to other diseases and in line with proposals from the report from SKaPa [23].

Further studies along these lines with other populations and age groups are needed to make a more

definite proposal about how long caries free period is needed from an occurrence of caries after which an individual could again be regarded as healthy. Measuring caries in the proposed way will make it possible to plan for each patient's needs better and also enable manpower planning on a more precise level. As Pitts stated in 2004, the "challenge for the future is to define a range of optimal caries measurement methods—in use or in development in recent trials, in clinical practice, and/or in caries epidemiology—that will best contribute to more efficient, modern caries clinical trials" [20]. Also, if the disease is to be diagnosed on an individual level in addition to the tooth/surface level and compared with other diseases, simple methods are needed. This is in line with the first objective of the International Consensus Workshop on Caries Clinical Trials (ICW-CCT), which was to "critically review modern caries definitions and measurement concepts..." [20]. One such method to determine the limits between the sick and the healthy individuals could be borrowed from other disciplines, e.g. methods in tumour treatment where a patient is defined as healthy and free from disease after a set period of time with no new tumours [7, 13].

Conclusion

The results highlights the poor results in terms of curing the caries disease for this age group, since only 17% of children with caries from baseline became free from active disease. It is also interesting that about the same percentage of adolescents went from the caries free group to the caries group (18%). Since dental caries is an individual disease that can be cured it is important to determine the level of signs and symptoms for the diagnosis of the disease and also how long an individual must be free from them before being considered free from the disease. Diagnosis of dental caries using ICD-10 on an individual level is not a substitute for diagnosis at traditional tooth or surface level (DMFT/S), but creates new opportunities to communicate results on group level and compare them with other diseases by using terms like incidence and prevalence in line with other medical areas.

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Dental nurses' experiences of performing a school-based fluoride varnish programme for children and adolescents in Sweden

EVA-KARIN BERGSTRÖM^{1,2}, ULLA MOBERG SKÖLD¹, DOWEN BIRKHED¹, MARGRET LEPP³

Abstract

© In many parts of Sweden today, school-based fluoride varnish programmes (FVP) are performed by dental nurses. Studies have shown that the dental personnel are largely responsible for creating the atmosphere related to children's and adolescents' experiences of the programmes. Knowledge of dental nurses' experiences of performing FVP is therefore crucial in order to develop and improve these programmes and the dental health of children and adolescents. The aim of this study was to describe dental nurses' experiences of performing FVP for children and adolescents in Sweden. Fifteen female dental nurses, strategically chosen, aged 40-63, from the Public Dental Service in the Västra Götaland Region, Sweden, were individually interviewed. The interviews were transcribed verbatim and analysed according to the phenomenographic approach. Three themes with a total of 11 categories, all describing the dental nurses' conceptions of performing FVP, emerged in the analysis. The main conclusions were that in overall terms, performing an FVP was found to be a positive experience for the dental nurses, as it meant meeting children and adolescents in a context in which the children and adolescents are comfortable and relaxed. The opportunity to identify children and adolescents with poor dental health or poor health and to be able to offer them assistance was regarded as a major advantage. In addition, the participants described a feeling of professional development originating from the challenges associated with working in an arena outside the dental clinic.

Key words

Dental nurse, Fluoride varnish, Phenomenography, School-based programme

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Tandsköterskors erfarenheter av att genomföra skolbaserade fluorlackningsprogram för barn och ungdomar i Sverige

EVA-KARIN BERGSTRÖM, ULLA MOBERG SKÖLD, DOWEN BIRKHED, MARGRET LEPP

Sammanfattning

☉ Skolbaserade fluorlackningsprogram utförs idag av tandsköterskor på många håll i Sverige. Tidigare studier har visat att tandvårdspersonalen är de som till största delen avgör hur barn och ungdomar upplever sitt deltagande i dessa program. Kunskap om hur tandsköterskors upplevelse av genomföra skolbaserade fluorlackningar är därför nödvändig för att kunna utveckla och förbättra dessa program och tandhälsan för barn och ungdomar. Syftet med denna studie var att beskriva tandsköterskors upplevelser av att genomföra skolbaserade fluorlackningsprogram för barn och ungdomar i Sverige. Femton kvinnliga tandsköterskor, strategiskt utvalda, i åldern 40–63 år, från Folktandvården Västra Götaland, Sverige, intervjuades individuellt. Intervjuerna transkriberades ordagrant och analyserades i enlighet med principerna för den fenomenografiska ansatsen. Tre teman, med totalt 11 tillhörande kategorier, som alla beskrev tandsköterskors upplevelser av att genomföra skolbaserade fluorlackningar, framkom i analysen. De viktigaste slutsatserna från studien var att överlag sågs uppgiften att bedriva skolbaserade fluorlackningsprogram som en positiv erfarenhet för tandsköterskorna genom att det innebar att möta barn och ungdomar i ett sammanhang där barnen och ungdomarna är bekväma och avslappnade. Möjligheten att identifiera barn och ungdomar med dålig tandhälsa, eller andra problem, och kunna erbjuda dem hjälp ansågs vara en stor fördel. Tandsköterskorna hade dessutom upplevt att de hade utvecklats i sitt yrke genom de utmaningar som var förknippade med att arbeta på en arena utanför kliniken.

Introduction

Dental nurses and the Public Dental Service in Sweden have a long tradition of working with different forms of school-based fluoride programmes. In the 1960s to 1980s, over a period of 25 years, this mainly involved fluoride mouth-rinsing programmes for all children and adolescents, which contributed to a reduction in caries prevalence of 20–30 per cent (15). Other fluoride products, such as fluoride varnish and fluoride tablets, have also been used (17).

By the mid-1980s, the dental health of children and adolescents in Sweden had improved substantially and the main reason was believed to be the more widespread use of fluoride toothpaste (6). As a result, the focus on dental health promotion in many areas shifted from a population strategy at schools to an individual strategy at clinics, aimed at those at risk. Nevertheless, several studies performed in the 1990s–2000s revealed the benefits of school-based fluoride varnish programmes (FVP) (2, 3, 14, 16, 19), one of which was performed in the Västra Götaland Region, Sweden (14).

The Västra Götaland Region, in the western part of Sweden, has approximately 1.5 million inhabitants, with Gothenburg as the largest city. The Public Dental Service is represented in all 49 municipal areas in the region, organising 116 clinics. In 2008, all these Public Dental Clinics were obliged to implement FVP for all children and adolescents aged between 12 and 15. Since 2008, FVP have reached more than 80,000 children and adolescents every year. More recently, similar programmes have been run in other parts of Sweden.

The caries-preventive effect of fluoride varnish is well documented (11), but knowledge of how children (age 6–12 years) and adolescents (age 13–16 years) experience FVP has been scarce. However, a recent study showed that adolescents have great confidence in dental personnel and that the dental personnel are largely responsible for creating the atmosphere related to the participants' experiences of the programme (5). Hedman et al. (9) interviewed dental nurses and dental hygienists with the aim of describing and interpreting their view of knowledge, learning, health promotion, expectations of and attitudes to the response from school children. They found that dental nurses and dental hygienists working at school focused more heavily on disease prevention than health promotion. Nevertheless, they stated that a positive basic tone, intelligibility, objectivity and reliability were important keys to successful oral health promotion. However, the

study revealed a lack of reflection from the dental personnel on the ethical considerations which could be important in a programme designed to influence adolescents' lifestyle.

Dental nurses represent the profession most commonly performing FVP in Sweden today. These dental nurses' profession includes performing many different work assignments, such as assistance to dentists, administration, prevention and health promotion. Nevertheless, as stated by Bentling and Jonsson (4), expertise comprises more than knowledge and skills, as there is also a personal aspect when it comes to using the knowledge and experience. Expertise is also determined by a personal approach in an organisation, as well as the way it is affected by the activity in which it is used. Acquiring knowledge of dental nurses' experiences of performing FVP is crucial in order to develop and improve these programmes and the dental health of children and adolescents.

The aim of this study was to describe dental nurses' experiences of performing school-based fluoride varnish programmes for children and adolescents in Sweden.

Materials and methods

Study design and approach

For this study, a qualitative research methodology based on interviews was chosen. The interviews were analysed according to the phenomenographic approach (10). This approach was first described by Marton (12) and it is particularly suitable when the aim is to collect a variety and broad range of experiences from a specific phenomenon. In this study, the phenomenon was experience of performing FVP.

The fluoride varnish programme

To perform a FVP is to meet children or adolescents at school in small groups for fluoride varnish applications (Duraphat®, 2.26% F) preceded by supervised flossing. The dental nurses apply fluoride varnish to all approximal surfaces from the distal surface of the canines to the mesial surface of the second molar on each child or adolescent. The child or adolescent is placed on a chair or a table facing the dental nurse during the applications, which are made using a syringe fitted with an Ultradent Microtip. In addition, the dental nurses are responsible for two lessons on oral health and tobacco use during the 6th to the 9th classes.

Participants

Fifteen dental nurses from the Public Dental Service

© Table 1. Characteristics of the interviewed participants

Participant	Age	Years of experience as a dental nurse	Working mostly in rural/city (R/C) area	Number of days performing the programme/year
1	51-55	21-30	R	~ 10
2	56-60	>30	R/C	~ 40
3	61-65	>30	R	~ 40
4	40-45	≤20	R/C	~ 120
5	56-60	>30	R	~ 120
6	51-55	21-30	R	~ 40
7	51-55	>30	R	~ 40
8	46-50	≤20	C	~ 200
9	46-50	≤20	R/C	~ 200
10	40-45	≤20	C	~ 160
11	61-65	>30	R	~ 20
12	56-60	21-30	C	~ 200
13	46-50	21-30	R	~ 40
14	40-45	21-30	R	~ 20
15	56-60	21-30	R	~ 10

in the Västra Götaland Region, Sweden, were chosen strategically in order to represent a wide variety of experience of FVP (Table 1). The participants were all female dental nurses, aged 40-63. The selection was made to find participants of different ages, from various parts of the region, working in both rural areas and in cities, with responsibility for the FVP in a different number of schools and with both long and short working experience from this field.

Data collection

Individual interviews were chosen for the data collection. The participants were invited by mail and asked to sign and return a consent form if they agreed to participate in the study. The place for each interview was chosen by the participant and the most common place was an office or a staff room at a Public Dental Clinic. The interviews were recorded and lasted for an average of 40 minutes (range 22-70 minutes). The interviews started with verbal information about the aim of the study, followed by some standard questions about each participant's background. The main open interview question was "Can you describe your experiences of performing FVP?". The participants were asked additional questions mainly focusing on their expectations, thoughts and feelings in relation to FVP. One of the authors (E-KB) carried out the interviews and transcribed them verbatim.

Data analysis

The data analysis followed the four steps described by Alexandersson (1). In the first step, all the interviews were read thoroughly several times after they had been transcribed verbatim, in order to obtain an overall impression of the material. The second step was devoted to noting similarities and differences in the material. In the third step, the statements were sorted into descriptive categories of conceptions. In the fourth and final step, the categories were reflected upon and the themes emerged, all describing the participants' experiences of performing an FVP.

Trustworthiness

To facilitate the readers' evaluation of the trustworthiness of the analysis, quotes from the interviews are given for each category. To further ensure correct data analysis, the results were tested by one of the co-authors (ML) and also by a group of PhD students and researchers working in the field of phenomenography.

Ethics

The participants received both written and verbal information about the study and signed consent forms prior to the interviews. Permission to perform the study was obtained from the Ethics Committee at the University of Gothenburg, Sweden (Dnr: 384-09).

© **Table 2.** Themes and categories that emerged in the analysis

Participant:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Theme 1. Working in someone else's arena																
1.1. The need to adapt to the school's conditions	x	x	x	x	x		x	x	x	x	x	x	x	x	x	14
1.2. Freedom and variety at work				x		x	x		x		x	x	x	x	x	9
1.3. Collaborating with the school's staff		x	x	x	x	x	x	x	x	x	x	x			x	12
1.4. Being a local celebrity				x			x				x	x		x		5
Theme 2. Meeting students in a school environment																
2.1. More security at school than at the clinic	x	x				x	x	x		x	x	x		x	x	10
2.2. Good contact with the students is meaningful		x	x	x	x	x	x	x	x	x					x	11
2.3. Identifying students with ill-health	x	x		x			x	x		x	x	x	x	x	x	11
2.4. Dealing with troublesome students				x	x	x		x				x			x	6
Theme 3. Being challenged and developing in one's profession																
3.1. Establishing yourself	x	x	x	x	x	x	x		x	x	x		x	x		12
3.2. Being able to plan		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
3.3. Being influenced by the clinic management and colleagues	x	x	x	x	x		x	x					x	x	x	10

Results

Three themes emerged in the analysis of the interviews with the dental nurses. The themes were as follows: "Working in someone else's arena", "Meeting students in a school environment" and "Being challenged and developing in one's profession". Each theme is represented by three to four categories which represent dental nurses' different conceptions of performing FVP (Table 2).

Theme 1. Working in someone else's arena

The first theme, "Working in someone else's arena", contains conceptions that deal with the participants' experiences of working with assignments outside the dental clinic, at school. The theme consisted of four categories; "The need to adapt to the school's conditions", "Freedom and variety at work", "Collaborating with the school's staff" and "Being a local celebrity".

1.1. Category: The need to adapt to the school's conditions

The first category contains conceptions related to the participants' experiences of having to adapt to the conditions at the schools that were visited. According to the statements, the participants found it difficult to make demands regarding the settings for the assignment at school. Furthermore, the schedule for the FVP could be directed by the schools and some participants felt that they had limited opportunities to question it.

The statements showed that the school was not regarded as the participants' normal workplace, even if most of the time was spent at school performing the programmes. Some statements showed a longing for a workplace that is one's own, with a feeling of being "at home":

"What I sometimes miss is having my own platform, feeling that this is my job, that I am at home. But I am never really at home." (no 10)

1.2. Category: Freedom and variety at work

In the second category, statements showed that performing FVP could be associated with a great sense of freedom. The freedom could consist of a less tight schedule, making room for more improvisation, but also freedom from the normal workplace at the clinic.

The variation was seen in the ability to meet and connect with a wide variety of children, adolescents, grown-ups and other professionals, such as school staff. Each encounter with a group or a person contributed to the conception of variety in work.

“... but we meet different children, different classes, different teachers, different schools. There’s always something new happening every day. That’s what makes it so much fun. It gives us tremendous freedom.” (no 4)

1.3. Category: Collaborating with the school’s staff

The statements in the third category showed that working at a school meant collaborating with other professions, such as the school staff. This collaboration could involve practical issues such as making sure all the children and adolescents attended the programme and helping to manage the groups. Some participants said that they could contribute to the classroom education in oral health, which was seen as profitable for both the teachers and the dental nurses.

“... first and foremost the science teachers and I have seen that some of the burden has been taken away from them when it comes to the mouth and things like that. They can ask ‘When are you coming?’ ‘OK, you’re coming then, that’s good, I can reorganise things a little to fit in with your visit and you can talk about the mouth and food, while we talk about the body at the same time.’” (no 10)

1.4. Category: Being a local celebrity

The statements in the fourth category revealed that a dental nurse, performing an FVP, could be recognised in the local community. Some participants had been interviewed in local newspapers about their work at school and had become known and recognised in the local community as a result. Furthermore, some statements showed that the participants had unintentionally acted as a reminder of dental health when they had been recognised in the community. The choices the school dental nurse makes in the local shop could attract attention and be commented on.

“You become a public individual. You can’t go to

the supermarket and buy what you like... You have to send the children if you want an ice-cream, don’t you? Because they keep a check on exactly what you buy. So you need to think about it.” (no 7)

Theme 2. Meeting students in a school environment

The second theme, “Meeting students in a school environment”, deals with the participants’ experiences of meeting children and adolescents at school instead of at the dental clinic. The theme consists of four categories; “More security at school than at the clinic”, “Good contact with the students is meaningful”, “Identifying students with ill-health” and “Dealing with troublesome students”.

2.1. Category: More security at school than at the clinic

The statements in the first category revealed that children and adolescents appeared to feel more comfortable at the school meeting dental staff compared with visiting the dental clinic. One reason that was given was that the children and adolescents in school are surrounded by their friends, creating a more relaxed feeling compared with visiting the dental clinic alone.

In some cases, this increased feeling of security could enhance the ability to reach the children and adolescents in a better way, according to the statements.

“You listen to the children. Perhaps they are afraid at the dental clinic, they don’t dare to speak and they don’t have enough time to speak. When we’re with them, on the other hand, they feel safe. They feel secure in their place in the classroom and we come to them, we’re the guests.” (no 8)

This contact at school could be helpful when it came to motivating the children and adolescents to accept dental care if needed, according to the statements. Even children and adolescents with a fear of the dentist were often seen to have the courage to participate in the FVP.

2.2. Category: Good contact with the students is meaningful

Some statements in this category revealed that establishing good contact with children and adolescents is an important key to the satisfaction of being involved in performing the programme. When the contact is increased and leads to better treatment, or, in a group, to good discussions, the task is seen to be meaningful. A perceived lack of connection with adolescents, on the other hand, could make the task seem meaningless or not worth the effort.

The meaningfulness could be found in good contact leading to learning or treatment and the fact that the dental nurse had the opportunity to be an adult person caring for the adolescents, according to the statements.

"All the people here who stay behind to talk a bit... I can actually say that I sometimes feel that I am really needed." (no 7)

2.3. Category: Identifying students with ill-health

The statements in the third category related to the opportunity to identify children and adolescents in school with poor dental health in need of extra care. In addition, it was not unusual to meet children and adolescents who were being bullied or had personal problems. According to the statements, some participants had experienced frustration when they had met children or adolescents with problems and had not been able to follow up on them. Other statements showed that dental nurses had been in contact with a Public Dental Clinic after an FVP, to make sure a child or an adolescent was offered an appointment at the clinic. In addition, some of the participants had the ability to contact suitable persons at school to help those in need.

"We also try specifically to identify children with really poor oral health and so I have contacted the relevant person and said something like 'I happened to see when I was applying varnish at the school, I'm the fluoride lady at XXX, and I saw that he had a huge amount of dental plaque, so I would really like to offer him an appointment.'..." (no 4)

2.4. Category: Dealing with troublesome students

The statements in the fourth category showed that some of the participants had met children and adolescents with acting-out attitudes which could be experienced as both frightening and offensive. Even with the insight that they are just children or adolescents and not adults, this could be difficult to handle, according to the statements. Even an offer to take part in the programme could be a source of negative behaviour from acting-out children and adolescents. Bringing along a colleague and performing the programme together was seen as the best way to feel safe and avoid unnecessary feelings of insecurity. The support from the teachers and school staff was also important, according to the statements.

"The students can't sit still, they are cheeky, they bring in tins of Coca-Cola and put them down, simply because they know that we come from dental care. They put down these cans and things right in front of

me in an attempt to provoke. So you have to pretend not to see them. But then they hide them behind the curtains and so on when we have finished." (no 5)

Theme 3. Being challenged and developing in one's profession

The third theme, "Being challenged and developing in one's profession", contains conceptions related to the way the participants have experienced their role as school dental nurses. The theme consists of three categories; "Establishing yourself", "Being able to plan", and "Being influenced by the clinic management and colleagues".

3.1. Category: Establishing yourself

Some statements in this category revealed that some participants had had quite a challenging start, feeling uncomfortable with the assignment, when the FVP was first introduced. The statements also showed that, in many cases, the initial resistance from both school staff and adolescents had changed into a much more positive attitude. Performing an FVP was also seen to be easier, as the adolescents became more and more used to the treatment and got to know the dental nurses. As the dental nurses became better known at the school, the assignment appeared to run more smoothly and easily.

"I think it's easier and easier with every year that passes, because your role at the school becomes increasingly well established. Everyone knows who we are. During the first few years, people could stand and say, 'Oh, God, who are you?' and 'I see, are we going to do that?' and things like that. Now everyone knows us..." (no 10)

3.2. Category: Being able to plan

According to the statements in this category, one of the most important parts when performing an FVP is careful, meticulous planning and organisation. The statements revealed that the participants sometimes found FVP tiresome and not always easy to perform with good ergonomics. Even if the ergonomics during the treatments were acceptable, other parts could be difficult for the body, such as the need to carry around a wide range of equipment, according to the statements. Also according to the statements, the strategy for handling every possible challenge was meticulous planning.

"We are used to it. We have a structure so that everything flows really well. It can sometimes be hard work, but it works... You need to think, plan, the whole time. There's a great deal of planning!" (no 4)

3.3. Category: Being influenced by the clinic management and colleagues

The statements in the third category revealed that the participants had experienced that FVP could be scheduled when convenient for the clinic without taking account of the planning at the schools. According to the statements, this could create some tension and stress. Performing the programme could be affected by the situation at the clinic, as some participants had experienced that their managers or colleagues wanted them to cut down on the time at school to help out at the clinic during busy periods. Furthermore, some statements showed that the programme could be the focal point of questioning from both the managers at the clinics and colleagues. The participants felt that they had to defend the amount of time spent and the need for supplies in the programme.

