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Treatment with a combination of a hard acrylic stabilisation appliance in the upper jaw and a soft appliance in the lower jaw.

page 11

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CONTENTS

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Editorial address
Swedish Dental Journal
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Evaluation of a periodontal risk assessment model in subjects with severe periodontitis

A 5-year retrospective study

HENRIK JANSSON[1], OLA NORDERYD[2]

Abstract

◎ The aim of this study was to evaluate a well-established periodontal risk assessment tool in patients with severe periodontitis included in a supportive periodontal treatment (SPT) program.

In total 20 individuals were included in the analysis. All subjects were randomly selected after successful periodontal treatment and at least 5 years SPT. Clinical and radiographic measurements were collected from patient records and analyzed according to the periodontal risk assessment model. Using the periodontal risk assessment model all subjects were classified as low, moderate, or high-risk patients.

According to the model 7 patients were classified as moderate risk patients and 13 as high-risk patients. When comparing all the patients using only bleeding on probing (BoP) mean prevalence of 20% as a cut-off point, 15 patients were categorised as having low-moderate risk for periodontitis progression and 5 subjects as having high-risk for disease progression.

The periodontal risk assessment model seems to overestimate the risk for disease progression. However the model is a suitable tool to visualize for both the clinician and the patient different variables of importance for periodontal health. The model is also beneficial to show how periodontal treatment can reduce further risk for periodontal disease.

Key words

Periodontal disease; risk assessment; risk factors; supportive periodontal therapy.

[1]Department of Periodontology, Centre for Oral Health Sciences, Malmö University, Sweden

[2]Department of Periodontology, The Institute for Postgraduate Dental Education, Jönköping, Sweden

Utvärdering av parodontal riskbedömningsmodell avseende patienter med grav parodontit

HENRIK JANSSON, OLA NORDERYD

Sammanfattning

◎ Målet med studien var att undersöka hur en väletablerad parodontal riskbedömningsmodell fungerar för riskgruppering av patienter med grav parodontit som behandlas och följs upp i ett parodontalt stödbehandlingsprogram.

Totalt undersöktes 20 patienter. Samtliga individer var slumpmässigt utvalda efter att varit med i stödbehandlingsprogrammet under minst 5 år. Kliniska och röntgenologiska variabler samlades in och analyserades enligt riskbedömningsmodellen. Alla försökspersonerna klassificerades som låg-, medel- eller högriskpatienter.

Sju individer var medelriskpatienter och 13 var högriskpatienter avseende fortsatt parodontal sjukdom. Däremot om endast blödning vid sondering (BoP) bedömdes och en cut-off nivå bestämdes till BoP 20% blev resultatet att 15 individer var låg-medelriskpatienter och 5 var högriskpatienter för fortsatt parodontitprogression.

Den undersökta riskbedömningsmodellen verkar överskatta risken för fortsatt parodontal sjukdomsprogression. Den kan emellertid fungera som ett pedagogiskt hjälpmedel för att belysa vilka variabler som är betydelsefulla och måste kontrolleras för att kunna bibehålla parodontal hälsa. Modellen kan också på ett lättfattligt sätt åskådliggöra hur parodontal behandling kan reducera risken för fortsatt parodontal sjukdom.

Introduction

Patients with severe periodontal disease are often referred to consultants in periodontology for periodontal examination, diagnosis, treatment planning, and necessary treatment. When the active phase in periodontal treatment is completed, a lifelong maintenance is needed for reducing the risk for relapse. Without this, the susceptible individual will be at risk for further periodontal disease progression (1, 2, 4).

The assessment of the individual risk level for disease progression would enable the therapist to determine the frequency and extent of professional support necessary to maintain periodontal health following active therapy. An adequate risk assessment model for periodontal disease would thus prevent both under and over treatment during maintenance care (3).

Different methods to identify individuals at risk for periodontal disease progression have been proposed, such as diagnostic tests, laboratory assays, subjective risk assessment, and multifactorial risk assessment models (5). Factors assessed independently may not predict further disease progression. However, the combination of risk factors in a functional risk assessment model may be useful in identifying individuals at risk for future disease. Today there is no golden standard for periodontal risk assessment.

The aim of this study was to evaluate a modified risk assessment tool by *Lang & Tonetti* (10) in patients with severe periodontitis included in a supportive periodontal treatment program.

Materials and methods

Twenty randomly selected patients with severe periodontitis were treated at the Department of Periodontology, Public Dental Health Service, Kristianstad, Sweden, and followed for at least 5 years. The following variables were analyzed after completed active periodontal therapy and after 5 years of supportive periodontal maintenance:

Number of visits;
Number of remaining teeth;
Bleeding on probing (BoP);
Probing pocket depth (PPD);
Smoking habits < 10 cigarettes/day or ≥ 10 cigarettes/day;
Presence of diabetes.

Radiographs derived from baseline examination and during follow up were analyzed.
Marginal bone level was assessed. A classification into three different classes according to the amount of marginal bone loss around each remaining tooth was made according to *Jansson et al* (7):

- 0 = no loss of supporting bone tissue;
- 1 = horizontal loss of supporting bone tissue > 1/3 of the root length in < 30% sites;
- 2 = horizontal loss of supporting bone tissue > 1/3 of the root length in > 30% of the sites.

The principal of how the multi-functional periodontal risk assessment model works has been described in detail by *Lang & Tonetti* (10).

Briefly, a hexagon where the six variables would include information about the following: (I) the percentage of sites with BOP, (II) the prevalence of residual PPD > 5 mm, (III) the number of tooth loss from a total of 28 teeth, (IV) loss of periodontal support in relation to the patient's age, (V) the daily consumption of cigarettes and finally (VI) systemic and genetic aspects. In this study we did not have any information about the patient's IL-1β genotype. All variables were entered in the hexagon for all patients both at the baseline examination and after 5 years of SPT. All patients were divided in different risk groups: low, moderate, and high. In Table 1 all variables are explained in detail and in Figure 1 is the investigated model presented. To be classified as a low risk individual at most only one variable could be in the moderate risk category. A patient classified as having moderate risk should at least have two

Table 1. Variables included and definition of different risk levels for the *Lang & Tonetti* model. Probing pocket depth (PD); bone loss (BL), estimation of bone loss in per cent of the root length at the worst site on radiographs. Genetic refers to Interleukin 1β genotype.

Risk	Bleeding on probing (%)	N of sites PD > 5mm	Tooth loss	BL/age	Environment = Smoking cig./day)	Systemic/ Genetic
Low	0-9	0-4	0-4	0-0.5	Non, Former	Negative genotype
Moderate	10-25	5-8	5-8	>0.5-1.0	10-19	
High	>25	>8	>8	>1.0	>19	Positive genotype or/ and diabetes

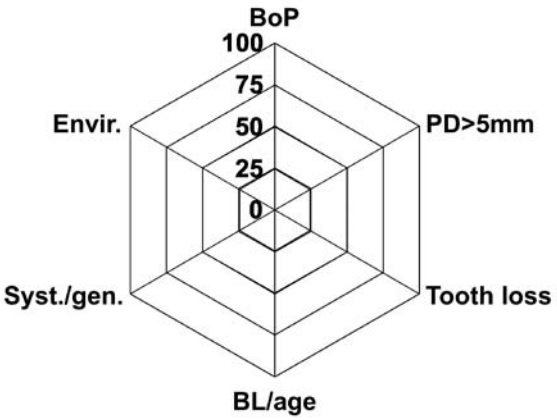

Figure 1. Variables included in the Lang & Tonetti model. According to table 1 the different values for all variables are plotted.
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variables in the moderate risk category and at most one variable in the high risk level. Finally, a high risk individual should have at least two variables in the high risk category.

Statistical analyses

All analyses were done using Statistical Package for Social Sciences (SPSS) for Windows, version 13.0, Chicago, Illinois, United States. The analyses included descriptive statistics and the non-parametric test, the Wilcoxon Rank-Sum Test. Two-sided P values (p-values) <0.05 were considered statistically significant.

Results

The patient characteristics at baseline are described in Table 2. Mean age of the study population at baseline was 48.4 years (SD: ±11.4). On average, they had 23.8 remaining teeth (SD: ±4.7). Seven subjects were identified as heavy smokers (≥ 10 cigarettes/day), four as light smokers (< 10 cigarettes/day) and one person was using snuff. Only one person identified had type 1 diabetes. All patients were diagnosed as having severe chronic periodontitis. The individuals had a mean BoP of 46.1% (SD: ±26.5%) and PD > 5mm of 31.8% (SD: ±21.1%). Five subjects had bone loss > 1/3 of the root length in < 30% sites, and 15 individuals had experienced bone loss > 1/3 of the root length in > 30% of the sites.

Table 2. Clinical characteristics of subjects with severe periodontitis at baseline.

Subject	Age	Number of teeth	BoP	PD >5mm	Marginal bone level	Smoking
1	46	29	31	13	2	<10
2	65	27	22	22	2	0
3	67	16	48	3	2	0
4	44	16	70	36	2	>10
5	35	30	73	48	2	<10
6	53	27	59	34	2	0
7	64	18	17	14	1	0
8	33	28	7	14	2	0
9	56	24	11	17	2	0
10	33	28	72	48	2	0
11	69	22	43	27	1	<10
12	54	19	82	61	2	<10
13	43	25	71	43	2	>10
14	39	20	60	40	2	>10
15	44	26	89	90	2	>10
16	40	18	60	25	1	>10
17	44	21	7	8	1	>10
18	40	28	53	53	2	0
19	43	25	21	23	2	>10
20	5	29	26	17	1	Snuff

Table 3. Periodontal risk assessment and changes of clinical characteristics from baseline (B) and the final follow up visit (FFU).

Subject	BoP <20 % at final follow up N teeth (FFU – B)	BoP % (FFU – B)	PD >5mm (% sites, FFU - B)	Mean number of visits per year	*Lang & Tonetti* risk classification	BoP >20 % at final follow up N teeth (FFU – B)	BoP % (FFU – B)	PD >5mm (% sites, FFU - B)	Mean number of visits per year	*Lang & Tonetti* risk classification
1	0	- 24	- 4	2,6	Moderate					
2	0	- 14	- 4	4,1	High					
3						0	- 20	+ 2	2,3	High
4	- 6	- 65	- 33	1,5	High					
5	- 3	-57	- 37	2,8	High					
6	- 3	- 41	- 25	2,8	High					
7	- 1	- 17	- 14	2,1	Moderate					
8	- 7	- 6	+ 3	2,6	High					
9	0	- 1	0	2,2	Moderate					
10	- 6	- 64	- 38	2,5	High					
11						0	- 18	- 17	1,6	High
12	- 9	- 67	- 56	3,1	Moderate					
13						- 2	- 33	- 17	3,6	High
14	- 2	- 56	- 37	5,2	High					
15	- 9	- 80	- 58	5,9	High					
16						- 2	- 38	- 16	4,4	High
17	0	- 1	+ 4	4,5	High					
18						- 1	- 32	- 45	2,1	Moderate
19	-3	- 15	- 16	3,4	Moderate					
20	- 3	- 15	- 14	2,7	Moderate					

In Table 3 changes between baseline and 5 years after baseline are presented. Individuals with BoP ≤ 20% had a mean loss of 3.5 teeth compared to 1 tooth for subjects with BoP > 20% and this difference was statistical significant (p=0.017). The active phase together with the SPT resulted in a clinically significant improvement for all subjects regarding BoP and the prevalence of PD > 5 mm. The mean reduction of sites with PD > 5 mm was of a similar magnitude in both groups, 22% in subjects with BoP ≤ 20% versus 19% in individuals with BoP > 20% (p=0.73).

Regarding the number of SPT visits per year, no significant mean difference could be observed, 3.2 visits for subjects with BoP ≤ 20% compared to 2.8 visits for subjects with BoP > 20%. Using the model proposed by *Lang & Tonetti* (10) 13 subjects were categorised as high-risk patients and 7 as subjects with moderate risk. When using only the BoP prevalence with a cut-off level of 20%, 15 individuals were placed in the low-moderate risk group and 5 subjects were defined as having a high-risk of future periodontitis progression.

Discussion

The key finding of this study is that the proposed risk assessment model may overestimate the periodontal risk. A majority of the subjects, 13 individuals, were classified as high-risk patients according to the *Lang & Tonetti* risk model. However, when categorising those 13 individuals using only the clinical recording of BoP, 10 subjects had ≤ 20% BoP. The main problem with different risk assessment models is to find appropriate cut-off levels and correlation between the different variables within the model to get a representative value. When analysing the different variables in the tested model, some variables do not seem to be reliable and finally which scientific evidence are the levels for low, moderate and high risk based on: Firstly, BoP visualise the gingival inflammation around all teeth. According to both earlier and more recent studies BoP as a single clinical indicator has shown to be a good measure of periodontal stability (8, 12). Patients with a mean BoP of ≤ 20% have a significant lower risk of further disease progression. Secondly, conventional periodontal therapy or extraction will result in lower amount of sites with PD > 5 mm. The same argument could be used when discussing the variable tooth loss. This

variable is also accumulating over time, and cannot be adjusted. Thereafter, BL/age might be improved after extraction, but on the other hand this will be seen as an increasing number of lost teeth. Smoking is also a variable where there is problem with reliability. How do we know that the amount is correct. Finally, systemic disease and IL-1β positive genotype: the risk genotype is based on the results from the study by *Kornman et al* (13). One has to have in mind the result from that study is based on non-smoking individuals and a limited number of individuals. It can also be discussed if it is possible to make such conclusion based on the investigated patients. The investigated IL-1β polymorphism is common, >30% in a Caucasian population have this risk genotype.