“Then you need to understand that it can be sometimes be schematically difficult or if someone is ill and you have to... In cases like that, someone else has helped with the varnishing. But... what more shall I say? I don't know if they always understand what we are actually doing or how it functions, the management, I mean. Sometimes it feels as though they don't.” (no 2)

Discussion

The aim of this study was to describe dental nurses' experiences of school-based fluoride varnish programmes (FVP), as our previous study found that the dental personnel are largely responsible for creating the atmosphere (5). The analysis emerged in three themes, all of which describe the participants' conceptions of performing the programme.

The first theme, “Working in someone else's arena”, revealed a variety of experiences of working outside the dental clinic. Being able to be a part of another workplace outside the dental clinic and meeting other professions was considered to be enlightening. This increased the dental nurses' insight into the schools' world and created a better understanding of the children and adolescents and opportunities to collaborate with the school staff. Performing in the school arena and meeting a large number of children and adolescents, as well as school staff, also meant that the dental nurse became more recognised in the local community and perhaps even acted as a “school dental nurse” outside both the clinic and the school. The negative experiences were the need to adapt to the visited school's conditions and the limited opportunities to make demands relating to the work

environment. According to the statements, making demands could lead to bad relationships and, in the worst-case scenario, it could perhaps even jeopardise the whole programme. This is possibly not the case, but the conception must nevertheless be taken into account and the dental nurses working at schools could probably benefit from more collaboration between the two fields, together with support from the dental clinic manager and the school head.

The second theme, “Meeting students in a school environment”, showed that the dental nurses experienced a difference when it came to meeting children and adolescents at school, compared with meeting them at the clinic. The school is the everyday place for most children and adolescents and, moreover, they are always close to friends and peers there. A review article from 2011 (20) concluded that there is a neglected field of study when it comes to the effect of dental staff behaviour on child dental anxiety and behaviour. Nevertheless, the review confirmed the existence of a relationship between the behaviour of certain dental staff and children's anxiety and/or behaviour in a dental setting. There is reason to assume that the setting, as well as the behaviour of the dental staff, is important, as shown in our study. According to the statements, a more relaxed attitude and a feeling of security could also enhance the learning and ability to receive information.

This is in agreement with other studies showing that an improvement in communication requires a shift in the balance of power between the physician and the patient (18). When a dental nurse enters the everyday life of the adolescents at school, this is probably experienced as a slight shift in the power balance, as the dental nurses are visiting the adolescents instead of the other way round. Establishing and maintaining good contact with children and adolescents was seen as one of the most meaningful assignments. This is probably due to the effect this appeared to have on the ability to affect oral health behaviour. This is in line with the study by Hedman et al. (9), which also found a great desire among dental staff to influence children and adolescents regarding oral health behaviour.

Even if most pupils feel fine at school, some of the dental nurses had been troubled or worried when they had met children and adolescents with poor dental health or who were bullied or had poor health. Challenges of this kind can be difficult to handle and, even if they are a part of working with children and adolescents, the participants sometimes felt they did not know how to act. Neverthe-

less, in Sweden, working as a professional with children and adolescents, people are obliged by law to report any suspicion that a child is not being treated well or abused to the social services.

Yet another situation in which some participants had negative experiences was when they had met pupils behaving less well, trying to challenge or tease the dental nurses. The dental nurses who had these experiences emphasised more than the others the routine of bringing along a colleague and never visiting schools alone.

The third theme, "Being challenged and developing in one's profession", also contained a variety of conceptions. Some participants had experienced some initial resistance from the school staff when the FVP was first introduced. Since FVP have been running for at least five years, the participants said that the programme was now accepted and established as a part of the health promoting and preventive work at school. The greatest challenge appeared to be the need for careful planning. The scheduling needs to be done well in advance, as it has to suit both the school and the clinic. This planning can also be affected by different events such as sudden events at school or the clinic. Being instructed to reschedule an appointment at school due to sick leave at the clinic created a great deal of stress and could raise the question on priorities of different tasks in dentistry. On the whole, this preventive programme at school has a high priority at the Public Dental Clinics. Being questioned about the amount of time or material used for the task was also stressful. In Scotland, a new category of dental staff has recently been created. They are called Extended Duties Dental Nurses (EDDNs) and are registered independently to perform some specific dental procedures. The role of these dental nurses appears to be very like the role of dental nurses in Sweden performing FVP. In a recent study by Zhou et al. (21), EDDNs were videotaped during fluoride varnish applications on preschool children and some differences in behaviour were found between the successful and the unsuccessful sessions.

The professional development and special duties associated with the performance of FVP should not be neglected, as regular further training is essential in any profession. In Sweden, FVP are ordinarily performed by dental nurses, as their education enables them to perform a variety of tasks. This is in contrast to the dental nurses in England, who have to take a special course to acquire the practical skills and theoretical knowledge required competently to

apply fluoride varnish to adults and children on the prescription of a dentist or as part of a community project (8). A recent study in England evaluating an fluoride varnish training scheme for dental nurses revealed that the course had contributed to the participants' professional careers and could be an example of "role enhancement" (7), which is in line with the results of the present study, even though the dental nurses in Sweden are already trained to perform fluoride varnish applications as part of their education.

In this study, 15 dental nurses from the Västra Götaland Region were interviewed individually. The chosen approach was suitable for the aim, which was to collect a broad range of experiences. Some of the conceptions found in the study could seem to be contradictory, and this is in agreement with the phenomenographic approach which strives to find the participants' personal experiences. One limitation in a study like this could be the difficulty involved in reaching the participants' inner experiences, also known as the second order perspective (13). There is a risk that the participants will describe their experiences in a somewhat superficial way and that the interviewer will fail to capture the participants' different ways of thinking. This could also be a risk when the interviewer is fairly inexperienced as an interviewer. Furthermore, the participants could be afraid to express their inner feelings when the interviewer is involved in the programme to some extent. However, in this study, the participants shared fear and negative experiences, as well as positive experiences, which indicates that they spoke freely and shared their thoughts and feelings. Nevertheless, it is possible that there are additional ways of experiencing the performance of an FVP. Another limitation was that the mean age of the participants was relatively high and there were no male dental nurses among the participants. It is possible that younger female dental nurses, or male dental nurses, could have contributed with different experiences not covered in this material, but, in spite of this, the distribution of age and gender is a fair reflection of the mean for current dental nurses in the Västra Götaland Region.

However, in this study, the dental nurses' experiences of performing FVP reflected a change in the power balance between the children and adolescents and the dental nurses. Conceptions related to professional development, originating from encountering challenges associated with working in an arena outside the dental clinic. Therefore, support for dental nurses' professional development focusing on man-

agement of these challenges could be recommended. To further improve the performance of FVP, the collaboration between the public dental services and the schools needs to be highlighted.

To conclude, in overall terms in this study, performing a fluoride varnish programme was found to be a positive experience for the dental nurses, as it meant meeting children and adolescents in a context in which most of them are comfortable and relaxed. In addition, the opportunity to identify children and adolescents with poor dental health or poor health and to be able to offer them assistance was regarded as a major advantage. The perceived negative experiences took account of both psychological and physical challenges, such as meeting children and adolescents with troubles and not knowing how to help them or inferior ergonomics when performing the assignment. Furthermore, it was associated with a high degree of independence and variation, as it involves planning and structuring one's own schedule in collaboration with the school staff. One challenge associated with performing an FVP was the perceived need to adapt to the school's conditions and terms, as it means working in someone else's arena.

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Prevalence of dental caries among 16-year-olds in Troms County, Northern Norway

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Abstract

© The investigation documents caries prevalence and associated factors in a sample of 16-year-olds from Troms County, Northern Norway. DMFT/S-values were 4.2/6.1, indicating dental health being similar to the south of Norway and the rest of Scandinavia. No ethnic differences were recorded. Out of a total of 22 tested variables, the following nine showed an independent strong association ($p=0,001$) with prevalence of dental caries: parental education, tooth brushing frequency, parental control of oral hygiene in young age, dental fear, self-rated dental health, BMI, self-rated general health, use of smokeless tobacco, and initial approximal caries. The final multivariate regression analysis indicated that use of smokeless tobacco, dental fear, self-rated dental health and initial approximal caries showed a strong independent association with prevalence of manifest dental caries. In addition, parental education and sugar consumption appeared to be of importance. Sedentary lifestyle with low level of physical activity or hours spent in front of a TV/computer screen did not show any correlation with prevalence of dental caries. Tooth brushing frequency, gingival bleeding, obesity and aspects of general health showed a strong bi-variate association that disappeared when controlling for other variables in a multivariate regression model. The results highlight the importance of including attitude and lifestyle modifiable factors in oral and general health education approaches. Additionally, focus should be set on the management of dental fear in the context of targeted oral health strategies. Finally, it would be beneficial to include initial approximal caries, life style factors, and perception and attitudes to general as well as dental health in caries prediction models.

Key words

Dental caries, adolescents, oral health, initial approximal caries

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Kariesförekomst hos 16-åringar i Troms fylke, nord-Norge

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Sammanfattning

⊙ Avsikten med denna studie var att beskriva tandhälsan hos 16-åringar i nord-Norge och relatera den till allmänhälsa, livsstil och hälsoattityder. Studien är en ungdomsdel av ett fortlöpande medicinskt epidemiologisk forskningsprojekt som har pågått sedan 1974 och där odontologiskt deltagande nu ingick för första gången. En allmän uppfattning är att, i jämförelse med övriga Norge och Skandinavien i stort, såväl allmänhälsa som tandhälsa generellt är sämre i nord-Norge och kanske speciellt för den etniska minoritet som den samiska populationen utgör. Samtliga 1301 ungdomar i första klass på gymnasiet i två kommuner i Troms fylke inviterades. Av dessa valde 1010 (78 %) att delta varav de 869 som var födda 1994 inkluderades i denna studie. Från september 2010 till maj 2011 genomfördes en fullständig klinisk undersökning, kompletterad med "bite-wings", studiemodeller och intraorala foton. Dessutom genomfördes en medicinsk undersökning och två omfattande frågeformulär besvarades. De innefattade tand- och allmänhälsa, socio-demografi, livsstil, kunskaper och attityder.

Ett DMFS-medelvärde på 6,1 hos dessa 869 16-åringar antyder klart att tandhälsan i nord-Norge närmar sig samma nivå som övriga Norge (Skandinavien) och resultaten kunde inte påvisa några etniska skillnader i tandhälsa. Av totalt 22 testade oberoende variabler (omfattande socio-demografi, livsstil, allmänhälsa, tandhälsa, uppfattningar och attityder till tand- och allmänhälsa) uppvisade följande 9 ett signifikant samband med DMFS på högsta nivå ($p=0,001$): föräldrars utbildningsnivå, tandborstningsfrekvens, föräldrars hjälp och kontroll vid tandborstning i unga år, tandvårdsrädsla, självuppfattad tandhälsa, BMI, självuppfattad allmänhälsa, bruk av snus och antal initiala approximala kariesangrepp. Den slutgiltiga multivariata regressionsanalysen indikerar att bruk av snus, tandvårdsrädsla, självuppfattad tandhälsa och initiala kariesskador visade ett oberoende starkt samband med prevalens av karies. Dessutom syntes föräldrars utbildningsnivå och sockerkonsumtion vara av betydelse. Resultaten från denna studie indikerar betydelsen av att inkludera livsstilsfaktorer tillsammans med uppfattningar och attityder till vård och hälsa när nya tandhälsostراتيجier utformas.

Introduction

Over the last 40 years there has been a marked improvement in dental caries status in developed countries (25, 28). In the Nordic countries, a reduction in average DMFT-scores during that period is well documented both for children and adolescents (5, 13, 37). In Norway, national data on caries experience recorded at dentin level (DMFT) for age groups 5, 12 and 18 have been collected annually at county level since 1985 (23). These data confirm the internationally reported decrease in caries prevalence.

This positive development is, however, not shared by all. Many risk factors for the development of caries are well known although caries etiology is complex and to some extent still not fully understood. Dental health varies with socio-economic background and dental caries still remains high in risk groups (17). Parental migration and immigrant background are associated with higher risk for caries in children and adolescents (18, 39). Furthermore, higher caries prevalence has been reported for children and adolescents in Northern Norway compared with the rest of the country (23, 38). Compiled national data on caries among adolescents with Sami background are lacking.

As the prevalence of manifest caries has declined, initial enamel caries has received increased focus in order to give a comprehensive picture of dental health in children and adolescents and consequently a better picture of the complete need for dental treatment including non-operative as well as operative treatment (14). Initial caries is, however, not included in the Official Statistics of Norway (33). It is therefore considered of interest to record initial caries and compare the prevalence of initial and manifest (DMFT/S) caries and how the DMFT/S index will vary according to the threshold used (32). Based on this background information, the aims of the present investigation were:

To record the prevalence of initial and manifest dental caries in a sample of 16-year-olds in Troms County, Northern Norway

To investigate if adolescents with immigrant or Sami background present with higher caries scores

To examine variation in caries prevalence related to selected, independent variables including lifestyle, oral health attitudes and perceptions, oral health parameters and general health.

Material and Methods

The present cross-sectional oral health study, carried out from September 2010 to May 2011, was part

of a larger epidemiological general health project, Tromsø epidemiological study (15, 40). All first year high-school students in Tromsø city (7 schools) and Balsfjord municipality (1 school), both located in Troms county, Northern Norway, were invited. Of a total of 1301 registered students, 1010 volunteered to participate in the oral part (78% attendance rate). Out of these 1010 students, all subjects born in 1994 (869) were included in the present analysis.

Recruitment took place at the schools and information was presented orally, electronically and by distributing a brochure for students and parents/guardians. Students interested in attending confirmed on internet by a link sent to their personal e-mail address and signed a written consent on arrival for the examination. In order to obtain a high participation rate, the survey was conducted during school hours. The participants were transported from the schools to the examination stations at the university by mini-buses, and a 200 NOK (35 \$ US) bonus check was handed out.

The project was approved by the Regional Committee for Medical Research Ethics (2012/1197 REK Nord) and the Norwegian Data Protection Authority (07/00886-11).

The oral health part of the study included a clinical examination and two bite-wing radiographs, impressions of the upper and lower jaws, eight intraoral clinical photographs and a questionnaire. The oral examination was performed at the University Dental Clinic, The Arctic University of Norway, Tromsø, and was carried out by an experienced dentist (IDJ) assisted by dental assistants. The clinical examination replaced the annual dental examination at The Public Dental Health Service (PDHS).

The variables used in the present study are shown in Table 1. Approximal caries was assessed radiographically and scored according to a scale 1 – 5 for increasing depth of radiolucency. Occlusal lesions were diagnosed and scored in a similar 5 graded scale with a combination of clinical and radiographic criteria, while buccal and lingual caries were diagnosed and scored in a 5 graded scale based on clinical criteria only (1). Grade 3, 4 and 5 lesions reaching into dentine (manifest lesions) were included in the DMF-scores, while grade 1 and 2 (enamel lesions) were assigned to initial caries and not included in the DMF-scores. The DMF index values were calculated by adding all “decayed”, “missing” and “filled” (due to caries) permanent teeth/surfaces. For initial caries, only approximal lesions registered from bite-wing radiographs were used as an independent vari-

© **Table 1.** Characteristics of the study population with regard to DMFS index values used as a continuous variable. Bi-variate analysis of variation (ANOVA) Study population: n = 869, mean DMFT/S = 4.16/6.09 (SD = 6.88))

Independent variables					
Socio-demographic		N (%)	DFMS mean	SD	P value
gender	male	449 (51.7)	5.79	6.93	0.189
	female	420 (48.3)	6.40	6.82	
ethnicity	Norwegian	715 (82.3)	6.12	6.96	0.892
	Sami	31 (3.6)	5.52	4.76	
father's education	immigrants	114 (13.1)	6.13	6.79	0.004
	college	287 (33.0)	4.90	5.98	
	high school	247 (28.4)	6.61	6.89	
mother's education	9 years or less	70 (8.1)	7.16	7.55	0.040
	don't know	237 (27.3)	6.64	7.52	
	college	363 (41.8)	5.32	6.07	
parents attended college/university	high school	231 (26.6)	6.49	6.80	0.001
	9 years or less	47 (5.4)	7.21	7.87	
	don't know	213 (24.5)	6.7	7.90	
family parental status	both	208 (23.9)	4.54	5.50	0.002
	one	234 (26.9)	6.19	6.77	
	none	239 (27.5)	7.23	7.51	
family parental status	don't know	188 (21.6)	6.21	7.29	0.002
	both parents	463 (53.3)	5.33	5.90	
	one parent	235 (27.0)	6.81	8.25	
family parental status	none of parents	162 (18.6)	7.25	7.00	0.002
	one parent	235 (27.0)	6.81	8.25	
	none of parents	162 (18.6)	7.25	7.00	
Lifestyle					
smoking	no	772 (88.8)	5.88	6.72	0.009
	yes	86 (9.9)	7.92	7.79	
snuff use	no	617 (71.0)	5.37	6.45	0.001
	yes	241 (27.7)	7.91	7.52	
sugar consumption	low	744 (85.6)	5.77	6.69	0.002
	high	107 (12.3)	7.95	7.06	
physical activity (intensity)	high	176 (20.3)	5.72	6.96	0.225
	moderate	234 (26.9)	5.97	6.85	
	low	272 (31.3)	5.84	6.01	
physical activity (frequency)	sedentary	178 (20.5)	7.04	7.93	0.298
	≥ 4 days/week	224 (25.8)	5.50	6.60	
	2-3 days/week	293 (33.7)	6.19	6.95	
leisure screen time (weekdays)	≤ 1 day/week	341 (39.2)	6.41	6.99	0.584
	<4 hours/day	514 (59.1)	5.99	6.88	
leisure screen time (weekends)	≥4 hours/day	344 (39.6)	6.25	6.88	0.090
	<4 hours/day	353 (40.6)	5.63	6.54	
leisure screen time (weekends)	≥4 hours/day	503 (57.9)	6.44	7.09	0.090
	<4 hours/day	353 (40.6)	5.63	6.54	

© Table 1. Continuation.

Independent variables					
Socio-demographic		N (%)	DFMS mean	SD	P value
Dental health related perceptions and attitudes					
Tooth-brushing frequency	twice or more daily	555 (63.9)	5.28	6.12	0.001
	once daily	198 (22.8)	6.64	7.57	
	less than once daily	103 (11.9)	9.18	7.91	
parental control of oral hygiene	yes	698 (80.3)	5.70	6.61	0.001
	no	164 (18.9)	7.65	7.51	
dental fear	no	801 (92.2)	5.71	6.63	0.001
	yes	56 (6.4)	11.02	7.73	
self-rated dental health	very good, good	493 (56.7)	4.44	5.69	0.001
	neither good nor bad	292 (33.6)	7.29	6.81	
	bad, very bad	77 (8.9)	11.90	9.17	
Dental health parameters					
initial approximal caries	<6	482 (55.5)	3.81	5.14	0.001
	≥6	387 (44.5)	8.92	7.68	
number of teeth with gingival bleeding	<4	148 (17.1)	5.05	5.30	0.017
	≥4	718 (82.6)	6.28	7.15	
General health status					
BMI	normal weight	620 (71.3)	5.63	6.56	0.001
	underweight	50 (5.8)	5.02	5.21	
	overweight	139 (16.0)	7.55	7.94	
	obese	59 (6.8)	8.44	7.88	
chronic diseases/allergy	no	621 (71.5)	5.92	6.84	0.255
	yes	245 (28.2)	6.51	7.00	
self-rated general health	very good, good	635 (73.1)	5.51	6.39	0.001
	neither good nor bad	180 (20.7)	7.43	7.47	
	bad, very bad	41 (4.7)	9.56	9.40	

able in the present analyses.

Periodontal status was measured according to the Community Periodontal Index for Treatment Needs (CPITN) index system. Due to low age of the participants, a simplified version including only six index teeth (16, 11, 26, 36, 31 and 46) was used (41). The scores registered were: number of teeth with presence of gingival bleeding and number of teeth with periodontal pockets 4-5mm or >5mm.

Body mass index was calculated by the formula weight/height². The adolescents were classified into four groups (underweight / normal weight / overweight / obese), according to the Extended Interna-

tional Body Mass Index by Cole and Lobstein (7).

The participants answered two closed questionnaires. One included questions concerning oral hygiene habits and oral health knowledge and attitudes as well as how they perceived parents (or guardians) dental health-related attitudes. The other questionnaire was covering family demographics, current psychological and physical health status, pain, medication, dietary habits and information on lifestyle.

Ethnicity was classified as being Norwegian, Sami or immigrant. Immigrants of Western or non-Western (countries outside EU, North America, Australia and New Zealand) background were identified.

Parents educational level was stratified according to years of schooling as: low (0-9 years), medium (high school or equal) and high (college or university). Family structure was identified based on living with both, one or none of the biological parents. Lifestyle habits covered use of snuff, smoking, sugar consumption, physical activity and time in front of the TV/computer screen. Sugar consumption was based on intake frequency of sweets and soft drinks with sugar. Scores were recorded for the two items in a scale from 1 (minimal - no consumption) to 5 (maximal consumption). The 9 resulting groups based on a combined score for sugar intake were further merged into 2 groups: score 2-6 (low)/score 7-10 (high).