Of the patients with > 20% BoP, only patient number 18 was categorised as having moderate risk for future periodontal disease according to *Lang & Tonetti.* However, that patient had a BoP of 21% and constitutes a borderline case. The other four patients are undoubtedly high risk patients according to both the *Lang & Tonetti* risk model and the clinical recording of BoP. In the present study subjects with BoP ≤ 20% had lost more teeth compared to those with BoP >20%. A possible reason could be that a more aggressive approach had been chosen for those patients in the initial treatment plan, resulting in more extractions of teeth. This finding is also confirmed looking at the mean reduction of sites with PD > 5 mm, which was of a similar magnitude in both groups.

In the present study we have not been able to genotype the patients, which is proposed by *Lang & Tonetti.* However, the relevance of genotyping is really uncertain, which also has been concluded in a new systematic review by *Huynh-Ba et al* (6). In that study it was concluded that there is insufficient evidence to establish if a positive IL-1 genotype contributes to progression of periodontitis and/or treatment outcome.

This study is to our knowledge the first evaluating the proposed risk assessment model. However, *Renvert et al* (11) have used another, similar risk assessment model, the functional periodontal pentagon risk diagram (PPRD). The surface of individual PPRDs was calculated and the area of risk was correlated to higher risk for acute myocardial infarction. An advantage with the risk assessment model is that it serve as a pedagogic instrument visualizing factors that may be possible to influence in order to decrease future disease progression.

The treatment outcome in this group of patients with severe periodontitis was very successful, despite the initial severity. Furthermore, all individuals have been enrolled in regular periodontal maintenance with different number of maintenance visits ranging from 2 to 6 visits per year, which is in accordance to *Kaldahl et al* (9).

In conclusion, this study has not been able to detect further advantages in using the proposed periodontal risk assessment model compared to the traditional clinical judgment. The risk assessment model seems to overestimate the risk for disease progression. However the model is a suitable tool to visualize for both the clinician and the patient different variables of importance for periodontal health. The model is also beneficial to show how periodontal treatment can reduce further risk for periodontal disease. There is need for additional development of this risk assessment model or development of a new model.

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References

1. Axelsson P, Lindhe J. The significance of maintenance care in the treatment of periodontal disease. J Clin Periodontol 1981; 8: 281-94.
2. Becker W, Becker BE, Berg LE. Periodontal treatment without maintenance. A retrospective study in 44 patients. J Periodontol. 1984; 55: 505-9.
3. Brägger U, Hakanson D, Lang NP. Progression of periodontal disease in patients with mild to moderate adult periodontitis. J Clin Periodontol. 1992; 19: 659-66.
4. Fardal Ø & Linden GJ. Re-treatment profiles during long-term maintenance therapy in a periodontal practice in Norway. J Clin Periodontol. 2005; 32: 744-749.
5. Heitz-Mayfield LJA. Disease progression: identification of high-risk groups and individuals for periodontitis. J Clin Periodontol 2005; 32 (Suppl. 6): 196-209.
6. Huynh-Ba G, Lang NP, Tonetti MS, Salvi GE. The association of the composite IL-1 genotype with periodontitis progression and/or treatment outcomes: a systematic review. J Clin Periodontol 2007; 34: 305-317.
7. Jansson H, Lindholm E, Lindh C, Groop L, Bratthall G. Type 2 diabetes and risk for periodontal disease: a role for dental health awareness. J Clin Periodontol 2006; 33: 408–414.
8. Joss A, Adler R, Lang NP. Bleeding on probing. A parameter for monitoring periodontal conditions in clinical practice. J Clin Periodontol 1994; 21: 402-408.

9. Kaldahl WB, Kalkwarf KL, Patil KD, Molvar MP, Dyer JK. Long-term evaluation of periodontal therapy: I. Response to 4 therapeutic modalities. J Periodontol. 1996; 67: 93-102.
10. Lang NP, Tonetti MS. Periodontal risk assessment (PRA) for patients in supportive periodontal therapy (SPT). Oral Health Prev Dent. 2003; 1: 7-16.
11. Renvert S, Ohlsson O, Persson S, Lang NP, Persson RG. Analysis of periodontal risk profiles in adults with or without a history of myocardial infarction. J Clin Periodontol. 2004; 31: 19-24.
12. Schätzle M, Löe H, Bürgin W, Ånerud Å, Boysen H, Lang NP. Clinical course of chronic periodontitis. J Clin Periodontol 2003; 30: 887–901.
13. Kornman KS, Crane A, Wang H-Y, diGiovine FS, Newman MG, Pirk FW, Wilson Jr TG, Higginbottom FL, Duff, G. The interleukin 1 genotype as a severity factor in adult periodontal disease. J Clin Periodontol 1997; 24: 72–77.

Address:
Dr Ola Norderyd
Department of Periodontology
The Institute for Postgraduate Dental Education
P.O. box 1030
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Treatment of temporomandibular disorders with a combination of hard acrylic stabilisation appliance and a soft appliance in the opposing jaw

A retro- and prospective study

ERIK LINDFORS[1] , HÅKAN NILSSON[2,3], MARTTI HELKIMO[1], TOMAS MAGNUSSON[1,4]

Abstract

◉ The aim of this study was to evaluate the treatment effect of a combined treatment with a stabilisation appliance and a soft appliance in the opposing jaw in patients refractory to previous TMD treatment. During a 5-year-period, 2001-2005, a total of 98 patients received the combined treatment at the Department of Stomatognathic Physiology, the Institute for Postgraduate Dental Education, Jönköping, Sweden. Before the patients received the combined treatment, they had already been given several different TMD treatments during a long period of time, either before referral or at the specialist clinic, with only minor or no effect on their TMD symptoms. The patients were followed prospectively (n=10), or analysed retrospectively (n=88). The data registered were gender, age, main indication for TMD treatment, number of visits to the clinic before and after the introduction of the combined treatment, as well as according to a clinical (Di) and anamnestic (Ai) dysfunction index.

The most common causes for treatment in the retrospective material were *problems of muscular origin* and *problems of both muscular and TMJ origin*. In the prospective material, most of the patients had mainly *muscular symptoms*. Both the clinical and anamnestic dysfunction index decreased statistically significantly in the retrospective material after the introduction of the combined treatment. There was a numerical improvement of both indices also in the prospective material.

In conclusion, the present investigation showed that a combined treatment with a hard acrylic stabilisation appliance and a soft appliance in the opposing jaw seems to give a remarkable improvement of TMD signs and symptoms in apparently therapy resistant TMD patients. General conclusions should, however, be made with caution due to the fact that the study did not include any control group. There is an obvious need for randomized controlled studies concerning the efficacy and effectiveness of the combined treatment presented in this study.

Key words

Temporomandibular disorders; treatment; splints; dentistry

[1]Department of Stomatognathic Physiology, The Institute for Postgraduate
[2]Department of Stomatognathic, Dental Education, Jönköping, Sweden
[3]Department of Stomatognathic, Physiology, Kalmar Hospital, Kalmar, Sweden
Physiology, Faculty of Odontology, Malmö University, Malmö, Sweden
[4]School of Health Sciences, Jönköping University, Jönköping, Sweden.

Behandling av funktionsrelaterade symtom i käksystemet med en kombination av stabiliseringskena och en mjuk bettskena i motstående käke. En retrospektiv och prospektiv studie.

ERIK LINDFORS, HÅKAN NILSSON, MARTTI HELKIMO, TOMAS MAGNUSSON

Sammanfattning

◎ I över ett sekel har bettskenor använts för behandling av bl.a. funktionsstörningar i käksystemet. Studiens syfte var att analysera om en kombinationsbehandling med stabiliseringsskena och en mjuk bettskena i motstående käke kunde ge någon behandlingseffekt hos tillsynes terapiresistenta patienter med funktionsstörning i käksystemet.

Under femårsperioden 2001-2005 behandlades 2154 patienter som remitterats till avdelningen för Klinisk Bettfysiologi, Odontologiska Institutionen i Jönköping. Under tidsperioden erhöll 98 patienter den aktuella kombinationsbehandling. Dessa patienter hade, innan insättning av kombinationsbehandlingen, erhållit en mängd bettfysiologiska behandlingar hos tidigare vårdgivare och/eller på specialistkliniken utan tillfredställande resultat. Tio av patienterna följdes prospektivt, och de övriga 88 patienternas journaler granskades retrospektivt. Helkimos kliniska och anamnestiska dysfunktionsindex användes för att utvärdera behandlingseffekten över tid.

Av de 88 patienterna i det retrospektiva materialet exkluderades 16 eftersom de av olika anledningar ej hade utvärderats. Av de kvarvarande 72 patienterna hade 51 endast erhållit kombinationsbehandling (Grupp I) medan 21 även erhållit någon typ av kompletterande behandling under utvärderingstiden (Grupp II).

Den vanligaste orsaken till behandling i Grupp I var besvär av muskulära besvär, medan det i Grupp II var besvär både från muskler och käkleder. I den prospektiva gruppen hade 7 patienter muskulära besvär, 2 patienter käkledsrelaterade besvär och 1 patient besvär både från muskler och käkleder.

Både det kliniska och anamnestiska dysfunktionsindexet minskade statistiskt signifikant i det retrospektiva materialet. Numeriskt noterades en förbättring även i den prospektiva gruppen.

Sammanfattningsvis visar studien att en kombinationsbehandling med stabiliseringsskena och mjuk bettskena i motstående käke verkar ge en betydande symtomlindring hos tillsynes terapiresistenta patienter med funktionsstörningar i käksystemet. Generella slutsatser bör dock göras med försiktighet, eftersom denna studie saknar kontrollgrupp. Det finns ett behov av randomiserade och kontrollerade studier som utvärderar effekten av den kombinationsbehandling som presenterats i denna studie.

Introduction

For more than a century different kinds of interocclusal appliances have been used for treatment of e.g. bruxism and temporomandibular disorders (TMD) (5, 13, 15). Many different appliances have been described in the dental literature (2, 17). The most commonly used appliances in Sweden are the stabilisation appliance made in hard acrylic, also known as the Michigan appliance, and the soft/resilient appliance (16, 20, 26). It has been estimated that approximately 30 000 - 40 000 interocclusal appliances are made every year in Sweden (17), making a yearly incidence of 0.3% to 0.4% of the Swedish population.

Only a few studies have evaluated the efficacy of soft appliances, and the results presented are contradictory (24, 28, 29). Despite this fact the soft appliance is commonly used in general dental practice in Sweden for treatment of bruxism and TMD (16). In contrast, a large number of studies have shown that the use of hard acrylic stabilisation appliances is an effective treatment for managing TMD and bruxism (6-12, 17, 20, 21, 26). In conclusion, the scientific support for the efficacy of hard acrylic stabilisation appliances is much better than that for soft appliances (23).

Despite the fact that interocclusal appliances have a positive effect on TMD signs and symptoms, their mechanism of efficacy has not been fully explained (20, 32). One out of several factors that has been considered is the alteration of the vertical dimension. Both animal and human trials have shown that an increased vertical dimension reduces the EMG activity in the masticatory muscles (18, 19, 26, 32). Furthermore, *Christensen et al* (3) have shown in an experimental study that the onset of pain, due to exercised tooth clenching, can be delayed if the EMG activity is reduced. This can in part explain the favourable effect of interocclusal appliances.

In a study by *Manns et al* (19), 75 TMD patients were divided into three groups. The groups were given occlusal appliances with a vertical dimension of 1.00 (group I), 4.42 (group II), and 8.15 millimetres (group III). Clinical symptoms showed a faster and more complete reduction for groups II and III compared to group I. Thus, thicker appliances seem to have a better treatment effect compared to thinner ones. However, having this knowledge in mind, the most important factor when deciding the vertical dimension of an appliance is that it must be comfortable for the patient. A vertical dimension of approximately 3-4 millimetres in the frontal region seems to be a reasonable clinical standard. If the patient does not respond as expected to this "standard" thickness, a thicker appliance could be considered (2).

Many indications have been suggested for soft appliances (16). One of these is the use of soft appliances in combination with stabilisation appliances to gain further alleviation of TMD symptoms (20, 31). In such cases, the soft appliance should be carefully adjusted to fit the stabilisation appliance with stable contacts in both maximal intercuspation and retruded contact position (Figure 1). The scientific support for this treatment modality is, however, nonexistent. According to one case-report, a patient with a post-traumatic stress disorder had a further reduction of symptoms when a stabilisation appliance in the upper jaw was combined with a soft appliance in the lower jaw (30). The additional treatment effect is supposed to be mainly a result of the increased vertical dimension. The possibility that the resilient material of the soft appliance dissipate forces when the patient clenches heavily (4), has also been discussed as a possible treatment effect (31). In contrast to this, some authors have stated that the resilient material can in fact increase clenching (17), muscle activity and TMD symptoms (24).

Figure 1. Treatment with a combination of a hard acrylic stabilisation appliance in the upper jaw and a soft appliance in the lower jaw.

The aim of this study was to evaluate the treatment effect of the combined treatment with a stabilisation appliance and a soft appliance in the opposing jaw in patients refractory to previous TMD treatment. The null hypothesis was that this combined treatment would not add any further treatment effect. The study was conducted in both a retrospective and a prospective manner.