Physical activity (frequency and intensity), based on participants' leisure activities, was registered and graded as sedentary, low, moderate or high. Frequency of actively doing sports or physical activities outside school hours was recorded in a 6-interval scale from "never" to "almost every day". The 6 categories were further converted into three (≤ 1 day a week, 2-3 days a week or ≥ 4 days a week). Time in front of a TV/computer screen was recorded for weekdays and weekends in a 7-graded scale from "none" to ≥ 10 hours /day" and dichotomized in <4 hours/day or ≥ 4 hours/day.

Information on dental health-related variables such as tooth-brushing frequency, parentally controlled oral hygiene and self-rated oral health were also recorded. The students reported whether their parents/caregivers supervised their tooth-brushing in young age recorded in "yes" or "no". Tooth-brushing frequency was given in a 6-graded scale from less than once a week to ≥ 2 times a day. Dental fear was measured based on missed dental appointments due to fear and recorded as "yes" or "no".

Self-rating of dental and general health were classified as "good" or "neither good nor bad" or "bad". In addition, chronic diseases including allergy-related conditions were registered.

Calibration

The principal examiner (IDJ) was calibrated with two experienced dentists. For calculation of inter-observer agreement regarding radiographic examination, BW-radiographs from 88 patients (10% of the study sample) were randomly selected. The three dentists independently examined the approximal surfaces from mesial surface of second molar to the mesial surface of first premolar in each quadrant, altogether 28 surfaces per patient, making a

total of 2464 surfaces and scored them in a scale of 0 (no finding) 1, 2 (enamel caries) 3, 4, 5 (dental caries). On average, the calculated kappa value between recordings of three examiners, was 0.61 (0.71). The linear weighted kappa score is given in parenthesis. Weighted kappa values are higher because some credit is given for differences in recordings when scores are close to each other. Kappa values were calculated by the statistical software MedCalc® version 12.4.0.0 (Ostend, Belgium). Intra-examiner agreement was also calculated between the two registrations of the principal examiner. Kappa value was 0.58 (0.63) comparing all grades and increased to 0.70 when all positive caries scored were pooled into one category (dichotomized). Corresponding calculation based on dichotomized scores for the BW examinations of 88 patients by three observers, showed a kappa value of 0.69.

Data Analysis

All statistical analyses were performed using SPSS 22.0. Students t-test and ANOVA were applied to test differences between groups using DMFS-scores as a continuous dependent variable. The DMFS-scores were then dichotomized at the mean and all independent variables with p-value ≤ 0.05 in the bivariate test (Table 1) were selected to be included in a multivariate regression model (parental education level was used instead of father's and mother's separately). A p-value ≤ 0.05 was considered statistically significant.

Results

Dependent variable - dental caries

The prevalence of dental caries according to the DMF-index was 82.7% in this sample of 16-year-olds. The distribution was highly skewed (skewness = 2.036). Mean DMFT of the sample was 4.16 (± 3.78), range 0-19, while a mean DMFT > 9 was recorded for 9.8%. Mean DMFS was 6.09 \pm 6.88, (range 0-48). For further details, see Table 1.

Independent variables

Socio-demographic

Boys had lower DMFS scores than girls but the difference was not statistically significant (Table 1). Norwegian adolescents constituted a majority of our sample (82.3%) with adolescents of immigrant or Sami background representing 13.1% and 3.6% respectively. There was no statistically significant difference in DMFS score between Norwegian and adolescents with immigrant or Sami background.

© **Table 2.** Multivariate logistic regression analysis including factors with p-values ≤ 0.05 from the bi-variate analysis (Table 1) included in the final model. DMFS-scores are dichotomized with cut-off point DMFS = 6.

Independent variables		Bi-variate p value	Multivariate OR (95% CI)	Multivariate p value
parents attended college/university	both	P = 0.001		P = 0.092
	one			
	none			
parental family status	don't know	P = 0.002		P = 0.133
	both parents			
	one parent			
smoking	no	P = 0.009		P = 0.962
	yes			
snuff use	no	P = 0.001	1	P = 0.010
	yes			
sugar consumption	low	P = 0.002	1.57 (1.12-2.21)	P = 0.084
	high			
tooth-brushing frequency	twice or more daily	P = 0.001		P = 0.798
	once daily			
	less than once daily			
parental control of oral hygiene	yes	P = 0.001		P = 0.222
	no			
dental fear	no	P = 0.001	1	P = 0.001
	yes			
self-rated dental health	very good, good	P = 0.001	1	P = 0.001
	average			
	bad, very bad			
initial approximal caries	<6	P = 0.001	1	P = 0.001
	≥ 6			
teeth with gingival bleeding	<4	P = 0.017	3.25 (2.39-4.43)	P = 0.553
	≥ 4			
BMI	normal weight	P = 0.001		P = 0.623
	underweight			
	overweight			
	obese			
self-rated general health	very good, good	P = 0.001		P = 0.734
	average			
	bad, very bad			

Adolescents where both parents had either college or university education had lower caries score compared to those having one or none of the parents with high education. Adolescents living with both parents had lower DMFS-score compared to those living with one or none of their biological parents. Recordings regarding these two parameters showed statistically significantly different values (Table 1).
Lifestyle

About 10 % of the adolescents reported to smoke

while 28 % reported regular use of snuff. Both groups of tobacco users had significantly higher caries score than non-users (Table 1). More boys than girls reported regular use of tobacco (12.4% vs 7.5% for smoking and 34% vs 21.8% for use of snuff). Regarding sugar intake, 12.5% of the adolescents reported frequent consumption. This was significantly associated with higher caries prevalence (Table 1). Frequent sugar consumption was more than twice as common in boys as in girls (17% vs 8%). Intensity

and frequency of physical activity and time spent daily in front of the TV/computer screen during weekdays or weekends were not associated with differences in caries scores (Table 1).

Dental health-related perceptions and attitudes

A majority of girls (80%) were brushing their teeth at least twice a day compared to 50% of the boys. There was a considerable difference in mean DMFS score between the three tooth brushing frequency groups ($p < 0.001$) (Table 1). Over 80% of the parents used to control oral hygiene of their children. These adolescents had significantly lower DMFS scores than adolescents without parental control of oral hygiene ($p = 0.001$) (Table 1).

Dental fear was highly significantly associated with higher mean DMFS scores and adolescents who rated their oral health as bad had almost 3 times higher mean DMFS scores than those who rated their oral health as good ($p < 0.001$) (Table 1).

Dental health parameters

Only 5.6% (49) of the adolescents were recorded completely caries free (DMFS = 0, and no initial approximal lesions), and 11.5 % (101) had only initial approximal lesions. About 23 % (196) had more than 9 surfaces with initial approximal caries. The prevalence of dentinal caries was statistically significantly associated with initial approximal caries scores (Table 1). Number of teeth with gingival bleeding showed an association with caries prevalence in the bi-variate analysis ($p = 0.017$) (Table 1) that disappeared in the multivariate model. Only 2.3% (20) of the participants had periodontal pockets ≥ 4 mm and only one presented with a pocket > 5 mm.

General health

Over 70% (620) of the students had normal weight, while 6.8 % (59) were obese. There was a statistically significant association between BMI and DMFS score ($p = 0.001$) due to higher caries prevalence linked to overweight/obesity (Table 1). Most of the recorded chronic diseases were allergy-related conditions. No association between DMFS scores and chronic diseases was detected. Adolescents who rated their general health as bad had almost 2 times higher mean DMFS scores than those who rated their general health as good ($p < 0.001$).

The final multivariate regression model comprised only the variables snuff use, dental fear, self-rated dental health and initial approximal caries, while the impact of the other selected disappeared

(Table 2) indicating substantial co-variance among the parameters included. However, parents education level and sugar consumption were close to statistical significance. Having ≥ 6 dental surfaces with initial approximal caries increased the chances to have high DMFS scores by O.R. 3.28.

Discussion

In Norway, the dental caries status in children and adolescents is regularly monitored through data collected annually at county level, reported by the PDHS (33). However, these data are collected in patient care settings by non-calibrated dental personnel and the criteria applied are mainly based on evaluation of operative treatment need. This differs from the criteria applied in epidemiological surveys (3). An epidemiological approach is therefore relevant and necessary for proper oral disease surveillance.

Adolescents were included in the latest series of repetitive cross-sectional Tromsø Health Studies (15), named "Fit Futures" (40). This gave a unique opportunity not only to examine the caries status of about 900 16-year-olds from Northern Norway, but also to relate the variation in caries prevalence to numerous variables representing socio-demographic and lifestyle-related factors including dental health perception and attitudes and aspects of general health.

The oral investigation was performed in a clinical setting and the principal investigator (IDJ) was thoroughly calibrated with experienced clinicians reaching acceptable intra- and inter-observer agreement (Kappa=0.63 and 0.71 respectively) securing reliability.

Parametric statistical tests (Students t-test and ANOVA) were applied for descriptive purposes (Table 1) using DMFS scores as a continuous variable. Although the caries data were skewed, these parametric tests are robust and acceptable considering the large number of observations (9). Multivariate regression analyses were used in order to estimate major effects (odds ratio) of selected independent variables (Table 2).

The prevalence of manifest dental caries in our sample of 16-year-olds was 82.7% with a mean DMFT/S of 4.2/6.1. Regarding the previously documented higher caries prevalence in the North of Norway (23, 37) comparable data from the South of Norway are not available due to the age of target groups used by Statistics Norway (5, 12 and 18 years of age). According to data from Statistics Norway (33)

the prevalence of caries-free (DMFT=0) 18-year-old individuals in the South of Norway was 17.5% in 2011. This was almost identical to our finding in 16-year-olds from Troms (17.3%). Furthermore, the mean DMFT score of 18-year-olds from the South of Norway was reported to be 4.4, while in our sample the mean value was 4.2. With the possible impact of methodological differences, the present data was in agreement with other comparable Scandinavian findings (13) and indicate that a regional difference between North and South of Norway is disappearing.

Investigations have documented that immigrant background in general and non-Western background in particular are associated with higher caries prevalence in children and adolescents. (16, 18, 39). In the present study, we did not find a difference in caries prevalence between ethnic 16-year-old Norwegians and 16-year-olds of Western or non-Western immigrant background. Neither was there any difference between ethnic Norwegians and adolescents of Sami background. This might indicate that these groups are well assimilated in society despite some minor socio-demographic differences detected in the study.

Parents socio-economic status was decided based on years of education, as information on parental position/income based on the participants own information was considered uncertain. There was a statistically significant association between parental level of education and DMFS-scores when relevant variables were considered independently. This is in agreement with previous studies (6, 17). However, this association disappeared in the multivariate regression analysis. The high percentage of students who did not report the education level of father (27%) or mother (25%) may represent a knowledge bias contributing to this result.

Regarding family status, living with both parents seems to be beneficial regarding caries status. This is in agreement with the results from other investigations (5, 6, 35). A functioning family environment is found to be associated with positive oral hygiene habits and attitudes, and lower frequency of dental problems among preschool and school children (24) and oral health related behaviors were found to be inferior among adolescents not living with both parents (19). Indeed, in the present study, adolescents living with both parents had fewer missed dental appointments due to dental fear and a lower percentage among them were snuff users or frequent sugar consumers. However, the impact from this variable

disappeared when controlling for other independent variables (Table 2) probably due to free dental treatment with emphasis on prevention up to 18 years of age.

Use of tobacco in general and smokeless tobacco (snuff) in particular show an association with caries prevalence. This is in agreement with the results from some studies (11), but not in agreement with others (12). The anecdotal assumption that snuff might have an antibacterial, caries-preventive effect is not supported. Our findings (Table 2) seem to confirm the argument that smoking is not associated directly with caries but is more a covariate to caries risk factors (2).

Sugar consumption is considered to be among the most important causal factors for dental caries (31). In the present study, the variable "sugar consumption" was a combination of quantity and frequency of consumption of candies and sugar-containing soft drinks. This variable showed a statistically significant association with caries prevalence. However, this association was reduced to a level slightly below the estimated level of significance ($p=0.08$) when included in the multivariate model (Table 2). The last finding may contribute to the discussion concerning the strength of association between high sugar consumption and caries in a modern, fluoride-exposed society (4).

One of our hypotheses was that a sedentary lifestyle possibly facilitate high snack consumption and use of soft drinks associated with higher caries prevalence. However, our results show that intensity and frequency of physical activity or hours spent in front of a TV/PC screen were not associated with caries prevalence.

Tooth-brushing frequency and plaque control are considered to be important caries-etiological factors (17, 22). It is, however, questionable whether these effects are due to plaque control or to fluoride exposure through dentifrices (30). In the present study we found an association between tooth-brushing frequency and caries prevalence that disappeared in the multivariate analysis (Table 2). The same pattern was detected for the impact of parental control of oral hygiene in young age. Gingival bleeding, an indicator of dental cleanliness, also showed a bi-variate association with the DMFS-level which was not confirmed in the multiple regression analysis indicating a high degree of covariance related to tooth-cleaning variables.

Gingival bleeding was very frequently recorded among the adolescents, particularly among males,

in the present investigation. This finding suggests the need for different dental health education approaches in males and females (8, 10). Our finding that a high percentage of the adolescents (about 80%) brushing their teeth at least two times a day presented with gingival bleeding, may indicate the need for preventive measures (10, 20).

The strong association between self-rated dental health and DMFS-scores indicates that 16-year-olds have a reliable concept of own oral health conditions (35). The strong association between dental fear and dental caries prevalence, was expected (17, 34). Frequently missing dental appointments due to dental fear is considered a caries predictor in caries prediction models (29).

Initial approximal dental caries was found to be strongly associated with prevalence of manifest caries. This is in agreement with previous findings (14, 26, 27, 42) and indicates that number of initial lesions might be an important predictor for further progression.

Our findings indicate that extreme overweight (obesity) might be a caries risk factor while underweight did not show any association with caries prevalence. However, the variable did not enter the final multivariate model (Table 2). Finally, our results could not demonstrate any association between chronic diseases/allergy and dental caries, while self-rated general health showed an impact that disappeared in the multivariate model (Table 2).

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Clinical performance of enamel-dentine bonded all-ceramic restorations: retrospective evaluation in a postgraduate clinic

LISA PRINTZELL¹, CARL FREDRIK HASEID¹, ANDERS EKVELDT¹, CARL HJORTSJÖ¹

Abstract

⊙ The aim of this retrospective study was to evaluate the clinical survival and success of five different types of adhesive bonded all-ceramic restorations, in a postgraduate clinic.

All ceramic enamel-dentin adhesive bonded restorations, either partial (n=94) or full coverage (n=145), were assessed by clinical examination using a modified Californian Dental Association (CDA) system for quality evaluation of dental care and a questionnaire assessing patient satisfaction (VAS) of 29 subjects with 239 restorations. The same 3-step adhesive bonding system in combination with dual-cured resin composite cement was used for all restorations. Rubber dam was used for moisture control. The ceramics were evaluated with respect to patient satisfaction, esthetics, technical and biological complications.

The reasons for treatment were mineralisation disorders (n=82), trauma (n=40), esthetic (n=57) and pathological tooth wear (n=60). Observation period for the restorations was up to 71 month (mean 33). All restorations were in place at the examinations (100% survival rate). Number of fractures and infractions were 28 and 20 respectively giving a 69% success rate. No significant difference was observed between full coverage and partial coverage restorations. Most of the fractures were small chippings of the veneering porcelain. From a biological point of view subgingival location of the restoration margin showed a significant correlation with bleeding on probing. The esthetic outcome seemed to depend on the ability of the selected veneering material to mask a severe tooth discoloration. The patients reported a high degree of satisfaction with both the esthetics and the function of their restorations.

In conclusion all-ceramic enamel-dentin-bonded restorations demonstrated good short-term survival rate. The success rate was found to be lower. Both technical and biological complications were present but mainly without any need of correction. The patients were in general very satisfied with the result of their dental treatment both esthetically and functionally.

Key words

Porcelain veneer, all-ceramic, enamel-dentin-bonded, clinical evaluation, educational.

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Kliniskt utfall av helkeramiska restaureringar utförda på en specialistutbildningsklinik

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Sammanfattning

☉ Syftet med denna retrospektive studie var att utvärdera behandling, med adhesivt cementerade helkeramiska skalkronor och fasader.

Urvalet utgjordes av 239 adhesivt cementerade restaureringar, på 29 patienter, antingen i form av skalfasader (94 st) eller skalkronor (145 st). Fördelen med att använda skalfasader och skalkronor är att denna innebär en minimal invasiv teknik jämfört med mer traditionell protetisk behandling. All cementering gjordes under kofferdam med samma 3-steps bonding system och med ett dualhärdande kompositcement. Califonia Dental Association (CDA) kriterier användes för utvärdering medan bedömning av patienttillfredsställelse och estetik gjordes med hjälp av en VAS skalor.

Indikationerna för behandling var mineraliseringsstörning (n=82), trauma (n=40), estetiska skäl (n=57) och patologiska tandslitage (n=60). Vid undersökningstillfället, efter en observationstid upp till 71 månader (i medeltal 33), var samtliga konstruktioner i funktion (100 % överlevnad) men 28 av de keramiska restaureringarna uppvisade frakturer och på 20 fanns infraktioner. Små porslinsfrakturer observerades frekvent. Totalt 69 % av restaureringarna var helt komplikationsfria. Vi fann en korrelation mellan subgingival placering av krongränsen och blödning (BoP). Det estetiska resultatet påverkas av det keramiska materialets förmåga att maskera underliggande missfärgningar. Detta ställer krav på behandlande tandläkares terapi. Patienterna rapporterade genomgående höga värden (VAS skalan) för både estetik och funktion. De var generellt nöjda med genomförd behandling.

Slutsatser: Adhesivt cementerade helkeramiska restaureringar uppvisar god funktion åtminstone i ett kort och medellångt perspektiv. Det förekom både tekniska och biologiska komplikationer men de flesta krävde ingen korrektion eller ytterligare behandling. Patienterna var i allmänhet mycket tillfreds med behandlingen både ur estetik och funktionell synpunkt.

Introduction

Most all-ceramic restorations have the advantage of being optimal in mimicing the translucency and structure of natural teeth. Enamel-dentin bonded all ceramic restorations are mainly used to optimize tooth form and positions e.g. restore teeth with pathological tooth-wear, mineralisation disorders and/or to cover or reduce tooth discoloration (17, 20). The minimal invasive preparations needed for the adhesive bonding technique also have the advantage to minimize most iatrogenic injuries like for instance impairment of the pulp (22, 23).

Previous reported clinical outcomes of porcelain veneers are contradictory. Failure rate for feldspathic porcelain veneers have been reported to range from 2% to 42% after five years (5, 19) and 4% to 47% after ten years (3,13). In a Swedish 15-year prospective evaluation of extensive dentin-enamel-bonded pressed ceramic coverages a failure rate of 24.1% was reported (22).

The adhesive bonding technique is a very time consuming and technique sensitive procedure. Therefore it is likely to assume that the prognosis highly depends on the handling of the restoration and bonding agents both by the dental technician and the dentist, as well as individual patient conditions (4). Factors related to the patient that may influence the survival of porcelain veneers are gender, age, parafunctional habits, patient's treatment need, and vitality of the abutment tooth (3, 22).

In recent years an increased number of different ceramic materials have been introduced for restorative treatment. The brittleness and low tensile strength of some of these materials before placement makes both the pre-bond handling and the actual bonding of the restoration essential in order to achieve optimal strength and avoid crack propagation (2, 9, 17). Bulk fracture and loss of retention have been reported as the main reasons for failure in posterior enamel-dentin-bonded restorations (23). Different concepts regarding the preparation of the abutment tooth have been advocated throughout the years, varying from removal of certain amounts of tooth structure to minimal or no preparation at all of the abutment tooth (17). However, as of today a golden standard for this procedure is still lacking.

All-ceramic restoration materials may be divided into three main categories: predominantly glass-based ceramics, particle-filled glass ceramics and completely polycrystalline ceramics (no glass) (9, 10). The later material is primarily used as a core-material in full crowns and does not bond to resin

cement without modifications (1, 16).

The aim of this study was to evaluate the clinical success, survival and patient satisfaction with enamel-dentin all-ceramic restorations placed in a postgraduate clinic.

Material and methods

Study design

A retrospective evaluation of patients treated with all ceramic enamel-dentin bonded restorations. All patients were referred for prosthodontic treatment to the Department of Prosthetic Dentistry, Faculty of Dentistry, University of Oslo (UiO), either in-house or from general dental practitioners in the Oslo surrounding area. The patients were treated by 10 different postgraduate students at the department between January 2006 and June 2012. The study was approved by the Regional Committee for Medical and Health Research Ethics, South East Norway (REK sør-øst 2012/1525 B).

The patients had been referred to the clinic for one of the following treatment needs: change of tooth morphology, post-orthodontic treatment, trauma, pathological tooth wear or for esthetic reasons.

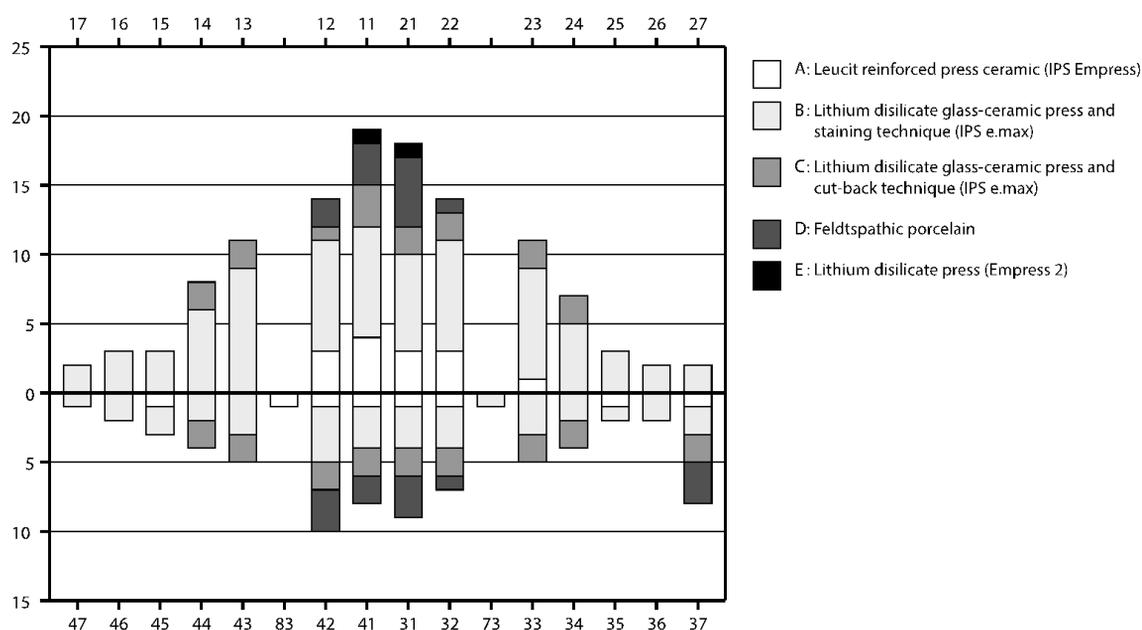
Subjects

Electronic search for patients were conducted in the computerised journal system (Salud Dental Suite, Dublin, Ireland) used at the institute of Clinical Dentistry.

Search criteria: Ceramic crowns and ceramic veneers cemented with resin cements, in the period between January 2006 and June 2012. *Inclusion criteria:* Patient treated with all-ceramic enamel-dentin bonded restorations, light or dual-cured total etch resin cements. *Exclusion criteria:* Polycrystalline ceramics (e.g. zirconia or aluminium oxide), conventional cemented restorations (i.e. non enamel-dentin bonded restorations) and self-adhesive cements.

Ninety-two subjects were identified. Manual review of the patient records excluded 39 subjects either according to pre-set exclusion criteria or because subjects did not meet the inclusion criteria.

Fifty-three subjects were attempted contacted by either telephone or by mail. Updated mailing list was obtained from the National Registry. Twenty-four persons could not participate for various reasons; impossible to reach (n=12), living abroad (n=5), did not want to attend examination (n=5) or did not show up at set appointment (n=2). Twenty-nine subjects did volunteer to participate in the study. 18



© Figure 1. Distribution of restorations according to the material used.

women and 11 men aged from 17 to 67 years with a mean age of 36.7 years

Ceramic materials used

Five different ceramic materials were used: A) Leucit reinforced press ceramic (Ivoclar Vivadent IPS Empress®, Schaan, Lichtenstein), B) Lithium disilicate glass-ceramic press and staining technique (Ivoclar Vivadent IPS e.max®, Schaan, Lichtenstein), C) Lithium disilicate glass-ceramic press with a cutback technique (Ivoclar Vivadent IPS e. max®, Schaan, Lichtenstein), D) Feldspathic porcelain, E) Lithium disilicate press (Ivoclar Vivadent Empress2®, Schaan, Lichtenstein). Distribution on restoration and individual level is presented in Fig 1.

Prosthetic procedure

The enamel-dentin bonded all ceramic restorations, on the minimal invasive prepared teeth, were manufactured in two different dental laboratories in Oslo, Norway. All restorations were cemented by use of the same adhesive bonding system (Bisco ALL-BOND 2®, Schaumburg, Illinois, USA) and the same dual cured resin cement (Ivoclar Vivadent Variolink II®, Schaan, Lichtenstein), according to the manufacturer's instructions. All the restorations were

bonded to the abutment tooth using a rubber dam for moisture control.

Registrations

All selected patient records were scrutinized and the following data were registered: gender, age, location and type of restorations, bonding system, adhesive cement, material, operator, dental laboratory, time in function and indication/diagnose for the treatment.

Clinical examination

The first five test subjects were examined with all authors present, giving a state of consensus evaluation of the clinical parameters used. One of the authors (CFH) served as the main clinical examiner assisted by (LP), the other authors (AE and CH) were consulted when necessary. None of the authors had performed any of the restorations themselves.

The restorations were examined in accordance with the a modified version of Californian Dental Association system for quality evaluation of dental care (18). Evaluating surface and colour (CDA SC), anatomy (CDA Anat) and marginal integrity (CDA Marg) of each restoration. The CDA scores: R=Range of Excellence, S=Range of Acceptability, T=Replace

© **Table 1.** Fractures and infractions according to material A: Leucit reinforced press ceramic (IPS Empress), B: Lithium disilicate glass-ceramic press and staining technique (IPS e.max), C: Lithium disilicate glass-ceramic press and cut-back technique (IPS e.max), D: Feldspathic porcelain E: Lithium disilicate press (Empress 2).

	Material	Number of restorations		Number of fractures		Number of infractions	
		Restoration level	Subject level	Restoration level	Subject level	Restoration level	Subject level
All restorations	A	30	2	16 (53%)	1(50%)	11 (37%)	1(50%)
	B	124	16	4 (3%)	0 (0%)	1 (1%)	1(6.%)
	C	41	4	0 (0%)	0(0%)	1 (2%)	0(0%)
	D	40	7	7 (18%)	1(14%)	7 (18%)	3(43%)
	E	4	1	1 (25%)	0(0%)	0 (0%)	0(0%)
Veneers	A	13	2	5 (39%)	1 (50%)	6 (46%)	1 (50%)
	B	47	5	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	C	9	1	0 (0%)	0 (0%)	1 (11%)	0 (0%)
	D	23	5	6 (26%)	1 (20%)	3 (13%)	2 (40%)
	E	2	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Crowns	A	17	0	11 (65%)	-	5 (29%)	-
	B	77	10	4 (5%)	0 (0%)	1 (1%)	1 (10%)
	C	32	3	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	D	17	2	1 (6%)	0 (0%)	4 (24%)	1 (50%)
	E	2	0	1 (50%)	-	0 (0%)	-

or correct for Prevention, V=Replace Statim. The examination comprised registration of a number of technical and biological data.

The technical parameters:

Fractures and infractions of the restoration material location of the restoration margin (sub-, supra- or equi- gingival), marginal fit (excellent, visible crevice on x-ray, catch of explorer without penetration, visible evidence of crevice with penetration of explorer) and degree of wear (no wear, small facet, or marked facet) of all restorations were recorded.

Occlusal contacts between the restorations and the opposing teeth were recorded in the maximal intercuspal position (MIP), at lateral excursion and protrusive movements using an occlusion foil (TrollFoil, Trollhätteplast AB, Trollhättan, Sweden).

The biological parameters:

Recordings at the abutment teeth included probing pocket depths, amount of plaque, pus and bleeding on probing (BoP, present or absent) at four sites (mesial, buccal, distal, lingual) and mobility. The amount of plaque was assessed according to a four-point scale by Silness & Loe.(21) Soft tissue around the restorations was evaluated in terms of colour,

shape and appearance of the papilla.

Success and survival

Survival was defined as the reconstruction remaining in situ with or without modifications over the entire observation period. This includes all restorations with CDA score R, S or T independently of the presence of either fractures or infractions.

Success was defined as restorations with CDA scores R and S remaining unchanged and free of all technical complications over the entire observation period according to Pjetursson et al 2007 (18).

Questionnaire

The subjects were asked to evaluate the appearance, function, discomfort and overall satisfaction with their restoration using a Visual Analogue Scale (VAS) (0 = not at all satisfied, 100 = extremely satisfied). The questionnaire also included questions about awareness of tooth grinding/tooth clenching at night and during the day (every day/night, some night/day per week, very seldom or never). Smoking and moist snuff (non-smoking tobacco) habits were recorded (no, yes).

© **Table 2.** CDA scores on restoration level. Corresponding values in percentage within brackets. CDA score R=Range of Excellence, S=Range of Acceptability, T=Replace or correct for Prevention, V=Replace Statim.

	Score	R	S	T	V
All restoration	CDA SC	99 (41. %)	118 (49. %)	21 (9%)	1 (0.4 %)
	CDA Anat	101 (42. %)	135 (57 %)	0 (0 %)	3 (1. %)
	CDA Marg	121 (51 %)	114(48 %)	3 (1. %)	1 (0.4 %)
All Veneers	CDA SC	46 (49%)	38 (40.%)	9 (10%)	1 (1.%)
	CDA Anat	36 (38.%)	55 (59%)	0 (0.0%)	3 (3.%)
	CDA Marg	45 (48%)	47 (50.%)	1 (1.%)	1 (1.1%)
All crowns	CDA SC	53 (36.6%)	80 (55.%)	12 (8.%)	0 (0.0%)
	CDA Anat	65 (44.8%)	80 (55.%)	0 (0.0%)	0 (0.0%)
	CDA Marg	76 (52.4%)	67 (46.%)	2 (1.%)	0 (0.0%)

Statistics

Descriptive statistics was used for presenting the data of all 239 restorations (restoration level) and on a subject level. Groups were compared using cross tabulation with Chi-Square test. The statistical analyses were performed using SPSS v.19.0 software (SPSS Inc., Chicago, IL, USA). To avoid the dependency among restorations in the same patient one random restoration in each individual were selected by random number generator. In total 29 restorations were identified to represent one restoration in each subject (subject level).

The significance level was set at $P < 0.05$.

Results

Clinical examination

A total of 239 enamel-dentine bonded all-ceramic restorations had been placed in 29 subjects, counting 94 veneers and 145 full-cover crowns. The treated subjects had received from 1 to 24 restorations each (mean 8.5, median 6).

The noted indications for treatment were (no. of restorations/no. of subjects): mineralisation disorders 82/5, trauma 40/8, esthetic reasons 57/6 and pathological tooth wear 60/10. Five different materials were used (A, B, C, D, E - distribution presented in figure 1 and Table 1).

The observation time of the assessed restorations ranged from a minimum of 5 month to a maximum

of 71 months, with a mean of 33 months and a median of 30 months.

Technical complications

All restorations were evaluated according to the CDA system and the CDA scores are presented for all restorations (*restoration level*) in table 2.

CDA-SC: Twenty-one restorations were assessed as Tango (Replace or correct for Prevention) for *surface and colour*. Twenty of the 21 restorations assessed as Tango for surface and colour were found in the same subject treated for amelogenesis imperfecta.

CDA-anat: Three restorations were assessed as failures. Two due to severe chippings and one had an inadequate anatomic form.

CDA-marg: Three restorations had “not acceptable *marginal integrity*”. They showed visible evidence of crevice and penetration of explorer. However, in these teeth there were neither signs of discolouration nor pathology such as caries or gingival inflammation.

Occlusal contacts between the restorations and the opposing teeth were registered for 147 (61.5%) of the 239 restorations in maximal intercuspid position (MIP) and for 142 (59.4%) of the 239 restorations in lateral or protrusive excursions. No wear facets were observed on 170 (71,1%) of the restorations, small wear facets on 54 (22.6%) and marked wear facets



© Figure 2. Enamel-dentine bonded restoration in feldspathic porcelain placed on teeth with mild amelogenesis imperfecta.



© Figure 3. Enamel-dentine bonded restoration in feldspathic porcelain placed on heavily discoloured teeth with severe amelogenesis imperfecta. These restorations failed to successfully mask the discoloured abutment teeth.

on 15 (6.3%) of the restorations.

The number of restorations with either a small fracture of the porcelain (chipping) and/or infraction registered were 28 and 20 respectively (Table 2) and were observed on 10 subjects each. Due to the randomisation used for transferring data to *subject level* only a few of these subjects are presented in Table 1. No difference was found between veneers and full coverage restorations. Four restorations displayed both types of complications and two of these restorations were observed in the same patient.

Leucit reinforced press ceramic (A) showed a higher frequency of fractures 16 (53 %) and infractions 11 (37 %), than the other materials used.

Lithium disilicate glass-ceramic press with staining technique (B) displayed few fractures 4 (3 %) and infractions 1 (1 %) (Table 1).

Patients treated for *trauma* or *pathological tooth wear* displayed a higher rate of infractions than the other subjects. Nine out of 40 (23 %) restorations placed due to *trauma* and 9 out of 60 (15%) restorations placed due to *tooth wear* displayed infractions. Only 1 out of 82 (1 %) restorations placed on patients

treated for *mineralisation disorder* and 1 of 57 (2 %) restorations made for *esthetic reasons* exhibited infractions.

There was a high number of both fractures and infractions present on restorations with *marked wear facets* (47 % fractures and 33% infractions) compared to those restorations with only *small wear facets* (15 % fractures and 11% infractions) or with no signs of *wear facets* (8 % fractures and 5% infractions).

Biological complications and oral hygiene

Bleeding on probing (BOP) was registered at 160 (67 %) of the 239 restorations. The majority 225/239 (94. %) of the restored teeth had a pocket depth of 4 mm or less and only 14 (6 %) displayed a pocket depth of 5 mm or more.

No plaque was registered on 124 (52 %) restorations, a thin layer on 99 (41 %) and moderate amount on 16 (7 %) respectively.

Correlations on subject level

There was a *significant correlation* found between numbers of infractions and the ceramic material used on the *subject level*. The all ceramic restorations fabricated in a feldspathic or a synthetic porcelain displayed more infractions compared to those made in a press ceramic material ($p=0.039$). Indeed lithium disilicate press ceramic displayed a significantly lower number of infractions as compared to all the other materials used ($p=0.033$). There was also a *significant correlation* found between reason for treatment and infractions as subjects treated for trauma displayed a higher rate ($p=0.034$). Regarding approximal surfaces (mesial and distal) a significant correlation was also found between placement of the restoration margin (sub-, supra- or equi- gingival) and bleeding on probing (BoP) ($p \leq 0.001$).

Survival and Success of the restorations

All restorations, including the three restorations that needed replacement following examination, had remained in situ during the observation period resulting in a 100% survival. The success rate at restoration level was 74 % (176/239) and the corresponding figure at the subject level was 69% (20/29).

Questionnaire

All 29 examined subjects completed the questionnaire.

Three patients reported daily clenching of the teeth while five patients reported to do so a few times

per week. One subject was aware of tooth grinding every night and seven did this a few times per week.

The median values of the VAS assessment for the esthetics and restoration function were both 90%. The patient's assessment of any possible problems with the restoration and their expectations of the dental treatment also demonstrated a high degree of satisfaction showing median value of the VAS assessment at 98%.

Discussion

The all-ceramic restorations, in this study, performed in general reasonable well during the observation period of this study. All restorations were still in place resulting in a 100% survival. Overall the subjects reported high satisfaction with the esthetics and the functions as well as their expectations of the dental treatment. Most of the fractures observed were small chippings with no need for corrections. Only three restorations had to be replaced, two as a result of severe fractures and one because of unsatisfactory anatomic shape. None of the recorded infractions had any esthetical or functional relevance. The success rate for all 239 restorations were lower (74 %) due to a strict definition of *success*, including only restoration that were free of all technical complications over the entire observation period (18). In other studies *success* are defined differently (7, 12, 22). In these studies *success* may include restorations with minor chippings, resulting in higher success rate then reported in our study. A meta-analysis concluded that the 10- year survival for feldspathic porcelain approached 95% (12). A 15-year prospective evaluation of pressed ceramic restorations reported 24.1% failure rate 18 lost, 16 fractured and 11 due to secondary caries (4). A systemic review of IPS Empress all ceramic crowns concluded that 3.8% of these crowns fractured after a mean observation period of 4.5 years(7). Defining failure only as fractures of the restoration, will exclude all other complications such as caries, minor chippings, infractions and discolorations. This might give a more favourable figure than the actual truth.

Dumfahrt et al. (5) used a modified CDA/Ryge criteria in their retrospective evaluation of veneers from 1-10 years of service. A failure rate of 4% was reported, the main reason for failure was fractures or partial debonding of the restorations. However, they also reported *suboptimal marginal integrity* in 36% (68/191) of the restorations which is comparable with our finding of 47.7% (114/239). In that study 1% of the restorations were classified as *not accept-*

able compared to 1.7% found in the present study.

In a 7-year prospective split-mouth study, comparing lithium disilicate press (IPS E.max) and leucite-reinforced CAD/CAM (Ivoclar Vivadent, ProCAD) restorations (6), the initial cohort of 25 patients with 40 restorations in each group were reduced to just 14 patients with a total of 24 restorations in each group at the 7-year follow-up examination. Though the authors presented a 100% survival rate (Kaplan-Meier) for Lithium disilicate press and 97% for Leucite-reinforced CAD/CAM their figures could probably be argued. The Kaplan-Meier *success rate* reported was reasonably lower; 84% and 58%, respectively. The authors attribute the low failure rate of Lithium disilicate press to the improved flexural strength of the pressed system (400MPa) and the homogeneity of the CAD/CAM material. In that study they also found a high number of restorations with increased surface roughness and impaired colour in the Lithium disilicate press restorations. This is in coherence with the present study.

In this study there was a significant correlation found between numbers of infractions and the ceramic material used both on subject and restoration level. The feldspathic or a synthetic porcelain displayed more infractions compared to those made in a press ceramic material on a subject level. However, on restoration level, the Leucit reinforced press ceramic reported a high frequency of both fractures and infractions. This may be explained by the selection process where one tooth is selected to represent that subject (table 2).

Being minimal invasive procedure one of the major advantages of enamel-dentin bonded all ceramic restorations are their excellent esthetic qualities, due to their often eggshell-thin and translucent character (Fig 2). However, these restorations also present some obvious disadvantages of which one is the increased risk for fractures and another is their poor ability to mask stained or discoloured tooth substance (9). Both drawbacks were observed in the present study. All ceramic materials have high compressive strength but low flexural strength (24) and this is probably the most likely explanation for all the infractions and fractures observed in present study

In one patient with amelogenesis imperfecta the greyish colour of the treated teeth was observed through the restoration giving a CDA SC score T for 20 restorations (table 2 and Fig 3). This complication was due to the high translucency of the used restorative material resulting in a suboptimal esthetic

outcome and it emphasises the interdependence between case selection and choice of restorative material. In patients with discoloured teeth other types of restorations/crowns with more opaque core-materials might be indicated providing a more esthetically satisfactory result. Being less invasive enamel-dentin bonded all ceramic restorations are still favourable in esthetically challenging cases in young individuals with amelogenesis imperfect (14).

In another retrospective five year follow up study, the highest complication and failure rates were seen in patients treated for amelogenesis - and dentinogenesis imperfecta revealing 4 out of 5 cases with complications (11).

The *clustering outcome* reported in this study, as a consequence of assessing several restorations in the same subject (Fig 3). Multiple dental restorations in the same mouth are exposed to the same local and systemic factors (13). Frequently, success and survival of porcelain veneers and crowns have been reported on a tooth level and not on subject level. Reporting several restorations in the same subject can potentially cause an interdependency bias (8). To minimize this statistical problem we have reported on both subject and restoration level. Our data shows good agreement between the *success rate* calculated on *restoration level* (74%) and on *subject level* (69%).

In a systematic review (12) only one of the included 6 studies reported results from both subject and restoration level, whereas the remaining 5 studies reported on restoration level only. The included studies reported a range from 50 to 155 subjects, while the number of restorations ranged from 87 to 499.

A supragingival placement of the cervical crown margin is normally preferable (15). In most cases a thin all-ceramic bonded restoration with an almost invisible transition between tooth and restoration makes a supragingival placement possible (22, 23). A significant correlation was found between the placement of the restoration margin (sub-, supra- or equi- gingival) and bleeding on probing at the approximal sites of the restoration confirming results in earlier studies (5, 17).

All treatments were performed in an educational setting by 10 postgraduate students in prosthodontics, and thus may not be comparable to similar data found among general practitioners. Postgraduate students are considered to be highly calibrated due to their educational situation, which includes a constant quality follow-up by highly trained supervisors.

The rather short mean observation time is a consequence of the period chosen. This period between 2006 and 2012 was chosen, because the use of all-ceramic enamel-dentin-bonded restorations escalated from the year 2006.

In conclusion, all-ceramic restorations performed reasonable well within the time period, with a 100% survival. However, the *success rate* calculated on *restoration level* 74 % and on *subject level* 69% were lower. The reasons for non-success were mainly attributed to small fractures and infractions of the porcelain or discoloration of the restored tooth due to high translucency of the restorative material. Considering these factors when planning the restorative treatment will probably ensure a higher success rate. Overall the subjects were *satisfied* with the esthetics and the function as well as their expectations of the dental treatment. Within the limitations of this retrospective study enamel-dentin bonded all ceramic restorations could be recommended in many esthetic challenging cases, providing the correct all-ceramic material is chosen for the clinical situation. Particularly in young individuals, the operative technique being less invasive compared to conventional crown and bridge work.