Material and methods

The study was performed at the department of Stomatognathic Physiology, the Institute for Postgraduate Dental Education, Jönköping, Sweden. Two experienced TMD-specialists and 2 dentist undergoing specialist training worked at the specialist clinic at the time for the study. The case records from all 2154 patients who had been treated at the specialist clinic during the 5-year-period 2001-2005 were scrutinized.

During this time period, prospective data from 10 subjects, who had received the combined treatment with a hard acrylic appliance and a soft appliance in the opposing jaw, had been registered. Data from these patients are presented separately.

Data from all other patients who had received this combined treatment during the 5-year time period were collected retrospectively. The data registered were gender, age, main indication for TMD treatment, number of visits to the clinic before and after the introduction of the combined treatment, as well as the clinical (Di) and anamnestic (Ai) dysfunction index according to *Helkimo* (14).

The results are presented as frequencies and mean values. For the statistical analyses of differences between variables and groups, Chi-square test, Mann-Whitney test and T-test have been used. To describe the treatment effect over time within the groups, a normal test for proportion with continuity correction was used. A p-value < 0.05 has been considered as statistically significant.

Results

During the time period 2001-2005, a total of 98 patients received a combined treatment with a stabilisation appliance and a soft appliance in the opposing jaw. Ten of these patients were followed prospectively, and the remaining 88 patients' case records were scrutinised retrospectively.

The prospective material consisted of 10 women. Their mean age was 36 years (range: 20-56). The majority of the patients in the retrospective material were women (83%). The mean age of these patients was 42 years (range: 15-73).

Sixteen of the 88 patients in the retrospective material had, for different reasons, not been evaluated and were therefore excluded from the analyses. Out of the remaining 72 patients, 51 had only received the combined treatment (Group I), while 21 patients had received some kind of complementary treatment during the evaluation period. Because of this, these patients are presented separately (Group II). The gender distribution and mean age did not differ statistically significantly between the 2 groups. None in the prospective material had received any complementary treatment during the evaluation time period.

On average, the combined treatment was introduced in Group I 28 weeks after the first visit to the department (range: 1-158 weeks). The corresponding figure in Group II was 33 weeks (range: 1-104 weeks). The mean evaluation time for Group I and II was 21 weeks (range: 4-86 weeks) and 48 weeks (range: 13-185 weeks), respectively ($p<0.001$). In the prospective group, the evaluation time period was 6 months.

The mean number of visits to the department before the introduction of the combined treatment was 5 visits in Group I (range: 1-16), and in Group II the corresponding figure was 6 visits (range 1-11, p=N.S.). The mean number of visits to the department after the introduction of the combined treatment was statistically significantly higher in group II (6 visits, range: 1-15) compared to group I (3 visits, range: 1-13, $p<0.001$).

The most common cause for treatment in Group I was *problems of muscular origin*, whereas in Group II it was *problems of both muscular and TMJ origin* (Table 1). In the prospective material, 7 subjects had mainly muscular symptoms, 2 had mainly TMJ symptoms, and one had a combination of both muscular and TMJ symptoms.

Many different treatments had been given to the

Table 1. Main indications for treatment in Group I and Group II. Percentage distribution.

Main Indication	Group I (n=51)	Group II (n=21)
Symptoms of muscular origin	55	40
Symptoms of TMJ origin	8	15
Symptoms of both muscular and TMJ origin	37	45

patients before referral and/or at the specialist clinic before the combined treatment was initiated (Table 2), and patients in Group II also received a variety of different complementary treatments after the start of the combined treatment (Table 3). In both groups, the two most common treatments (beside stabilisation appliance) before the combined treatment were therapeutic jaw exercises and prescription of NSAID (Table 2).

The clinical dysfunction index was statistically significantly higher in Group II compared to Group I when the combined treatment was introduced ($p<0.05$), while there was no difference between the groups in respect of the anamnestic dysfunction index.

Both the clinical and anamnestic dysfunction index decreased statistically significantly in both retrospective groups after the introduction of the combined treatment (Figure 2 and 3, Table 4 and 5, $p<0.001$). According to the clinical dysfunction index, a total of 5 patients showed a change for the worse (4 in Group I and 1 in Group II). The other patients had either an unchanged or an improved situation. No one showed a change for the worse according to anamnestic dysfunction index.

There was a numerical improvement of both indices also in the prospective group (Table 4 and 5).

The change of the five different variables that constitute the clinical dysfunction index is presented in Table 6. In Group I, all the 5 variables were statistically significantly improved (see Table 4 for p-values). The two variables that showed the greatest improvement were "*Muscle pain*" and "*Temporomandibular joint pain*" ($p<0.0001$). In Group II, only "*Muscle pain*" and "*Temporomandibular joint pain*" showed a statistically significant improvement ($p<0.05$ and $p<0.001$ respectively).

Table 2. Main indications for treatment in Group I and Group II. Percentage distribution.

Treatment	Group I (n=51)	Group II (n=21)
Stabilization appliance	51 (100)	21 (100)
Soft appliance	7 (14)	0 (0)
Jaw exercises	40 (78)	15 (71)
Occlusal adjustment	5 (10)	4 (19)
Acupuncture	4 (8)	0 (0)
NSAID	14 (27)	6 (29)
Intraarticular cortisone injection	7 (14)	2 (10)
Intramuscular injection with local anaesthetic	0 (0)	1 (5)
Antireumathic drugs	0 (0)	3 (14)
Physiotherapy	7 (14)	2 (10)
Biofeedback	1 (2)	0 (0)

Table 3. Complementary treatments received in Group II after initiation of the combined treatment. Percentage distribution within brackets.

Treatment	Group I I n=21
Jaw exercises	2 (10)
Occlusal grinding	2 (10)
Acupuncture	3 (14)
NSAID	4 (19)
Intraarticular cortisone injection	7 (33)
Intramuscular injection with local anaesthetic	1 (5)
Antireumatic drugs	1 (5)
Physiotherapy	4 (19)
Biofeedback	1 (5)
Chiropractor treatment	1 (5)
Floating	1 (5)
Antidepressants	2 (10)
Central local anaesthetic blocks (performed by a physician)	1 (5)
Arthroscopy	2 (10)

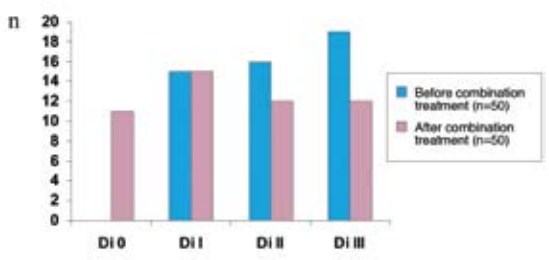

Figure 2. Changes in Helkimo´s clinical dysfunction index, Di, in group I. The decrease in Di was statistically significant (p<0.001).