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Non-specific chronic orofacial pain patients' experiences of everyday life situations: a qualitative study

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Abstract

⊙ Chronic orofacial pain is a complex condition with consequences that affect daily living. The aim was to analyse nonspecific chronic orofacial pain patients' experiences of everyday life situations, using a qualitative approach. Eleven women and 3 men (21 to 77 years) were selected through a purposive sampling among chronic orofacial pain patients referred to the Faculty of Odontology's orofacial pain unit at Malmö University, Malmö, Sweden. All selected subjects agreed to participate. Data were obtained via two thematic in-depth interviews with each subject. Interviews were taped and transcribed verbatim. Text dealing with the subjects' daily experiences was identified in all interviews and analysed using qualitative content analysis that focused on manifest content. In everyday life situations, the analysis of nonspecific chronic orofacial pain patients' narrations exposed a fear of conflict, of personal weakness, and of the intangible; they also exposed self-blame and avoidance of fear-triggering situations. Eight of the 14 subjects did not spontaneously mention any situation in which they were content during daily living. When the patients spoke about everyday life experiences, the main finding was that unpleasant emotions dominated the subjects' experiences. In conclusion, the chronic orofacial pain condition cannot be understood as an isolated phenomenon; it must be considered in relation to the person who is suffering from the condition.

Key words

chronic pain, facial pain, fear, guilt and shame, qualitative research

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Svårförklarad kronisk ansiktssmärta – patientens upplevelse av vardagssituationer. En kvalitativ studie

EVA WOLF, MARIA NILNER, KERSTIN PETERSSON

Sammanfattning

⊙ Kronisk ansiktssmärta är ett komplext tillstånd med konsekvenser som påverkar hela livssituationen. Syftet med studien var att med ett kvalitativt angreppssätt analysera upplevelsen av vardagssituationer för patienter med svårförklarlig kronisk ansiktssmärta. Elva kvinnor och tre män (21 till 77 år) valdes strategiskt ut bland de patienter med kronisk ansiktssmärta som remitterats till Orofaciala smärtenheten vid Odontologiska fakulteten, Malmö högskola, Malmö, Sverige. Samtliga utvalda informanter accepterade att delta. Data samlades in genom två tematiska djupintervjuer med varje informant. Intervjuerna spelades in med en digital ljudupptagare och skrevs ut ordagrant. Den text som berörde vardagssituationer identifierades i samtliga intervjuer och analyserades med kvalitativ innehållsanalys. Analysen av informanternas berättelser om vardagssituationer avslöjade en rädsla för konflikter, för den egna svagheten och för det okända. Analysen avslöjade också att informanterna uttryckte självanklagelser och att de undvek situationer som kunde orsaka rädsla. Åtta av de 14 informanterna nämnde inte någon vardagssituation de kände sig tillfreds med. Informanternas upplevelser av vardagssituationer dominerades av negativa känslor. Sammanfattningsvis kan kronisk långvarig svårförklarad ansiktssmärta inte förstås som ett isolerat fenomen utan måste beaktas i relation till den individ som drabbats av tillståndet.

Introduction

Chronic pain and chronic orofacial pain are complex conditions. Complicated sensory mechanisms—with interacting emotional, social, and cultural circumstances—contribute to the complexity (10, 21). When patients and pain conditions are difficult to understand, caregivers might consider the pain to be nonspecific, which further strengthens impressions of complexity. The prognosis is reported to be unsatisfactory (1,5,17,20,25), which increases risk of adverse consequences such as (i) emotional drain on individuals, (ii) frequent return visits to caregivers, and (iii) sick leave periods that are costly for individuals and society.

Chronic pain treatment strategies that are proven to have some success are directed toward a patient's entire life situation. Caregivers need knowledge about individuals' varying chronic pain components and the consequences that affect daily living. They must also know how to individually align treatment strategies according to this knowledge (16). So understanding patients' perspectives by exploring an individual's context-specific experiences might be significant within chronic orofacial pain research. A scientific method that embrace qualitative design allowing access to an individual's perspective, presented in thoughts, ideas, feelings, and attitudes, therefore was considered suitable for this research topic (3,9).

Other results based on qualitative analyses concerning the patients included in this study have been reported previously (23,24). These results suggested that communication between patients and caregivers was unsatisfactory and that patients demonstrated limited abilities to cope with pain (24). The patients revealed that the essence of chronic orofacial pain was something that eludes perception and comprehension. Analyses of patients' narratives of their lives with pain revealed that they experienced their chronic orofacial pain to have no limits and to repressively permeate all aspects of their existence (23).

For chronic orofacial pain patients, pain often is the dominant experience in various life situations. However, obviously in some situations the pain is secondary. To further understand the complexity of the chronic orofacial pain condition, the aim of this study was to analyse nonspecific chronic orofacial pain patients' experiences of everyday life situations, using a qualitative approach.

Material and Methods

Subject participation inclusion criteria were one or both:

A. No reasonable explanation for the chronic orofacial pain condition.

B. A pain behaviour that, to an experienced clinician, appeared to be incongruent with the pain described.

Subjects were selected from 191 patients referred to the Faculty of Odontology's orofacial pain unit at Malmö University, Malmö, Sweden from 2002 to 2004. The sample formed a heterogeneous group when it comes to clinical diagnoses, reasons for selection, employment, marital status, and education. All 14 subjects were European (11 women and 3 men; ages 21–77); 12 were Swedish. A purposive sampling was done, that is, a strategic selection of subjects whose pain condition in combination with attitude, expression, and non-verbal language was considered to be especially difficult to understand (Table 1). Eight were selected during clinical consultations at the pain unit, and 6 were selected based on information in their records. Eight subjects also reported pain outside the orofacial region. All subjects signed an informed-consent form before the study.

Data collection, processing, and analysis

The interviewer (EW) made primary contact with the subjects, presented the study, and scheduled interviews. Each subject was interviewed on 2 occasions for 45 to 110 minutes at an interval of 1 week to 4 months. The interviews were conducted and audio taped in a nonclinical environment, either at the Faculty of Odontology or in subjects' home. Interview areas were chosen to cover reflections on (i) the context of the orofacial pain condition, (ii) reflections on the first interview and (iii) subjects' view of the future (Table 2). The interview technique encouraged subjects to narrate experiences in their own words and perspectives. The interviewer's task was to minimize interview bias by encouraging free-flowing narratives related to the interview areas. To facilitate and enhance reflection, make comments, and correct misunderstandings, each subject received a copy of the first interview and was asked to listen to it before the second interview was performed.

The present study implemented qualitative content analysis based on principles formulated by Graneheim & Lundman (7). To make text manageable for analysis, the following process was initially accomplished for the entire material (Table 3):

© **Table 1.** Sex, age, reasons for selection, clinical diagnoses, employment, marital status (including number of children living at home) and education

Sex	Age	Reasons for selection	Clinical diagnoses	Employment	Marital status	Education
Female	76	Inconsistent descriptions of the pain location Atypical facial pain	Myofascial pain with limited opening	Retired	Widow	compulsory
Female	40	Contradictory body language	Myofascial pain Osteoarthritis Episodic tension headache Atypical odontalgia Fibromyalgia	Sick-listed	Single	upper secondary
Female	66	Suffered much, but declined further treatment	Osteoarthritis Disc displacement without reduction with limited opening Myofascial pain with limited opening	Retired	Single	-
Female	74	Extreme anger about the health care received Pain description inconsistent with clinical results	Myofascial pain with limited opening Atypical facial pain	Retired	Married	upper secondary
Female	77	Extreme fatigue from the pain syndrome ^a	Burning mouth Lingua geographic	Retired	Married	compulsory
Male	68	Requested removal of amalgam fillings Explained the pain in a bewildering fashion	Atypical facial pain	Self-employed	Married (1)	university degree
Female	32	Did not accept medical explanations of the pain Demanded further treatment	Atypical odontalgia	Employed	Married (2)	upper secondary

The interviewer transcribed the interviews verbatim including implicit expressions.

Interview transcripts were read several times to get an overall impression from the material.

The text was cut at the point that a change in meaning occurred; *meaning units* that contained text related to the same content and context were identified.

Meaning units were condensed into more succinct formulations by excluding all unnecessary words; consequently, *condensed meaning units* were identified.

The content of each condensed meaning unit was abstracted and assigned a code that reflected the central meaning in the unit

The repeated reading of the transcribed interviews, the meaning unit identification, the condensation and the coding was done by the first author. The two co-authors read two interviews and the identification of meaning units as well as coding were discussed for these interviews. The co-authors, familiar with the context due to a several year experience from the Orofacial Pain Unit at the faculty, checked the entire coding for trustworthiness.

Everyday life experiences when pain was not in focus were spontaneously brought up by all but one of the patients during the interviews. As the unit of analysis for this paper was the patients' everyday life situations without pain focus, the meaning units covering this topic were identified and selected for

© **Table 1.** Sex, age, reasons for selection, clinical diagnoses, employment, marital status (including number of children living at home) and education

Sex	Age	Reasons for selection	Clinical diagnoses	Employment	Marital status	Education
*Female	57	Requested removal of amalgam fillings Pharmacological agents provided no pain relief	Atypical odontalgia Sjogren's syndrome	Sick-listed	Married	compulsory
Male	54	Did not complete the pain examination Preferred alternative health care	Chronic tension headache Myofascial pain	Employed	Married	compulsory
Female	37	Provocative attitude at pain examination	Myofascial pain Arthralgia Atypical facial pain	Employed	Single (3)	upper secondary
Female	61	Requested removal of amalgam fillings	Atypical odontalgia	Self-employed	Married	compulsory
Female	21	Extensive personal demands Described an extreme fatigue	Myofascial pain with limited opening Arthralgia Chronic tension headache Cervical pain	Employed	Single	upper secondary
Female	69	Did not accept medical explanations of the pain Pain description inconsistent	Myofascial pain limited opening Atypical odontalgia	Retired	Widow	upper secondary
Male	42	Did not accept medical explanations of the pain Demanded further, not medically accepted treatment	Chronic tension headache Myofascial pain Atypical facial pain	Student	Single (2)	compulsory

- Missing information

analysis.

Using qualitative content analysis gives the possibility to analyse a collected material for manifest content (the visible, obvious components) and the latent content (interpretation of the underlying meaning) (7). The collected material for this study was considered too weak to allow for an analysis of the latent content, thus, to limit the analysis to the manifest content was decided.

When codes were clustered, varying patterns in the subjects' experiences were revealed. Rereading the interviews enabled re-contextualization of the identified patterns. To communicate the patterns that emerged (including variations) a classification into categories and subcategories was made. Via

questions, comparisons, and discussion, the authors reached consensus regarding the categories. Quotations from the interviews, which were used as illustrations, were transcribed from spoken Swedish and then forward translated into English.

Ethical issues

The study has been conducted in accordance with the 1964 Declaration of Helsinki (2000 revision, www.wma.net). The Regional Ethical Review Board, Lund University, Lund, Sweden approved this study.

Results

The analysis identified the main category: *imbalance between positive and negative feelings* and three

© Table 2.

Themes chosen to explore the personal experience of pain in interviews with non-specific chronic orofacial pain patients

Interview 1

- The present state of pain
- The latest instance of pain
- Other concrete instances of pain
- The commencement of pain
- Life before commencement of pain
- Life between possible instances of pain

Interview 2

- The patients' reflections following interview 1
- The interviewer's reflections following interview 1
- The future

subcategories: (i) *feelings of pride and strength*, (ii) *feelings of fear and anxiety*, and (iii) *feelings of shame and guilt*. These findings characterized nonspecific chronic orofacial pain patients' daily living experiences when pain was not in focus. The findings comprised ordinary emotions frequently experienced by human beings but feelings of pride and strength were extremely rare and instead, an overwhelming amount of unpleasant emotions with a fear of personal weakness overshadowed the expressions concerning life experiences.

Feelings of pride and strength (i)

While the aforementioned categories describe ordinary, frequently experienced human emotions, only 8 of 14 subjects spontaneously expressed pride or strength in being able to manage certain daily living situations. When pride or strength did emerge in their narratives, it was most frequently expressed

in terms of being a professional in work situations such as this comment by a professional female artist:

Yes, I also make sculptures. Brass net, steel net and plastic tubes and mobile sculptures. Plus jewellery ..., some really nice stuff, actually.

Feelings of fear and anxiety (ii)

The analysis revealed that feelings of fear and anxiety permeated a pronounced part of daily living when subjects talked about ways in which they handled daily situations and identified nuances of fear and anxiety:

- Fear of conflicts
- Fear of personal weakness
- Fear of the intangible

Fear of conflicts

Fear of intra- and interindividual conflicts became evident in the narratives. Internal (intraindividual) conflict associated with fear and regret materialized, for example, when subjects realized during the interview that they had talked about emotionally sensitive issues. Later on, they said these issues were irrelevant, and they wanted to withdraw their comments. To state an opinion or to make a decision and then to stand by the opinion or decision often engendered fear in the subjects, which was frequently associated with anxiety and sometimes ambivalence.

I've been thinking of getting a divorce I don't know how many times, but I guess I need the security. When I get ready to start divorce proceedings, I get so anxious that I just want things to be normal [sighs and laughs].

Experiences of interindividual conflicts, associated with feelings of discomfort, also emerged during the analysis. For example, subjects mentioned

© Table 3. Qualitative content analysis process used to analyse interviews and extract results. Two meaning units condensed into more succinct formulations, i.e., condensed meaning units are visualized with the corresponding code, subcategory and category

Meaning unit	Condensed meaning unit	Code	Subcategory	Category
They come with their hieroglyphs, you know. And I, I have to write, and then I have to make slides, and then they are supposed to teach. I . . . , I did that., but I was very pleased with my work, I have to say.	I was very pleased with my work.	Pride	Feelings of pride and strength	Imbalance between positive and negative feelings
(The recording device stops) I talk far too much; the tape runs out (laughs). EW Yes, they last 45 minutes, they do.	I talk far too much; the tape runs out (laughs).	Self blame	Feelings of shame and guilt	Imbalance between positive and negative feelings

discomfort and fear when having face-to-face confrontations with supervisors. Some subjects seemed to persuade themselves that conflict did not really exist or that it was quite okay to not deal with certain conflicts, as illustrated by this quotation from a woman who was forbidden to come home because she was pregnant at age 18:

... and pregnant besides.

EW: When you're an 18-year-old girl?

Of course. Today you can use the pill and get abortions. But back then ..., it was never mentioned. But how could I [emphatically] ..., *his* daughter [emphatically] do such a thing?

EW: Daddy's girl?

Yes. He was happy for all of us. And so proud of all five. [...] But later we got along just fine.

EW: Did you two ever talk about it?

Never.

EW: Never?

Not once. We never did. There was nothing to bring up. What happened, happened.

Fear of personal weakness

Feelings of fear and anxiety, together with an expression of an internal weakness, appeared in the narratives and were sometimes expressed ambivalently as was self-anger:

I don't like it when I am weak. I don't think it is bad to be weak, but I get angry at myself. I just must try harder.

Feelings of weakness were also indirectly expressed, for example, when subjects joked or laughed and smiled in an attempt to moderate what was emotionally difficult to express. Prominent was a fear of not being good for anything and of making mistakes, which was expressed in various situations: as a professional, a grandparent, and a fellow human being. This quote from one of the second interviews illustrates fear of making mistakes:

The recorded tape lay at home in the kitchen, and I thought: "No, ugh, I don't want to listen [laughs]."

EW: What were you thinking then?

I didn't want ... I don't know [laughs]. I thought it would be strange to sit here again and listen to how I had expressed myself then. And so, perhaps, it would be a little wrong when I came back here later. You think: "God, how I talk." I preferred to be silent. I was afraid that it might not be right, what I said on the tape.

Two of the subjects decided not to listen to the

recorded interview and another two had listened to the recording with their husbands.

Fear of the intangible

The third aspect of feelings of fear and anxiety was a disclosed fear of situations that were difficult to grasp and dominate. The subjects' expressions were interpreted to describe fear of living in an uncontrollable world in which risk of illness, poisoning, infections, accidents, robberies, and losing a child existed.

The hospital was our other home. Having a boy with asthma is like walking a tightrope between life and death every day.

Fear of getting old, with subsequent loss of capacity, was expressed as was fear of death. Even life itself, with its attendant responsibilities and uncertain future, was experienced by some subjects as demanding and threatening.

I am afraid of everything. [...] And it doesn't get better with time.

Feelings of shame and guilt (iii)

The feelings of shame and guilt subcategory accounts for subjects' expressions of unpleasant emotions associated with perceiving oneself as being responsible for negative consequences and escaping from the bad things in life. The analysis revealed these nuances:

- Self-blame
- Avoidance

Self-blame

Self-disparaging expressions surfaced in various situations. The subjects blamed themselves *directly* in words and *indirectly* in descriptions of self-destructive behaviour.

I'm the type of guy who punishes, punishes myself when I have done something stupid. I've done this since I was a kid. I can sit and torment myself by thinking the same thing all the time. I can refrain from eating (sighs). I can sit and cut myself with razor blades and all such things, because I have to feel the pain. I must suffer.

Self-denying behaviour emerged in the interviews when the subjects questioned the relevance of their participation and when they narrated experiences of abuse. A violent former husband was repeatedly forgiven, and a rapist was pitied.

Sometimes I feel sorry for him. He can never experience anything for real.

Patients expressed feelings of guilt when discussing issues of right and wrong behaviour in various situations, like trying to manage daily living or babysitting:

... and the little rascal. He showered so carelessly that I couldn't get him out of the bathroom. The floor was drenched. So were the socks and underwear. I couldn't stand it. I stood in the doorway and yelled to them: "look at this. Are grandma and grandpa supposed to go in here? It's not very nice." [...] And then I thought: we're only here for a few hours. Why do I act like this? Why do I talk like this?

Avoidance

Feelings of shame and guilt were revealed when the subjects described evasive behaviour as soon as a fearful daily living situation occurred. Conflicts were avoided whenever possible, those in the present *and* those that had occurred in the past. When opinions and desires were expressed, they were immediately abandoned when questioned by others. One striking example of avoidance occurred in the narrative of a woman who had separated from her son's father because he abused her. The separation resulted in joint custody, but the woman instead let the youngest boy live with his father because the boy's narratives about the times he spent with his father were too painful for her to listen to:

I just can't listen to my child being badly treated, so right now, he lives full time with his dad.

Avoidance was evident when subjects gave the impression that they were denying anger, other kinds of negative feelings, and difficulties connected with these feelings—as illustrated by this quote from an elderly retired patient who suffered from pain:

Everything's fine with our immediate family. Never had any problems. [...] It's, well, incredibly good.

Discussion

Although the subjects had various educational and socio-economic backgrounds, clinical characteristics, diagnoses, and reasons for being selected, similar patterns were revealed in the analysis. Fear, anxiety, shame, and guilt characterized the basic pattern that emerged in the analysis, namely, *domination of negative emotions*. For some subjects, these emotions seemed to permeate everything. For other subjects, the emotions emerged but not in all situations. The data revealed that the subjects did not demonstrate a rational way to constructively manage fear and

certain difficulties that arise in daily living. These results are similar to ways in which the subjects seemed to handle pain, as previously reported by Wolf et al. (23,24).

The use of in-depth interviews allowed the subjects' narratives to be heard. A qualitative study design improved understanding of areas in patients' lives and provided opportunities to get an insider's perspective and explore ways in which patients made sense of and talked about everyday events.

In the present study, all subjects (except one who solely talked about pain) ordered their thoughts during the interview and spontaneously described everyday life situations. Mode of expression and topics introduced by the subjects varied and were more or less comprehensive. Despite this variation, clear patterns emerged. Elucidation of the subjects' spontaneous narratives on aspects of the individual's life made the complex character of the pain experience even more clear and strengthened the importance of understanding that a shift within dental care *from* the chronic orofacial pain condition *to* the *patient* with this condition is necessary.

Fear avoidance as a concept in chronic pain literature is well known (14); the concept describes patients' tendency to avoid physical activities for fear of invoking pain. The present study revealed that the subjects also demonstrated fear avoidance behaviour. Fear is a justified reaction when real danger threatens. But an overabundance of fear, especially when the threat is not perceived as distinct and manageable, can negatively influence patients' mental balance. This happens when an individual uses mental resources of the consciousness to try to keep primitive emotions in check, which then occupy an abnormally large part of an individual's thought-life (13). The subjects in the present study expressed an unmistakable fear associated with intra- and inter-individual conflicts that they found difficult to manage. Conflicts are natural in life; in a positive aspect, they stimulate a person to reflect and subsequently undergo a transformation toward a more nuanced perspective of life (6). But analysis of data in the present study revealed that constructive attempts to solve problems were often non-existent.

When analysing the patients' chronic pain experience, an earlier study suggested that the patients have the pain as a substitute object—as something concrete to relate to that hides underlying negative feelings and makes suffering comprehensible (23). In the present study's analysis of everyday life experiences, an exaggerated fear in connection with the in-

tangibility of existence—commonly characterized as anxiety—emerged from the data. Typically, with such fear, there is nothing concrete to be dealt with, which sometimes implies that a substitute object is needed. From this perspective, chronic pain as a substitute object might be highly likely. This way of using pain is less constructive, but it can still be seen as an attempt to manage more frightening negative feelings, and paradoxically, pain can provide some relief (6).

The earlier study also reported that the patients did not appear to have a constructive way of managing chronic pain (23), which is in line with findings of other studies (11). Studies with a quantitative design focused on the self-efficacy concept, where a low score implies a negative impact on coping capacity (4).

The present study provides some insight into the nature of the negative impact and the lack of constructive tools for managing life's difficulties. The subjects primarily used defensive strategies. Personal desires received low priority—so low that they were almost self-effacing, as exemplified by one subject's self-harm behaviour. This subject was an abuse victim—a circumstance shown to be highly destructive, because both body and mind are injured. Kirkengen (12) reports that humiliation, due to violated personal boundaries is especially harmful. The subjects in the present study seemed to distrust their abilities to resolve their difficulties. They directed deep negative feelings mainly toward themselves. Their feelings of guilt and shame inhibited their abilities to change their focus and get control of their fears. So the subjects seemed to lack confidence when faced with changes and to lack readiness for managing problems. Insufficient capabilities can be troublesome because the ability to act is most effective when individuals are conscious of their fears—while not allowing their fears to overpower them (19).

To live with chronic pain is a complex process in which the pain *and* its importance vary—depending on the patient's circumstances. Although it is never possible to totally enter another personal world, with an inside-looking-out perspective, in which the complexity of an individual's personal experiences and consequences of pain emerge, the need to meet patients where they are emotionally is nevertheless obvious. Negative experiences seem to dominate life for all of these patients—not just in relation to the pain (23)—but also in relation to life itself.

Guiding patients toward recovery is a demanding task for health care providers. Because 8 of the 14 subjects related a few positive reflections, primarily associated with professional life, an interpretation

could be that fundamental problems in life mainly stem from the private sphere. So if patients and caregivers cooperate to identify and turn to advantage patients' strengths in life, the results might be beneficial for care recipients (22).

Many patients seek dental care because of chronic orofacial pain. Some clinicians might consider this a problem because neither graduate nor postgraduate dental education provides required skills to fully diagnose and care for patients with complex conditions such as chronic orofacial pain. This skill is probably unnecessary for all dentists, but because repeated care-seeking is common (2,26) and dissatisfaction with provided treatment was reported (24), development of such care (i.e., improvement of dentists' expertise) is essential. That the dentist is engaged not only in the disease but in patients' experiences of illness, which includes observation of patients' social and emotional reality, ought to be advantageous—not least to avoid harmful further unhelpful treatments. Another option is multidisciplinary care, whereby dentists cooperate with pain centres.

Research questions must drive scientific methodology selections to ensure that epistemology is aligned with research settings and aims. Using questionnaires and psychometric tools in order to study the chronic orofacial pain patients' physical and emotional functioning is common and also recently it is concluded that chronic orofacial pain has a negative impact on patients' lives (8,15). However, the qualities of the individual's restricted life are difficult to reach with quantitative approaches solely. To understand human beings and what they are, the object of the study can also be human beings in their own contexts as a source of understanding rather than an object to be studied (12,18). Consequently, a qualitative research methodology was considered to be an adequate tool for achieving the aim of the present study.

Transferability of results from the present study to a chronic orofacial pain population is weak and was not the purpose of this study. In previously published (23,24) studies concerning the same patients, the selected units of analysis emanated from the patients' thoughts on chronic pain. Those results, exactly like the present study's results, enable expression of the descriptive content (manifest level) (7). Combining and analysing the present study's results with previously published results might provide opportunities to identify underlying (latent level) meaning of the content (7) of the patients' experiences and might thus provide opportunities for transferability to other groups of patients or contexts.

Conclusion

The analysis revealed that patients who suffer from nonspecific chronic orofacial pain experienced:

- Unpleasant emotions that dominate daily living.
- Exaggerated fear of conflicts, of personal weakness, and of the intangible.
- Self-blame and avoidance of situations that triggered fear.

Consequently, we can conclude that a chronic orofacial pain condition cannot be understood as an isolated phenomenon; it must be considered in relation to the person who is suffering from the condition.

Acknowledgments

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Caries treatment in Swedish adults: effectiveness, costs and equity. A 4-year follow-up study of data from the Swedish national dental health register

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Abstract

© At a national level, planning and management of dental services should be based on assessments of equity, effectiveness and costs. In Sweden, data for the adult population are now accessible through The Swedish dental health register, at The National Board of Health and Welfare. This study, on two large cohorts of Swedish adults, is based on longitudinal follow-up data, retrieved from the Swedish dental health register. The aims were twofold: to assess frequencies and costs of fillings and crowns, including subsequent repair; secondly to study the relationship between preventive and restorative dental treatment. The Swedish dental health register provides data on the adult population which offers a new perspective on public health aspects of management of dental care at the national level. A longitudinal, prospective study model was used to follow-up two large cohorts for over four years. In the first cohort, data on 1,088,923 adult patients were analysed with reference to provision of single crowns and fillings over a period of 42 – 48 months. The second cohort comprised 1,703,147 adult patients: the data were analysed with reference to preventive interventions over a period of 48 – 54 months. Frequencies of distribution of dental care by age group showed that the cohorts were representative for the whole patient group. With respect to equity, the average number of dentist appointments per 1,000 inhabitants for all 21 regions of Sweden was 140 to 160, despite major variations in geographic conditions and population densities. With respect to effectiveness, about 76% of the teeth with index interventions required no additional intervention over four consecutive years of follow-up. For the remaining 24% of the teeth 77% had only one additional intervention. When differences of case-mix were taken into account, the costs of repairs to earlier interventions were basically similar, regardless of age-group. There were no gender differences. However, there were pronounced differences, of up to three intact teeth, among patients from different regions of Sweden. Follow-up of effects of caries prevention showed no gender differences. However, costs for reparative interventions increased with higher costs for preventive treatment. Moreover, the longer the interval between preventive interventions, the lower the costs for reparative interventions. The national dental health register is a potentially valuable source of data for dental research. In this study, longitudinal registry data on restorative and preventive treatment were retrieved and analysed, with reference to efficacy, costs and equity. The results have potential application in improving management of public dental health.

Key words

Dental care, epidemiology, health register

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Kariesbehandling av vuxna i Sverige: effektivitet, kostnad och jämlik vård. En uppföljning av data från tandhälsoregistret under 4 år

ANDREAS CEDERLUND, FRIDA LUNDGREN, SOFIA TRANÆUS, ANDERS NORLUND

Sammanfattning

Planering och styrning av tandvård på nationell nivå bör baseras på utvärderingar av jämlik fördelning, effektivitet och kostnader. Med inrättandet av tandhälsoregistret vid Socialstyrelsen öppnas möjligheter för studier av tandvårdens processer och resultat. Syftet med studien var att utifrån två identifierade kohorter longitudinellt följa och analysera frekvens och kostnader för ny fyllning eller tandkrona på tidigare restaurerad tand (omgörningar) samt relationen mellan förebyggande tandvårdsåtgärder i relation till reparativ och restaurativ tandvård orsakad av karies. Med hjälp av tandhälsoregistret studerades två kohorter omfattande den vuxna befolkningen. En longitudinell modell användes för uppföljning. I den första kohorten följdes 1 878 887 tänder hos 1 088 923 patienter mellan 42 och 48 månader. I den andra kohorten följdes 1 703 147 patienter under en period av mellan 48 och 54 månader. Fördelning av tandvård för olika åldersgrupper visade att kohorterna var representativa för hela patientgruppen. Fördelning av tandvårdsbesök varierade mellan 140 och 160 räknat per 1 000 invånare trots olika geografiska förutsättningar. Resultaten baserade på den första kohorten visar att 76% av tänderna inte fick någon ytterligare åtgärd med fyllning eller tandkrona under uppföljningsperioden, och att för resterande 24% av tänderna fick 77% endast en ny åtgärd. Det förelåg ingen könsskillnad, däremot skillnader på upp till tre intakta tänder mellan olika regioner.

Resultat från den andra kohorten visade heller ingen könsskillnad. De genomsnittliga kostnaderna för reparativa åtgärder på grund av karies ökade gradvis i relation till ökade kostnader för förebyggande åtgärder. Vidare var kostnaderna för reparativa åtgärder lägre ju längre tid som följde mellan förebyggande åtgärder. Det nationella tandhälsoregistret utgör en värdefull källa för forskning om tandvård. Longitudinella registerdata för reparationer och preventiva åtgärder kan användas för att studera effektivitet, kostnader och jämlik fördelning av tandvård. Resultaten har en potential för förbättrad styrning av tandvården.

Introduction

Good oral health is an important goal for most individuals and this motivates them to adopt habits which will maintain good dental status. This leads to what is sometimes called a derived demand for dental health habits (1), such as consuming food with less sugar content, but also for a derived demand for preventive dental care. In many countries the goal of maintaining good dental status in the population is enhanced by dental professionals and politicians. Thus the availability of preventive dental care may be improved, for instance by an increase in the number of dental hygienists. Another means of improving availability is by subsidizing preventive dental care. Dental care in Sweden is to a large extent self-funded i.e. paid for by the patients themselves (60% in the year 2011). A dental care reform, introduced in 2008, included increased government subsidies. In order to be eligible for the subsidies, dentists were required to register their patients in a computerized system: a national dental register. The register comprises data for what might be regarded as a system for management information and administrative control of dental care, at a high organizational level i.e. from a public health perspective. Although not collected specifically for research purposes, a database can still provide important information based on observational data (2). Thus, the reform can be followed-up from different managerial aspects. For example, in this study dental care outcomes are compared with dental care objectives to reveal "effectiveness", the distribution of these aspects of effectiveness in society is analysed to reveal "equity", costs are analysed to reveal "productivity", and professional caries preventive measures are followed-up. Although recently established, this register offers new potential for assessments not only of the clinical effectiveness, but also of the cost-effectiveness of dental care. Such information is increasingly sought after (3). This paper presents some results of the initial evaluation of the 2008 Swedish Dental Reform, based on analysis of four years of data retrieved from the national dental register. To date, findings reported in the literature are contradictory. A study based on an administrative database of dental service records for more than 500 000 Canadians, followed for eight years, failed to disclose any association between regular dental attendance and lower expenditure on dental care (4). In contrast, an Irish study of 1 271 937 patients with a 12-year follow-up, reported that increased preventive treatment was associated with improvements in oral health (5). However, costs were not included

in this study. A recently published mapping of economic evaluations of caries preventive programs reported an increasing number of published studies, but concluded that the quality of reporting needed improvement (6). Thus, there seems to be no evidence of cost-effective preventive dental care based on studies of efficacy (7), and studies based on large databases, i.e. effectiveness, express conflicting results (4, 5). A relevant question is whether longitudinal effectiveness data, based on a large Swedish database, could shed some light on associations between regular dental attendance and lower expenditure on dental care. In the present study, data were retrieved from the Swedish dental health register. The aims of the present study were to assess frequencies and costs of fillings and crowns, including subsequent repair, and secondly to study the relationship between preventive and restorative dental treatment.

Method

The Swedish Dental Health register is a national register introduced in July 1st 2008. Four basic categories of information are registered:

-**patient data:** gender, age, residence, personal identification number, citizenship, country of origin, civil status

-**dental care data:** name and address of dental clinic or dental practice

-**administrative data:** dates of treatment, reference fees for dental care

-**clinical data:** diagnoses, tooth number and position, type of intervention, number of standing teeth, number of intact teeth.

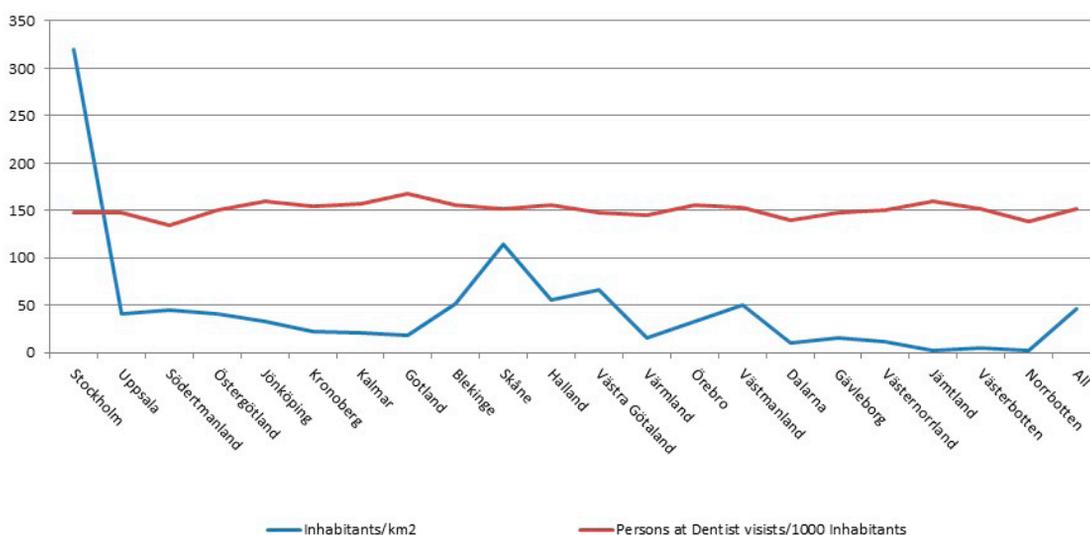
Thus, dental care outcomes were compared with the intended objectives ("effectiveness"), how these aspects of effectiveness are distributed in society ("equity"), as an analysis of costs ("productivity"), and finally as a follow-up of caries preventive measures, here defined as dental diagnostic/preventive appointments.

The reference fees for different items of dental treatment were (and still are) determined by a government agency, The Dental and Pharmaceutical Benefits Agency of Sweden (Swedish acronym TLV), assumed to correspond to the costs of different dental interventions. The definition of costs used by TLV, in each consecutive year, was also added to this paper. Two patient cohorts were included in the study. The first comprised adult patients (20 years of age and older) who had undergone restorative treatment, for single crowns or fillings, between January 1st and June 30th 2009. This treatment was followed

© **Table 1.** Patients included in cohort number 1, as a percentage of the total Swedish population aged >19 years

Age groups	Cohort %	Population %	All patients in dental care %	Ratio cohort vs. population	Ratio cohort vs. all patients
20 – 29	6.1	16.8	9.0	0.36	0.68
30 – 39	11.3	16.8	12.9	0.67	0.88
40 – 49	16.7	17.9	16.9	0.93	0.99
50 – 59	22.9	16.0	19.7	1.43	1.16
60 – 69	25.6	16.1	22.4	1.59	1.14
70 – 79	12.2	9.6	12.5	1.27	0.98
80+	5.2	6.8	6.6	0.76	0.79

© **Figure 1.** Inhabitants in Swedish regions per square km and dental attendance



for each consecutive year until December 31st 2012. Third molars were excluded from this analysis because these teeth are often extracted when problems occur, and thus restoration is seldom an option. The second cohort comprised adult patients (20 years of age and older) who had received preventive dental treatment between January 1st and June 30th 2009, followed for each consecutive year until June 30th 2013. Thus, register data covering the period from July 1st 2008 (Time 0) up to June 30th 2013 (Time 1), were analysed in retrospect during the second half of 2013. As no socio-economic variables were included in the analyses, the potential for analyses of socio-economic aspects was limited. The currency exchange rate in 2012 was 1 Euro = 9.033 SEK.

The statistical analyses were conducted using de-

scriptive statistics such as mean, standard deviation, median and percentiles, based on SAS version 9.4.

Ethical considerations

The Swedish national Board of Health and Welfare is a government agency and is permitted by Swedish law to use population-based registers in order to monitor and analyse health and social conditions in the population. Data were retrieved in such a way that individuals could not be identified.

Results

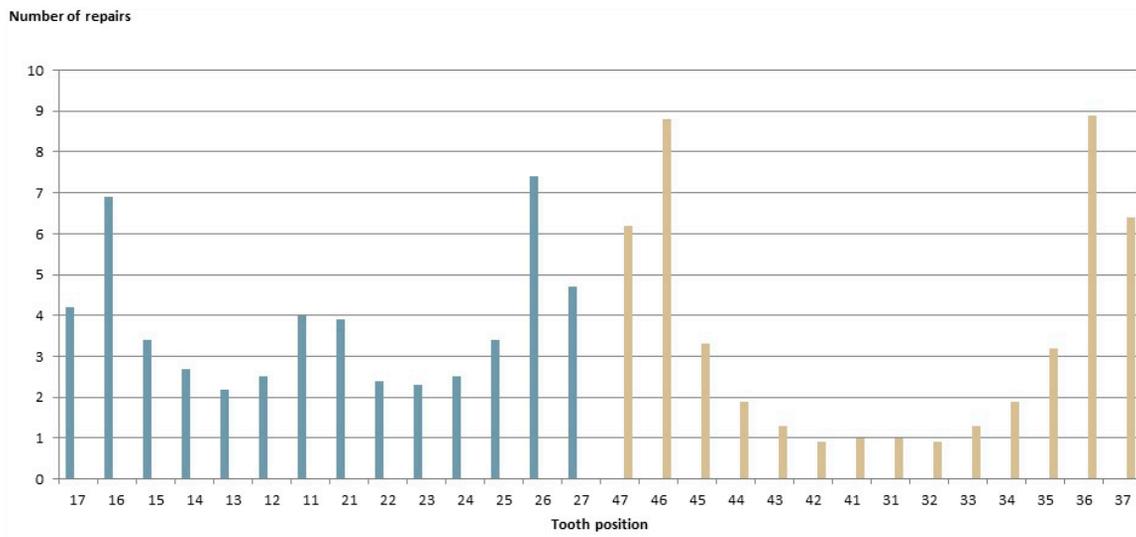
Cohort number 1

From January 1st 2009 to June 30th 2009, 2,830,378 dental appointments with private or public health dental practitioners were recorded in the register.

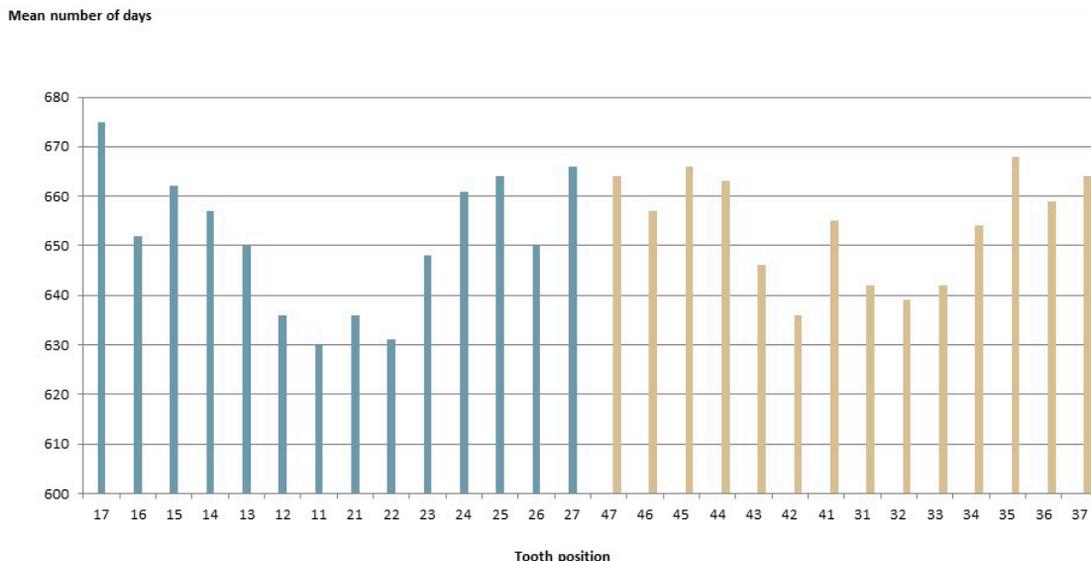
The cohort receiving restorative treatment in the form of single crowns or fillings comprised 1,088,923 patients: in all 1,878,887 teeth were restored with single crowns or fillings. Females comprised 52.3% of the cohort; 43% of all patients were aged 60 years or more (Table 1). Compared to the age distribution of the Swedish population, the dental care cohort comprised fewer from the age group 20-39 years, about the same from the age group 40-49 years,

higher numbers of those aged 50-79 years, and fewer from the oldest age group, 80+ years. The distribution of dental attendance in the cohort, expressed as the number of patients per 1,000 inhabitants over a period of six months, showed an average of 140 to 160 patients for all 21 regions of Sweden (Figure 1). The average for men was 145 per 1,000 inhabitants (range 7.3% to -13.4%) and for women, 156 per 1,000 (range 6% to -10%). Despite geographical differenc-

© Figure 2. Number of repairs of earlier restorations according to tooth positions



© Figure 3. Mean number of days from initial restoration to further intervention, per tooth position



© Table 2. Percentage of restored teeth and of costs of restorative treatment stratified according to age group

Age group	% of volume of restored teeth	% of costs for restoring teeth	Mean cost of restorations SEK	Fillings, mean costs SEK	Crowns, mean costs SEK
20-29	3.3	2.5	1 165	925	3 954
30-39	7.7	6.6	1 296	960	3 964
40-49	14.4	13.8	1 392	979	3 987
50-59	24.9	26.1	1 481	968	4 022
60-69	29.5	31.6	1 502	928	4 025
70-79	14.1	14.0	1 383	877	3 905
80+	6.1	5.4	1 241	827	3 592
All	100	100	1 423	934	3 973

es in population densities, expressed as inhabitants per square kilometre, the number of dental appointments was similar across the country.