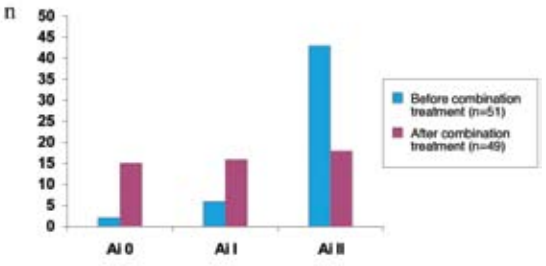

Figure 3. Changes in Helkimo´s anamnestic dysfunction index, Ai, in group I. The decrease in Ai was statistically significant (p<0.001).

The 10 patients that had been followed prospectively had had their symptoms for on average 8 years (range: 1-20 years). Six months after the introduction of the combined treatment, 4 out of 10 patients in the prospective material reported a significant improvement of their subjective symptoms, 5 reported some improvement and one reported no change. These data had not been registered systematically in the retrospective material.

Since no systematic recordings of the patients' opinions about subjective improvement of their symptoms had been made in the case records, an estimate was made of the treatment outcome from the written information in the case records also for the patients included in the retrospective groups. This was possible in all cases except 2. A vast majority of the patients both in Group I and Group II had some improvement (11.8% and 57.1%, respectively) or a good improvement (62.7% and 23.8% respectively).

Discussion

Many studies on TMD patient populations have shown that middle-aged women are overrepresented. The gender distribution and mean age of the patients in this study was in accordance to a previous study made from the same specialist clinic including 3194 patients (1).

Before the patients received the combined treatment, they had already been given many different treatments during a long period of time before referral and/or at the specialist clinic with only minor or no effect on their TMD symptoms. Despite this, many patients responded positively to the combined treatment according to both the clinical and the anamnestic index used. In placebo research it is a well known fact that the more ineffective treatments a patient receives, the more likely are future treatments to fail (22). Due to the poor or non-existent effect of several previous treatment attempts, it is not likely that the positive treatment effect after the initiation of the combined treatment of a hard acrylic appliance and a soft one can be attributed to a placebo effect. Still, the present study design can not control for true placebo, regression to mean, natural course of disease, or unidentified parallel treatment interventions. To control for these factors, a ran-

Table 4. Change in Helkimo´s clinical dysfunction index, Di, in Group II (combined treatment + complementary treatment) and in the prospective group. Number of patients.

	Di o		Di I		Di II		Di III	
Group	Before	After	Before	After	Before	After	Before	After
Group II	0	1	0	8	8	7	11	5
Prospective group	0	0	0	4	5	4	5	2

Table 5. Change in Helkimo´s anamnestic dysfunction index, Ai, in Group II (combined treatment + complementary treatment) and in the prospective group. Number of patients.

	Ai o		Ai I		Ai II	
Group	Before	After	Before	After	Before	After
Group II	0	3	0	6	20	9
Prospective group	0	0	0	3	10	7

Table 6. Change of the five variables that constitute Helkimo´s clinical dysfunction index, Di, in Group I and Group II..

Symptom		Group I (n=51) Before treatment n=50	After treatment n=50	p-value	Group II (n=21) Before treatment n=19-21	After treatment n=20-21	p-value
Impaired range of motion				p<0.05			n.s.
	0	42	49		13	16	
	1	8	1		6	3	
	5	0	0		0	1	
Impaired function of the temporomandibular joint				p<0.05			n.s.
	0	28	33		13	15	
	1	22	17		6	6	
	5	0	0		1	0	
Pain on movement				p<0.001			n.s.
	0	33	40		11	12	
	1	6	7		4	6	
	5	11	3		5	3	
Muscle pain				p<0.0001			p<0.005
	0	5	19		0	2	
	1	17	12		3	8	
	5	28	19		17	11	
Temporomandibular joint pain				P<0.0001			p<0.001
	0	8	22		0	6	
	1	22	12		9	11	
	5	20	16		12	4	

domized study controlled with both a placebo group and a no treatment group is needed.

The patients in Group II also required some complementary treatment beside the combined treatment. One possible explanation for this is that the patients in Group II had a statistically significantly higher clinical dysfunction index to begin with compared to Group I ($p<0.05$). Apart from this, there were no statistically significant differences between the groups regarding gender, age or main indication for treatment.

It should be underlined that many factors that can make a difference in treatment outcome, e.g. psychosocial factors, occlusion and general health factors, were not possible to analyse in the present study. Because of this, the results should be interpreted with caution.

The most common complementary treatments made in Group II after the introduction of the combined treatment were different pharmacological, mainly anti-inflammatory, ones. It can be speculated that the combined treatment performed has a poorer effect in cases with more pronounced inflammatory conditions.

It is no surprise that the patients in Group II, due to the complementary treatments they had received and the initially higher degree of clinical signs, had significantly longer mean evaluation periods, as well as more visits to the clinic compared to Group I ($p<0,001$).

There was no difference in treatment outcome between the two groups. This means that even in a group of seemingly therapy resistant patients, who previously have tried a number of different treatment modalities without sufficient effect, and who do not respond satisfactorily to the combined treatment alone, further complementary treatments may give a remarkable alleviation of symptoms.

The combined treatment was more effective in reducing the pain variables than improving the functional ones. One explanation for this might be that the patients in the current study mainly had pain problems and did not have severe functional impairment when the combined treatment was introduced. Thus, the improvement of the range of motion and the function of the TMJs was less notable than the reduction of pain symptoms.

In conclusion, the present investigation showed that a combined treatment with a hard acrylic stabilisation appliance and a soft appliance in the opposing jaw seem to give a remarkable improvement of TMD signs and symptoms in apparently therapy resistant TMD patients. Therefore the null hypothesis must be rejected. General conclusions should, however, be made with caution due to the fact that the study did not include any control group. There is

an obvious need for randomized controlled studies concerning the efficacy and effectiveness of the combined treatment presented in this study.