Effectiveness of interventions

The need for further treatment of an earlier intervention, considered as the index intervention, was used to express effectiveness. Over a follow-up period of 42 – 48 months, on average 75.6% of the teeth with index intervention required no further treatment: the geographical spread between regions was 71.0% to 78.2%. Of the 24.4% of teeth requiring further intervention, on average 77.1% required only one further intervention. While there was no difference related to gender with respect to further intervention, there were differences with respect to tooth type (Figure 2). The highest frequencies were for the first molar teeth in all quadrants, accounting for 32.1% of all interventions. Moreover, only one further intervention was required in 76% of all interventions for the first molar teeth. There was a mean number of additional interventions expressed as tooth positions of 1.78 for men and of 1.67 for women, respectively. The median was however 1.0 tooth for both men and women. As presented above, 24.4% of the teeth with index intervention required additional treatment during the four years of follow-up. The median interval between initial treatment and further intervention varied, depending on tooth type (Figure 3). The average mean interval, regardless of tooth type, was 655 days, i.e. about 22 months, with a range from 0 to 1452 days. The central and lateral incisor teeth had the shortest mean interval before further intervention (630 to 655 days); the longest was for the second molar teeth (664 to 675 days). In total, 24.4 % of the index teeth needed at least one additional repair within 48 months. Including the

index intervention and the additional repair interventions, each tooth underwent on average 1.3 interventions during the follow-up period.

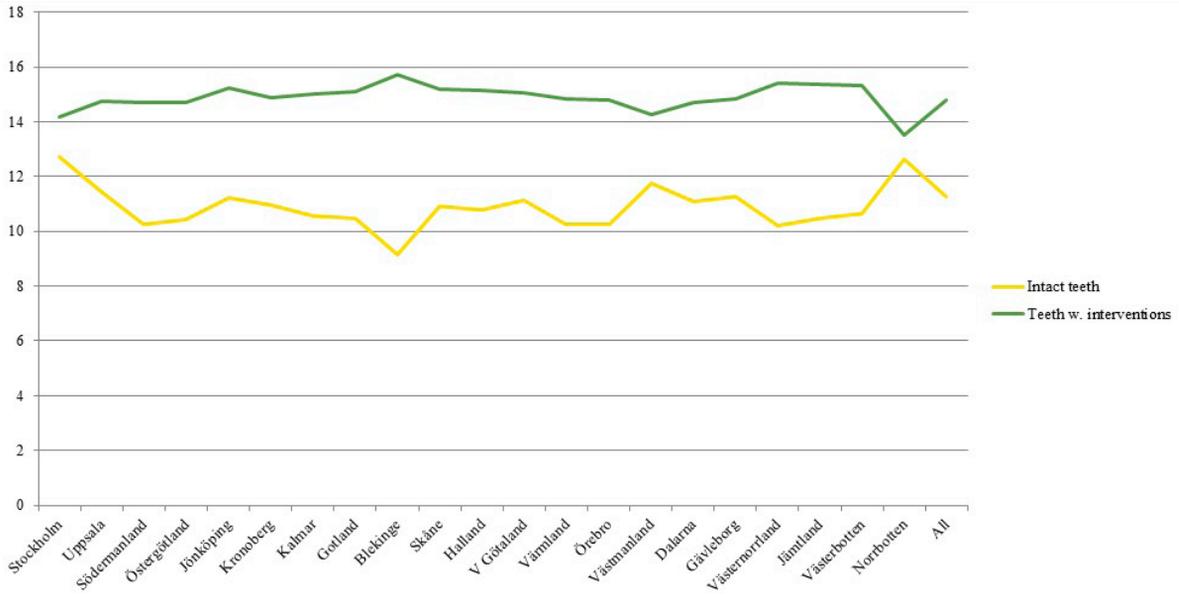
Costs of interventions

The distribution of costs of further intervention, compared with the distribution of dental appointments per age group, showed a smaller proportion of costs for patients aged 20 – 49 years than for those aged 50 – 69 years (Table 2). However, the mean costs of fillings and crowns, respectively, were fairly similar in all age groups. This indicates that with increasing age there is a greater need for interventions, which leads to higher costs, i.e. that in older patients there is a different case-mix of crowns and fillings. This was also reflected in the average cost of further interventions: 1,165 SEK (129.00 Euro) for the age group 20-29 years, compared to 1,502 SEK (166.30 Euro) for the age group 60-69 years. The total average for all age groups was 1,423 SEK (157.55 Euro). However, fillings accounted for 83.6% of all renewals, and crowns the remaining 16.4%. The average cost for renewal of crowns was about 4 times greater than for fillings. The oldest age group, 80+ years, had a somewhat lower average cost for renewal of fillings as well as for crowns.

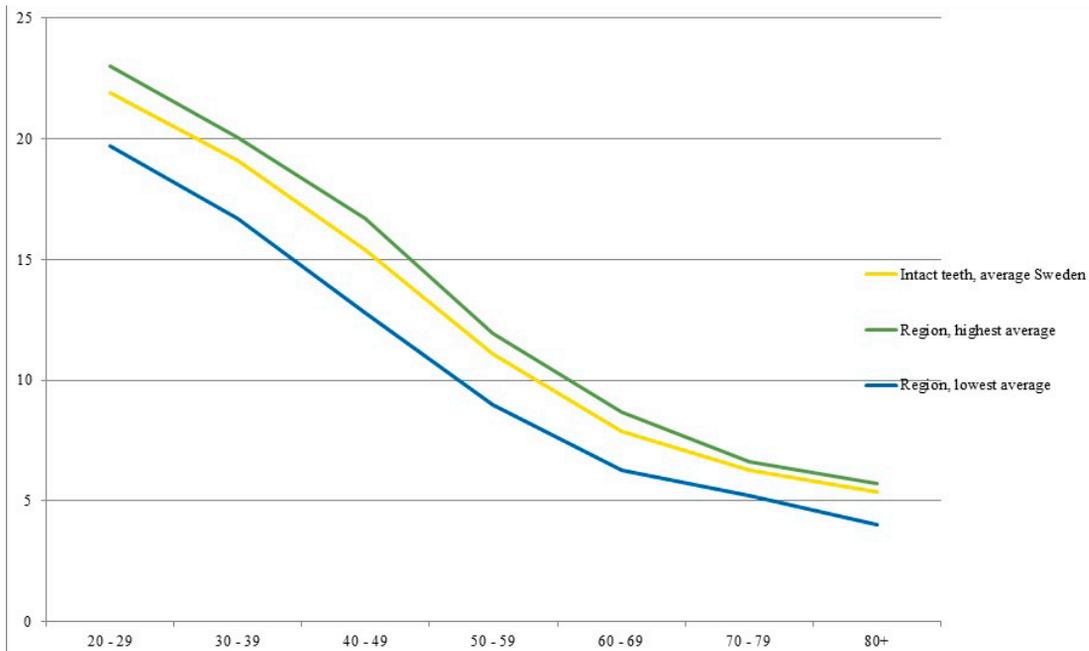
Equity

The average number of standing teeth, for all regions of Sweden, was 26.1, with a range of 24.9 to 26.9, presented in Figure 4 as two groups: intact and restored teeth. Stratified according to age, the number of intact teeth decreased successively, from about 22 in the age group 20-29 years, to about 5 for those aged 80+ years (Figure 5). The number of intact teeth, as an expression of outcome of quality of tooth-health, was fairly equally distributed among all regions in

© Figure 4.
Intact teeth and restored teeth per Swedish region



© Figure 5.
Number of intact teeth according to age group



Sweden, with an average of 11.3 intact teeth and a range of 9.2 to 12.7 (Figure 4). However, analysis at group level disclosed regional differences. For those aged 20 – 59 years, there was a difference of almost 3 teeth between the regions with the highest and lowest average numbers of intact teeth. Even at age 80+ years, regional differences remained.

Cohort number 2

Out of a total of 2,830,378 dental appointments registered for the period January 1st to June 30th 2009, the second cohort comprised 1,703,147 patients registered as receiving caries preventive treatment, through private practices or public dental clinics: 46.5% were women. Compared with all patients in dental care, patients included in cohort number 2 aged 20 – 49 years were somewhat more frequent, and patients aged 60 – 80+ of cohort number 2 were somewhat less frequent (Table 3).

Effectiveness of preventive interventions

About 6 % of the patients had only one dental check-up in 4.5 years, 13 % about every second year, and 25 % had three check-ups in 4.5 years, and 31 % had about one per year. The remaining 25 % of the cohort had dental appointments more than once a year. There was no difference in the pattern of dental attendance between women and men (Table 4). Accumulated data showed that for 70% of the patients the costs of diagnostic and preventive treatment, over a period of 4.5 years, were less than 3,000 SEK (€ 332), i.e. less than 500 SEK (€ 55) per year, calculated as a weighted average. Compared with the costs of restorative treatment, the number of appointments for preventive treatment indicated a positive correlation (0.12) (Figure 6). The solid horizontal line represents median values and the columns represent costs of repairs for the 4th quartile. As shown

in Figure 7, in each consecutive quartile the average cost of restorative treatment gradually increased with higher costs for preventive treatment (Figure 7). The average interval (in weeks) between check-ups and the cost of new restorative treatment indicated a minor negative correlation, 0.13; somewhat higher for men than for women, -0.15 and -0.12, respectively. Although weak, this correlation indicates that the longer the interval between preventive interventions, the lower the costs for restorative interventions. Based on the average costs of diagnostic and preventive interventions between age groups, the range of costs was highest for the age group 70-79 years, and lowest for the age group 20-29 years (Figure 8). The oldest age group also had the highest range of costs for preventive interventions, and costs were higher for women than for men.

Discussion

Of fundamental importance for determining dental health service priorities at a high organizational level is the availability of reliable outcome data for the population. However, the underlying data is not always readily available (8, 9). This study describes a means of finding outcomes for the Swedish adult population, by analysis of follow-up data from a recently introduced national dental health register, which includes scheduled fees for service. The outcome measures, revealed by analysis of follow-up of data on two large cohorts from the national dental register, were effectiveness, equity, and the costs of minor restorative treatment and caries preventive measures. The main strengths of the study lie in the size of the cohorts and the prospective follow-up design. The major limitation is the lack of socio-economic data. With respect to effectiveness, about 76% of the teeth registered for index intervention required no further treatment during consecutive

© **Table 3.** Patients included in cohort number 2

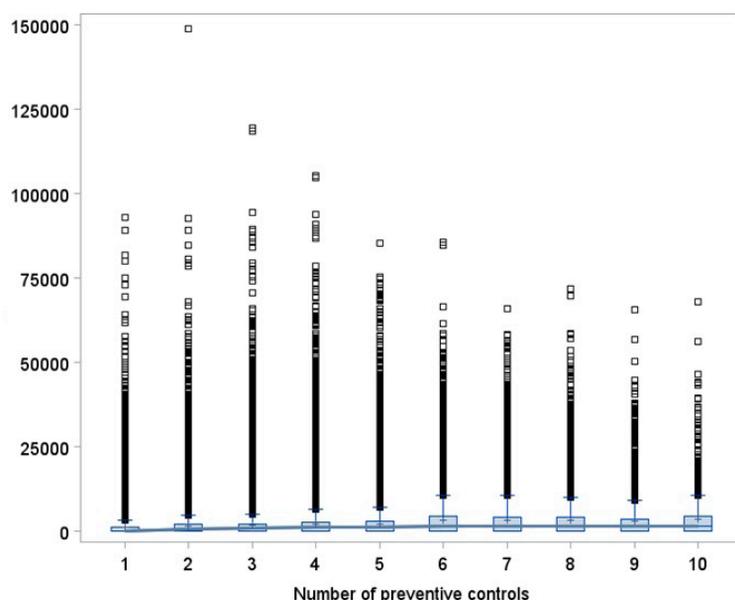
Age groups	Cohort %	Population %	All patients in dental care %	Ratio cohort vs. population	Ratio cohort vs. all patients
20 – 29	10.5	16.8	9.0	0.63	1.2
30 – 39	14.6	16.8	12.9	0.87	1.1
40 – 49	18.0	17.9	16.9	1.0	1.1
50 – 59	19.4	16.0	19.7	1.2	1.0
60 – 69	21.1	16.1	22.4	1.3	0.9
70 – 79	11.5	9.6	12.5	1.2	0.9
80+	4.9	6.8	6.6	0.7	0.7

© **Table 4.** Number of dental check-ups over 4.5 years

Visits	Women	%	Men	%
1	50,937	6	51,654	7
2	116,227	13	102,860	13
3	226,606	25	191,055	24
4	284,526	31	237,793	30
5	178,776	20	162,643	21
6-	54,470	5	45,600	5
Total	911,542	100	791,605	100

© **Figure 6.**

Number of diagnostic/ preventive appointments vs. Costs of restorations

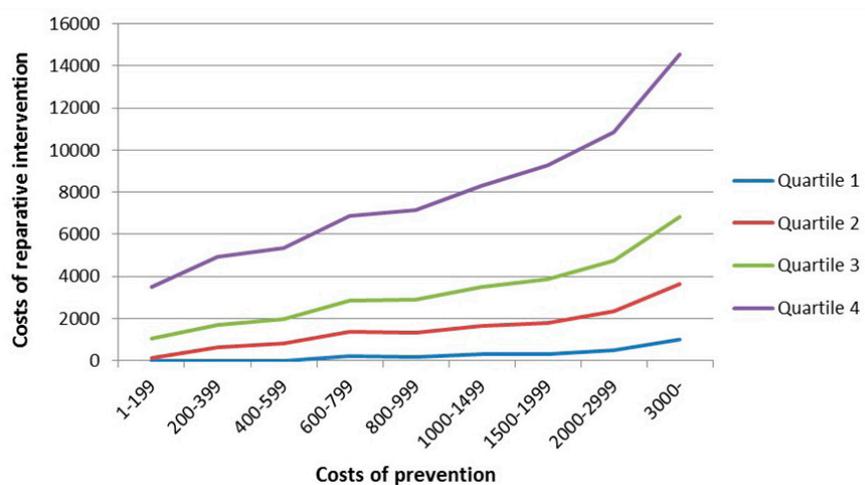


follow-up of up to 4 years. Of the remaining 24%, about 77% required only one further intervention. The interval between initial treatment and subsequent repair varied from 21 to 23 months, depending on tooth type. Including both the index-interventions and the subsequent repair, the average need for interventions was 1.3 per tooth. Whether these expressions of effectiveness can be considered acceptable or not depends upon the objectives determined by the dental authorities. There were no gender differences, thus in this respect effectiveness seems adequate and also fulfils the goal of society to minimize gender differences. With respect to the costs of further repair to earlier interventions, the mean costs for fillings and single crowns, respectively, are

basically similar regardless of age-group, except for the oldest age-group, 80+ years. When costs for fillings and for crowns are combined, there is a greater percentage difference between age groups. This is attributable to differences of case-mix: repair of crowns was more frequent from 50+ years, whereas in the younger age groups, repair of fillings dominated. With respect to equity, there were no important differences in the number of dental appointments per 1,000 inhabitants, despite differences of regional population densities due to geography. Nor were there any major interregional differences in the number of standing teeth. However, there were some pronounced regional differences in the number of intact teeth. Thus, with respect to equity, it may be

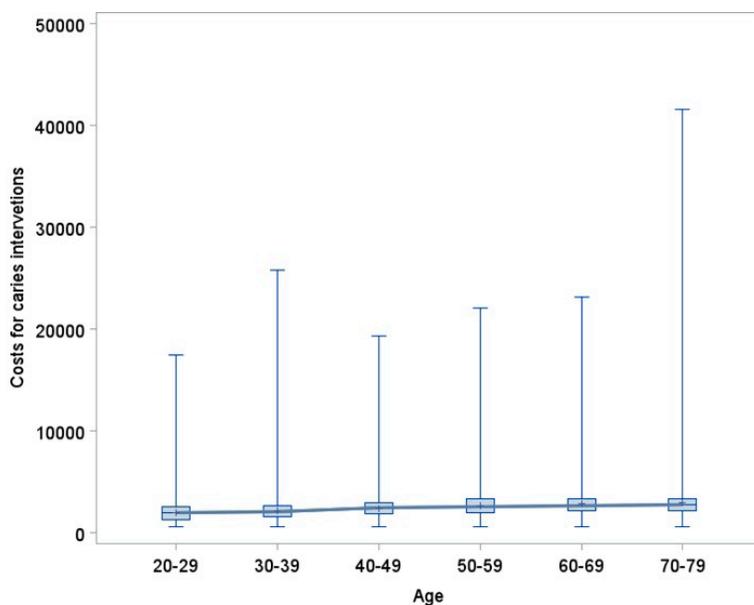
© Figure 7.

Costs of caries preventive interventions vs. Costs of restorative treatment, Quartiles 1 to 4



© Figure 8.

Costs of caries preventive interventions for different age groups



stated that for the Swedish population, access to dental care seems to be relatively equally distributed. However, the pronounced regional differences in the number of intact teeth could indicate that distribution of dental care resources is less than optimal. The ethical platform adopted by the Swedish parliament (10), requires that priorities in healthcare should be

determined on the basis of three fundamental ethical principles: human dignity, treatment need and solidarity, and cost effectiveness. In the present study, some issues of special ethical interest were disclosed. Firstly, there is a possible discrepancy between effectiveness and efficacy of treatment. Approximately 75% of the index teeth in this study required no

further intervention in the following 42-48 months. For comparison, efficacy data have shown a survival rate for dental fillings of at least 85% up to 12 years, calculated as an average for four evaluated variables in Table 2 of the study by van Dijken (11). A possible influencing factor is that restoration of teeth by fillings or single crowns is a surgical procedure, and therefore highly operator dependent. Secondly, the fact that in Sweden, adults pay for most of the dental care themselves may create distributional effects. Individuals who are well-off can access the more expensive treatments, while those with poor finances may be forced to refrain entirely from treatment. Subsidies for more advanced, more expensive treatment procedures may lower the threshold for those who can benefit from such care, but this does not solve all distributional problems. In particular, it is likely that people in the lower economic strata are those least able to take advantage of the subsidy. Moreover, the responsibility for maintenance of fillings could be a financial burden for the elderly, those with multiple diseases, the disabled and those with limited finances. There might also be a risk that in patients presenting with major restorative treatment needs, preventive measures are overlooked, however, no important regional differences in the number of fillings and replacements emerged and no age or gender differences were disclosed. There were regional differences in the number of intact teeth, for which no explanation is forthcoming. Analysis of data on effectiveness failed to disclose any results to support the assumption that preventive interventions reduce the costs of treatment of dental caries. The opposite result was actually found. Moreover, there was a negative association of -0.13 between the interval between check-up/preventive appointments and the costs of fillings and repairs, i.e. a longer interval between preventive interventions was associated with lower costs for reparative interventions. This might be explained by the fact that patients most susceptible to caries are recalled for more frequent preventive treatment i.e. there is a potentially greater treatment need among those receiving frequent preventive interventions than in those recalled less frequently. The latter association could not be confirmed from the data available for the present analysis. Thus, it was not possible to determine an interval between check-ups which would be optimal for minimizing the costs of repairs and of fillings. These results correspond to what could be expected according to a longitudinal Canadian study (4). Furthermore, no particular association was dis-

closed between age and the costs of caries preventive interventions. One interpretation of this lack of association between the frequency of caries preventive interventions and operative interventions is that tooth brushing twice daily with fluoride toothpaste gives good protection against caries (7). Thus, the additional benefits from other preventive measures will become less evident. This is in accordance with a recently published conference report based on reviews of professional and self-care prevention of caries (12). Another interpretation is that there may be some sub-groups of patients with a greater need of caries preventive interventions. These patients would not have been identified through analyses of data retrieved from the whole cohort of patients. However, this interpretation should be explored by detailed analysis in future assessments based on data from the dental health register. There are subsidies for dental care in Sweden, but the fact that adults are personally responsible for the bulk of the cost of their dental care may create distributional effects. Although it seems likely that most individuals seek interventions for problems caused by dental caries, it is possible that the derived demand for regular dental check-ups may differ according to the individual patient's means. In conclusion, the study shows that data retrieved from the Swedish national dental health register can be analysed longitudinally with respect to various aspects of dental care in the adult population, the present study analysed the effectiveness, costs and equity of minor restorative dentistry and assessed the role of professional caries preventive intervention. From a public health perspective, this information is of fundamental importance to management of dental services at the national level.

Conflict of interest

The authors declare no conflicts of interest.

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Diagnostic accuracy of carious lesions in digital radiographs at a public dental clinic – can it be improved by optimizing viewing conditions and further education?

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Abstract

🕒 Objective: This study investigated the diagnostic accuracy of digital dental radiography for detecting carious lesions on approximal surfaces before and after optimization of the environment, and after joint training on evaluation and review of x-rays. A further aim was to evaluate differences in diagnostic accuracy between general dental practitioners (GDPs) and dental hygienists (DHs). Materials and methods: One hundred extracted teeth (premolars and molars) underwent standardized radiography. Eleven participants (seven GDPs and four DHs) evaluated digital images for approximal carious lesions in three sessions: (1) at current conditions with no optimization or further training, (2) under optimized viewing conditions, and (3) under optimized viewing conditions after a short educational session. Receiver operating characteristic curves were used to evaluate the results. Histological evaluation was made and served as a criterion standard for differentiating sound teeth and teeth with carious lesions. Kappa statistics evaluated intra-observer agreement. Results: Diagnostic accuracy in the GDP group differed significantly for all types of carious lesions between the first and third evaluations ($p=0.002$), and also between the second and third ($p=0.015$). Diagnostic accuracy also differed significantly for carious lesions into the dentin between the first and third evaluations ($p=0.010$) and between the second and third ($p=0.015$). Conclusion: Most of the staff had optimized the environment when evaluating digital radiographs. A short educational session highlighting the difficulty of caries diagnostics in digital dental radiography can increase diagnostic accuracy. Diagnostic accuracy in the detection of approximal carious lesions on digital radiographs did not differ between GDPs and DHs.

Key words

caries detection, dental radiography, observer agreement, public health care

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Kariesdiagnostik med hjälp av digitala röntgenbilder i allmäntandvården – kan den förbättras med optimala granskningsförhållanden och fortbildning?

ALEKSANDAR MILOSAVLJEVIC, JANE WESTERBERG, KRISTINA HELLÉN-HALME

Sammanfattning

🕒 Målsättningen med studien var att utvärdera om den diagnostiska säkerheten av approximala kariesskador i digitala röntgenbilder kan höjas vid optimering av granskningsförhållanden och genom en mindre utbildningsinsats. Målet var också att undersöka om det fanns några skillnader mellan tandhygienister och tandläkare. Studien genomfördes på en Folk tandvårdsklinik. Totalt ingick 11 personer i studien, 4 tandhygienister och 7 tandläkare.

Extraherade tänder (100 tycken, 200 approximala ytor), både premolarer och molarer, röntgenundersöktes under standardiserade former, totalt 30 digitala röntgenbilder. Alla bilder granskades vid tre olika tillfällen på kliniken. Första utvärderingen: alla observatörer gjorde som de brukade. Ingen justering gjordes med avseende på granskningsförhållanden eller inställningar på monitorer. Andra utvärderingen: granskningsförhållanden och monitorer optimerades. Tredje utvärderingen: efter en kortare utbildning/seminarium.

ROC (Receiver operating characteristic curves) användes för att analysera resultaten från utvärderingarna. En histologisk utvärdering gjordes av tänderna och detta användes som en "sanning" om de approximala ytorna hade en karieslesion eller om de var friska. Kappa statistik användes för att utvärdera intra-observatörsvariationer.

För hela gruppen av observatörer fanns signifikanta skillnader i den diagnostiska säkerheten för approximala kariesskador som nått in till dentinet mellan den första och tredje observationen ($p=0.002$) och mellan andra och tredje observationen ($p=0.015$). För tandläkargruppen var resultaten liktydiga, dvs. signifikanta skillnader fanns mellan den första och tredje observationen ($p=0.010$) och mellan den andra och tredje observationen, ($p=0.015$) för skador som nått in i dentinet. I tandhygienistgruppen kunde ingen skillnad ses mellan observationerna.

De flesta observatörer hade bra förhållanden när digitala röntgenbilder granskades. En mindre utbildningsinsats som poängterar svårigheter med kariesdiagnostik i digitala bilder kan öka den diagnostiska säkerheten vid diagnostisering av approximala kariesskador i digitala röntgenbilder. Ingen skillnad kunde ses mellan tandhygienister och tandläkare i den diagnostiska säkerheten för att detektera kariesskador i digitala röntgenbilder.

Introduction

Previous studies have shown that the digital radiographic technique is as accurate as the analogue film technique in diagnosing various carious lesions in teeth (18,25,27). The studies have also concluded that different digital radiographic systems are almost equal regarding diagnostic accuracy of dental carious lesions in images. Over the years, studies have examined and evaluated the digital detectors used in dental care (17,23), and the need for standardized viewing environments and calibrated monitors has been highlighted (3,6,7,9 11,12).

Daily, general dental practitioners (GDP) must assess the presence of carious lesions in dental radiographs. Frequently, dental hygienists (DHs) perform this assessment. In Sweden, DHs are licensed (26) and qualified to work independently from the GDP in preventing caries and evaluating dental radiographs to find carious lesions. In Skåne County, Sweden, the public dental health organization (Folk tandvården Skåne AB) provides guidelines specifying the proper environment and monitor settings for evaluating digital radiographs.

Studies have shown that intra- and inter-observer agreement can differ widely in diagnosing a variety of oral conditions (10,12,21,23). Many factors can influence observer variation. The sample material used is vital for the validity of observer studies (16), as is the education level and experience of the observer (13).

For many years the dental community has discussed whether and how it might be possible to calibrate the dental staff (GDPs and DHs) to detect carious lesions in digital radiographs. Studies (1,5) have concluded that calibration can be useful, but they have also shown that calibrated observers relapse to their former evaluation practices over time when diagnosing carious lesions.

We found no previous studies evaluating whether a short education program (less than 1 h) to calibrate observers can improve their diagnostic accuracy in detecting lesions on approximal surfaces in digital radiographs.

This study investigated whether optimization of the environment such as the viewing conditions, and joint training on evaluating and reviewing x-rays improved diagnostic accuracy for carious lesions on approximal surfaces. A further aim was to evaluate differences in diagnostic accuracy between GDPs and DHs.

The hypotheses were that detection of approximal carious lesions in digital dental radiographs would

not differ significantly with viewing conditions, education level or after a training session and that there would be no difference between the GDPs and DHs.

Materials and methods

Our study used 100 human teeth (40 premolars and 60 molars) from a group of extracted human teeth. The teeth were donated after extraction and could not be connected to any specific person. On visual inspection, the approximal surfaces had either small carious lesions or were intact. Half of the sample (n=50) were visually healthy, and half had carious lesions of varying extensions on the approximal surfaces. Two approximal surfaces (1%) had a visible cavity. We mounted the teeth in 30 blocks made of PRESIDENT putty (Coltène Whaledent AG, Cuyahoga Falls, OH USA) with three or four teeth in each block and produced radiographs using a standardized technique with a plate of 1-cm thick Plexiglas (24) placed in front of the sensor and teeth to simulate soft tissue.

We exposed all 30 blocks using a dental digital system (Schick CDR Wireless 2, Schick Technologies Inc., Long Island City, NY USA) and a Prostyle Intra x-ray machine (Planmeca Oy, Helsinki, Finland). Exposure settings were 60 kVp, 8 mA, and 0.12 s. The distance from the X-ray focus to the object was 22 cm.

Participants

All (GDPs) and DHs at a public dental health care centre in Skåne, the Southern county of Sweden, participated in the study. Seven GDPs and four DHs acted as observers on three different occasions. Time between evaluations was four weeks.

Evaluations

Each observer evaluated the 30 digital radiographs in order to grade approximal carious lesions, in total 200 surfaces on 100 teeth. Each observer evaluated the radiographs under the same conditions. The radiographs were evaluated in the same order between the observers. The observers rated their level of confidence about the presence of approximal caries lesions in the radiographs using a 5-point scale:

- 1 = definitely not caries
- 2 = probably not caries
- 3 = questionable caries
- 4 = probably caries
- 5 = definitely caries

Evaluation 1:

The observer evaluated the radiographs with the room set up as usual when evaluating digital radiographs for carious lesions. We measured ambient light and checked whether the monitor was calibrated or not, noting the monitor's contrast and brightness settings and whether these were optimal for evaluation of low-contrast objects (12). We also recorded the model of monitor used and measured the luminance value for black and white and colour using TG18 test images (3 and a light meter (Light-O-Meter, P-11, Unfors AB, Billdal, Sweden) (Figures 1a and b)).

Evaluation 2:

When necessary, we optimized viewing conditions, by (i) reducing ambient light below 50 lux, (3) as measured with a light meter (Light-O-Meter, P-11, Unfors AB, Billdal, Sweden); (ii) calibrating the monitor according to the DICOM standard (9) with a Barten (6 curve as a program installed in the monitors. Luminance (measured in the TG18 image, Figure 1a) was 156 cd/m² (range 148-167 cd/m²) on average. Residual luminance (measured in the TG18 image, Figure 1b) was 0.9 cd/m² (range 0.5-1.3 cd/m²) on average, and (iii) turning the screen away from the window. This second evaluation was made at least four weeks after the first one. The radiographs were displayed in the same order as the first time.

Evaluation 3:

Viewing conditions were optimized, as for Evaluation 2. One week before the third evaluation, one of the authors (AM) gave a seminar to all dental staff at the clinic. The seminar discussed how to best evaluate digital radiographs and included efficiency of diagnostic methods (sensitivity and specificity) for different kind of carious lesions. At the end of the seminar, each participant evaluated five teeth, which

were either sound or had various degrees of carious lesions. This was followed by a group discussion which concluded by revealing the true condition of the teeth with a photograph of each sliced tooth magnified under a microscope. The time between the second and third evaluation was four weeks.

After a minimum of 2 months, all observers re-evaluated 70 surfaces under optimal conditions so that intra-observer agreement could be determined.

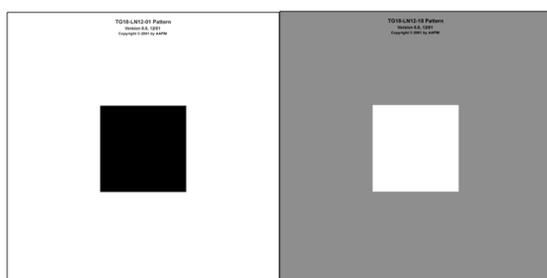
Histological evaluation

The exact procedure of histological evaluation was described in previous studies(1, 14, 15, 27). Briefly, each tooth was cut in 1-mm slices with a low-speed saw and diamond blade (IsoMet® II-1180 Low Speed Saw and IsoMet®, Diamond Wafering Blade, 4 x 0.012 [10.2 cm x 0.3 mm]; Buehler Ltd; Greenwood; IL USA). The sliced teeth were attached to a microscope slide with transparent glue. Two observers, one author (K H-H) and a specialist in oral pathology, evaluated the teeth for caries under a light microscope (magnification x4). In cases of disagreement, the observers discussed with each other to reach a consensus. These results provided a criterion standard (27) with the presence of caries defined as demineralization observed as opaque-white to dark brown colour changes. The observers graded the 200 approximal tooth surfaces on a scale from 0 to 3 where 0 = sound, no visible lesion; 1 = lesion confined to the enamel; 2 = lesion involving the enamel and enamel-dentine border but not the body of the dentine; and 3 = lesion involving the enamel and the body of the dentine undisputedly. The grades 1 and 2 carious lesions were considered to be enamel carious lesions.

Statistical analysis

We used receiver operating characteristic (ROC) curves (20) to analyse all radiographic evaluations. ROCFIT software (Charles Metz, Department of Radiology, University of Chicago, Chicago, IL, USA) calculated the areas under the curves (A_z). Data from all the observers each group of observers was pooled before analysis. The observers were also divided into two groups, GDPs and DHs, and the data was pooled together for each group as well. A paired *t*-test (2) analysed differences between both the observer groups at the different evaluations and differences between the three evaluations, for all observers combined. The *t*-test was made pair-wise: Evaluation

© **Figure 1.** TG18 LN12-01, black image, and TG18LN 18, white image, for testing the luminance values of a monitor.



© **Table 1.** Results of the histological evaluation of the 200 approximal surfaces of the teeth.

Lesion (grade)	No. of surfaces	Per cent
Sound	100	50.0
Enamel caries	75	37.5
Enamel-dentin border	14	7.0
Dentin caries	11	5.5

© **Table 2.** Mean area under the ROC curves for each group of observers and each type of carious lesion.

Observers	Carious lesions		
	All	Enamel	Dentin
GDP			
First evaluation	0.56	0.50	0.63
Second evaluation	0.55	0.48	0.63
Third evaluation	0.61	0.52	0.70
DH			
First evaluation	0.60	0.52	0.68
Second evaluation	0.57	0.50	0.67
Third evaluation	0.63	0.52	0.71

GDP = general dental practitioners

DH = dental hygienists

© **Table 3.** Area under the ROC curves for diagnosing dentin carious lesions by observer at each evaluation.

Observer	Evaluation		
	First	Second	Third
1	0.63	0.62	0.75
2*	0.78	0.74	0.68
3	0.60	0.57	0.69
4	0.62	0.50	0.72
5*	0.60	0.60	0.70
6	0.59	0.62	0.73
7	0.71	0.66	0.71
8	0.71	0.68	0.73
9	0.71	0.72	0.75
10*	0.66	0.69	0.72
11*	0.60	0.69	0.66

* = Dental hygienist

1 with 2, 1 with 3, and 2 with 3. The analyses were made for the whole group of observers, in all, eleven observers and four GDPs and DHs separately. All carious lesions were pooled and analysed for carious enamel lesions and dentin lesions. The significance level was $p \leq 0.05$.

We used weighted Kappa statistics to estimate intra-observer agreement (8) and Altman's adaptation (2) of the Landis and Koch (19) guidelines to interpret the values.

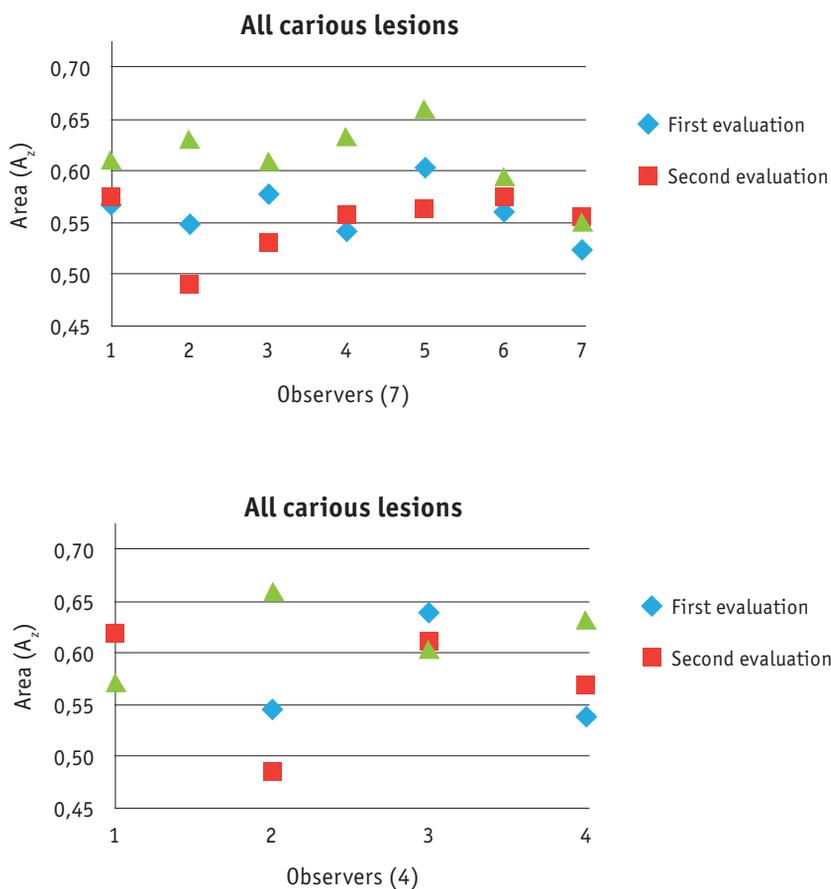
Results

During Evaluation 1, three GDPs and one DH used an ambient light over 50 lux, (696, 1340, 761, 100 lux). At Evaluations 2 and 3, all participants dimmed their ambient light below 50 lux to an average of 21 lux (range 10--35 lux).

One hundred surfaces were sound and 100 surfaces had a carious lesion. Table 1 presents differences in carious lesion depth.

In all evaluations of all carious lesions, diagnostic accuracy of the seven GDPs differed significantly between Evaluations 1 and 3 ($p=0.002$) and Evaluations 2 and 3 ($p=0.015$). Diagnostic accuracy also

© **Figure 2.** The area (A_z) under the receiver operating characteristic (ROC) curve for all carious lesions, for each observer at each evaluation session. The GDP group. The DH group.



differed significantly in the GDP group, for carious lesions into the dentin between Evaluations 1 and 3 ($p=0.010$) and 2 and 3 ($p=0.015$). Table 2 shows mean areas under the ROC curves for each group of observers for the various carious lesions at each evaluation. Table 3 presents the areas under the ROC curves for detection of carious dentin lesions for each observer at the various evaluations. Figures 2a and b show the mean area (A_z) for all carious lesions at the three evaluations for GDPs and DHs, respectively. For carious enamel lesions, there were no significant differences in diagnostic accuracy between the three evaluations. We found no significant difference between GDPs and DHs at any evaluation. The DHs did not differ in any of their evaluations between the three occasions.

Intra-observer agreement varied from moderate to poor (0.54, 0.38, 0.32, 0.31, 0.30, 0.27, 0.23, 0.22, 0.16, 0.14).

Discussion

The main purpose of this study was to examine the evaluation of dental radiographs to detect carious lesions in a public clinical environment and determine whether it was possible to increase diagnostic accuracy with a practical expenditure of time and effort. This study showed that most of the dental staff evaluating radiographic images had embraced previous research showing that low ambient light is preferable when assessing digital radiographs for carious dental lesions. At the first evaluation, only four observers were evaluating their images in bright

ambient light. So it was no surprise that diagnostic accuracy did not differ between the first and second evaluations (12). Before the third evaluation, all participants attended a seminar discussing caries diagnostics. The seminar related that caries diagnoses are one of the most difficult tasks a dental professional has to deal with on a daily basis and focused on how to optimize the environment and equipment to help clinicians perform their best. The seminar also thoroughly discussed the concept of sensitivity and specificity.

The teeth included in this study came from a large group of extracted teeth. The teeth were chosen to mimic the prevalence of carious lesions in a general population. (29) As a result, fifty per cent of the teeth were sound and the other half had carious lesions at various depths. However, only one surface had a cavity. Previous studies with similar materials have shown similar results (22,27). These kind of studies are very sensitive to the material. Greater numbers of large carious lesions will, of course, increase the areas under the ROC, and levels of both inter- and intra-observer agreement will be higher. In this study, the number of sound teeth and teeth with minor carious lesions were in the majority. Thus, we expected the areas under the ROC to be relatively low.

The study revealed that the clinic used calibrated monitors for evaluation of digital radiographs. Almost all medical radiology departments use DICOM (9) calibrated monitors. The American Association of Physicists in Medicine (AAPM) (3) recommends use of a Barten curve (6) or similar to increase the potential for detecting small dark objects with very low contrast. A study by Pakkala et al (22) found no difference in the diagnostic accuracy for different types of carious lesions at various ambient light settings and on monitors with different luminance levels. A previous study (11) also found no differences in diagnostic accuracy for approximal carious lesions between three monitors with varying quality standards.

All dental licenced clinic staff participated in this study. Hintze et al. (14) concluded that both the number of evaluated surfaces and the number of observers can affect study results. In this study, the size of the group of GDPs was adequate while the group of DHs was smaller but also adequate according to Hintze et al. (14) Inter- and intra-observer agreement were similar compared to other studies, (11,22,27. Both GDPs and DHs dimmed the ambient light when evaluating the radiographs. However,

this might be because they all knew they were participating in a study. Nevertheless, the results of this study imply that the staff was aware of the clinical implications of previous research regarding difficulties in evaluating carious lesions in digital radiographs (7,12,22).

As the results indicate, carious enamel lesions are very difficult to detect in a radiograph. This study showed similar results to those of other studies for carious enamel lesions (4, 10, 27) It seems that it is very difficult to improve the diagnostic accuracy for carious enamel lesions in dental radiographs, according to the results in this study. For caries that has reached the dentin, the areas under the ROC curves are similar to that found in former studies (13,25,27). We found no differences in the evaluations made by the DH group between the three evaluations. This could be because the group was small. It might also depend on individual variables such as time from graduation, additional training, and the like. This study found no differences between the GDP group and the DH group. These findings differed from those of a previous study (13) that concluded that level of education mattered. However, it seems generally that a small educational effort can increase awareness of the difficulty of evaluating digital radiographs for carious lesions. On the other hand there is a risk that this new awareness will not last and the participants will go back to their original ways of evaluating digital radiographs. In this study, intra-observer agreement was low; lower than in many previous studies (12,22,25,27) This shortcoming must be considered in interpreting the results. Nevertheless, the main findings show it is useful to focus on the difficulties of evaluating digital radiographs for carious lesions. We cannot stress enough that dental staff have an ongoing challenge and responsibility to improve the quality of the diagnosis process.

We conclude that a short educational session highlighting the difficulty of caries diagnostics with dental radiographic technique can increase diagnostic accuracy amongst GDPs and DHs. We found no difference between GDPs and the DHs in their diagnostic accuracy for detecting approximal carious lesions.

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