References

1. Anastassaki A, Magnusson T. Patients referred to a specialist clinic because of suspected temporomandibular disorders: a survey of 3194 patients in respect of diagnoses, treatments, and treatment outcome. Acta Odontol Scand 2004;62:183-92.
2. Carlsson GE, Magnusson T. Management of Temporomandibular Disorders in the General Dental Practice. Chicago: Quintessence, 1999. pp.50-1.
3. Christensen LV, Mohamed SE, Harrison JD. Delayed onset of masseter muscle pain in experimental tooth clenching. J Prosthet Dent 1982;48:579-84.
4. Craig RG, Godwin WC. Properties of athletic mouth protectors and materials. J Oral Rehabil 2002;29:146-50.
5. DuPont JS, Brown CE. Occlusal splints from the beginning to the present. J Craniomandib Pract 2006;24:141-5.
6. Ekberg EC, Vallon D, Nilner M. Occlusal appliance therapy in patients with temporomandibular disorders. A double-blind controlled study in a short-term perspective. Acta Odontol Scand 1998;56:122-8.
7. Ekberg EC, Eskafi M, Petersson A, Nilner M. Occlusal appliance therapy in a short-term perspective in patients with temporomandibular disorders correlated to condyle position. Int J Prosthodont 1998;11:263-8.
8. Ekberg EC, Nilner M. The influence of stabilisation appliance therapy and other factors on the treatment outcome in patients with temporomandibular disorders of arthrogeneous origin. Swed Dent J 1999;23:39-47.
9. Ekberg E, Vallon D, Nilner M. Treatment outcome of headache after occlusal appliance therapy in a randomised controlled trial among patients with temporomandibular disorders of mainly arthrogenous origin. Swed Dent J 2002;26:115-24.
10. Ekberg E, Nilner M. A 6- and 12-month follow-up of appliance therapy in TMD patients: A follow-up of a controlled trial. Int J Prosthodont 2002;15:564-70.
11. Ekberg EC, Vallon D, Nilner M. The efficacy of appliance therapy in patients with temporomandibular disorders of mainly myogenous origin. A randomized, controlled, short-term trial. J Orofac Pain 2003;17:133-9.
12. Ekberg E, Nilner M. Treatment outcome of appliance therapy in temporomandibular disorder patients with myofascial pain after 6 and 12 months. Acta Odontol Scand 2004;62:343-9.
13. Goodwillie DH. Arthritis of the temporo-maxillary articulation. Arch Med 1881;5:259-63.
14. Helkimo M. Studies on function and dysfunction of the masticatory system. II. Index for anamnestic and clinical dysfunction and occlusal state. Swed Dent J 1974;67:101-21.
15. Karolyi M. Beobachtungen über Pyorrhea Alveolaris. Oesterreich-Ungarische Vieteljahrsshrift für Zahnheilkunde 1901;17:279-83.
16. Lindfors E, Magnusson T, Tegelberg Å. Interocclusal appliances - indications and clinical routines in general dental practice in Sweden. Swed Dent J 2006;30:123-34.
17. List T, Tegelberg Å, Lundeberg T, Orbach R. Smärtlindring i Ansikte och Huvud ur Bettfysiologiskt Perspektiv. Stockholm: Gothia, 1999. pp.76-81.
18. Manns A, Miralles R, Guerrero F. The changes in electrical activity of the postural muscles of the mandible upon varying the vertical dimension. J Prosthet Dent 1981;45:438-45.
19. Manns A, Miralles R, Santander H, Valdivia J. Influence of the vertical dimension in the treatment of myofascial pain-dysfunction syndrome. J Prosthet Dent 1983;50:700-9.
20. Magnusson T, Carlsson GE, Nordberg I. Bettskenor i Kliniken och på Laboratoriet. Invest-Odont AB; Stockholm, 1987. pp. 39-41, 71-2.
21. Magnusson T. Bruxism och tandslitage. Tandläkartidningen 2004;96(11):52-6.
22. McMahon SB, Koltzenburg M. Textbook of Pain. Elsevier Churchill Livingstone, 2006. p. 361.
23. Nilner M. Application of principles of evidence-based medicine to occlusal treatments for temporomandibular disorders: Are there lessons to be learned? Critical commentary. J Orofac Pain 2004;18: 27-30.
24. Okeson JP. The effects of hard and soft occlusal splints on nocturnal bruxism. J Am Dent Assoc 1987; 114: 788-91.
25. Okeson. Management of Temporomandibular Disorders and Occlusion. Mosby. 2003, pp. 532-4.
26. Ramfjord SP, Ash MM. Reflection on the Michigan occlusal splint. J Oral Rehabil 1994;21:491-500.
27. Rugh JD, Drago CJ. Vertical dimension: a study of clinical rest position and jaw muscle activity. J Prosthet Dent 1981;45:670-5.
28. Wright E, Anderson G, Schulte J. A randomized clinical trial of intraoral soft splint and palliative treatment for masticatory muscle pain. J Orofac Pain 1995;9:192-9
29. Wright EF. Using soft splints in your dental practice. Gen Dent 1999 ;47:506-12.
30. Wright E, Thompson R, Paunovich E. Post-traumatic stress disorder: Consideration for dentistry. Quintessence Int 2004;35:206-10.
31. Wright. Manual of Temporomandibular Disorders. Blackwell Munksgaard. 2005, pp. 131, 163.
32. Yaffe A, Tal M, Ehrlich J. Effect of occlusal bite-raising splint on electromyogram, motor unit histochemistry and myoneuronal dimensions in rats. J Oral Rehabil 1991;18:343-51.

Address:
Dr Erik Lindfors
Department of Stomatognathic Physiology
Specialisttandvården Kaniken
Box 1813
SE-751 48 Uppsala
E-mail: erik.lindfors@lul.se

Oral health in the adult population of Västerbotten, Sweden

– a comparison between an epidemiological survey and data obtained from digital dental records

HANS FORSBERG[1], LARS SJÖDIN[1], PER LUNDGREN[2], ANDERS WÄNMAN[3]

Abstract

◎ The objective of this study was to analyse the possibilities and limitations of using data drawn from electronic dental patient records (EDPRs) in monitoring dental health among adults in a northern Swedish county. Materials and Methods: The study population comprised all 35-, 50-, 65- and 75-year-old patients who were examined and, where required, received treatment at the Public Dental Service (PDS) in Västerbotten, Sweden, in 2003 and in 2004. In total 2,497 patients in 2003, and 2,546 patients in 2004 met the inclusion criteria. As controls, 779 subjects randomly drawn from the adult population in the same age groups and from the same county were used. They participated in an oral health survey and were examined clinically between October 2002 and March 2003. Results: When oral health was estimated based on EDPRs the prevalence of edentulous subjects was significantly underestimated, while the mean numbers of teeth and the mean values of sound teeth were significantly overestimated. No statistically significant difference was found in prevalence of primary decayed tooth surfaces (DS). The prevalence of filled teeth (FT) was fairly similar between the study samples. Registrations of periodontal status were mainly missing in the EDPRs. Since registrations related to temporomandibular disorders are not included in the T4 system its prevalence could not be assessed and accordingly not compared with the epidemiological sample. Conclusion: The study shows that clinical registration based on EDPRs is at present not accurate enough to be used as indicators of oral health status among adults in a community.

Key words

Epidemiology, dentistry, oral health, monitor, dental record

[1] Department of Strategic Management, County Council of Västerbotten, Umeå, Sweden

[2] Public Dental Health Service, Lycksele, Sweden

[3] Department of Odontology/Clinical Oral Physiology, Faculty of Medicine, Umeå University, Umeå, Sweden

Tandstatus hos Västerbottens vuxna befolkning. En jämförelse mellan en epidemiologisk undersökning och data hämtat från digitalt journalsystem.

HANS FORSBERG, LARS SJÖDIN, PER LUNDGREN, ANDERS WÄNMAN

Sammanfattning

◎ Syftet med studien var att undersöka möjligheter och begränsningar med att nyttja registerdata tagna ur T4-journalen för att beskriva tillståndet i mun och käkar bland den vuxna befolkningen i Västerbotten. Material och Metod: Som undersökningspopulation ingick samtliga 35-, 50-, 65- och 75 åringar som blev undersökta och vid behov behandlade inom Folktandvården i Västerbotten åren 2003 respektive 2004. Totalt ingick för år 2003, 2,497 patienter och för år 2004, 2,546 patienter. Som jämförelsepopulation användes 779 slumpmässigt utvalda individer från samma region och i samma åldrar. Dessa deltog i en epidemiologisk studie och blev undersökta mellan oktober 2002 och mars 2003. Resultat: Information om tandförhållanden baserat på journaldata underskattar antalet helt tandlösa individer medan medelvärdet för antalet tänder överskattas. För bedömning av primärkarierade tandytor fanns ingen statistiskt signifikant skillnad mellan undersökningsgrupperna. Även förekomsten av lagade tänder (FT) var tämligen likartad mellan undersökningsgrupperna. Registreringar av parodontalt status i T4 journalen fanns endast i få fall. Eftersom det i journalsystemet T4 inte finns förberett för registreringar av käksystemets funktion (underkäkens maximala rörelseomfång, muskelsmärta, käkledsfunktion) så kan förekomst av funktionsstörningar i käksystemet inte bedömas baserat på registerdata tagna ur T4 journalsystemet. Konklusion: Undersökningen visar att kvaliteten i statusuppgifter tagna ur journalregistreringar inte håller tillräckligt hög kvalitet för att nyttjas för att bedöma tillståndet i mun och käkar hos vuxna individer.

Introduction

Epidemiological surveys to gain knowledge of a population's state of health and its longitudinal development are important for planning health services and allocating resources. Large epidemiological studies are, however, both time-consuming and costly. The willingness of the population to participate in such surveys seems to be diminishing and high drop-out rates can severely hazard the interpretation of results.

In Västerbotten, Sweden, dental health in children has been monitored within the Public Dental Service (PDS) at yearly check-ups since 1965. The prevalence and incidence of caries in children and adolescents has accordingly been analysed, which has proved an important tool in prevention (1, 6, 12). A similar follow-up system has not been adopted for the adult population of Västerbotten. In a study from the UK the authors considered collection of epidemiological data by general dental practitioners a possible alternative to conventional surveys of adult dental health (2). The introduction of electronic dental patient record (EDPR) systems has widened the possibility to follow the development of dental health in the population and this at a low cost. It is therefore of interest to examine whether, and to what degree, registrations in EDPR systems can mirror the oral state of health in the adult population. In one review of research based on administrative databases the authors concluded that the strongest designs were found in investigation of longevity or consequences of care (7). Dental records can lack information on certain health aspects (3) and oral health profile registrations may be biased towards the regular dental care attendee. Still, health planning organizations would gain a great deal if data taken from digital dental registration systems were of a high quality. Such data could be used to follow oral status or development and outcome of dental care (8). Money spent on general population surveys could instead be allocated to specific sub-populations of interest, such as refugees, the elderly and institutionalized individuals.

The aim of this study was to analyse the possibilities and limitations of using data drawn from electronic dental records to monitor the dental health status among adults in a northern Swedish county.

Materials and methods

Study populations

The cases comprised all 35-, 50-, 65- and 75-year-old patients examined and, where required, treated at the PDS in Västerbotten in 2003 and in 2004. Altogether 2,497 patients (1,261 men and 1,236 women) in 2003 and 2,546 (1,244 men and 1,302 women) in 2004 met the inclusion criteria (Table 1). The oral clinical examination and registrations were done at the dental clinics at each patient's ordinary scheduled check-up examination. Data were registered in the Swedish version T4 of the Dental Practice Management System (Eastman Kodak Company, New York, NY, USA). Clinical registrations included in the record system were number of teeth, type of dental restorations and site of restoration, fixed and removable dental prostheses, dental caries, and periodontal pocket depth. During the dentist's examination and report on oral status, a chair-side assistant transferred registration data to the software program by clicking on a screen chart. Performed dental therapies were accordingly registered into the software program for documentation and as a basis for billing the patient. Information on clinical status and performed dental treatment procedures was transferred to an SQL database for further analysis.

The controls were randomly drawn from the adult population in the county of Västerbotten. A survey

Table 1. Total population of 35-, 50- , 65- and 75-year-olds living in Västerbotten, Sweden, in 2002, subjects drawn from the population, who participated in the clinical examination (controls), and patients who received complete dental treatment at the Public Dental Service (PDS) in Västerbotten in 2003 and in 2004 (cases).

Group	35-year-olds	50-year-olds	65-year-olds	75-year-olds	Total
Total population, 2002	3,464	3,375	2,460	2,025	11,324
Controls					
Clinically examined	214	190	199	176	779
Cases					
PDS patients, 2003	904	697	532	364	2,497
PDS patients, 2004	850	742	566	388	2,546

of oral health among 35-, 50-, 65- and 75-year-olds was started in October 2002 and ended in February 2003. The population was stratified into those living on the coast (urban) and those living in the inland (rural) region of Västerbotten. It was decided that each stratum would consist of 150 individuals from each age group. Thus, altogether 1,200 control subjects, 577 women and 623 men, were included in the study. The selected subjects were informed by letter about the study and invited to participate. Out of these randomly selected subjects, 768 (64%) agreed to both complete the questionnaire and participate in a clinical examination, 11 (0.9%) participated in only the clinical examination, and 219 (18.2%) completed the questionnaire but did not come to the clinical examination. In addition, 128 (10.7%) subjects were interviewed by telephone, 7 (0.6%) had deceased and 67 (5.6%) could not be reached or were unwilling or unable to participate because of illness or disabilities. Those who were used as controls in this study all had complete clinical registrations, in total 779 subjects (409 men and 370 women). Characteristics of the study population, controls and cases analysed in this study are presented in Table 1.

The examinations were done by four dental teams comprising one dentist and one chair-side assistant at a fully equipped dental clinic as close to the subject's home as possible. Before the study started, the examiners were calibrated to the standardized clinical methods used. These included registration of the number of teeth, supporting zones (Eichner index), dental restorations, fixed and removable prostheses, dental caries, periodontal pocket depth, signs of temporomandibular disorders and maximal jaw opening capacity. Details have been presented elsewhere (13, 14). The clinical status was directly registered on a computer equipped with a program especially developed for oral health surveys (DFT, Per Lundgren).

The following variables were used to compare oral health status between cases and controls:

- Number of teeth (1–32). Partially erupted teeth as well as roots that could be used for restoration were registered as teeth.
- Number of sound teeth. Teeth with neither caries nor previous restorative therapy.
- Primary decayed surfaces (DS). Presence of primary caries was registered clinically and from radiographs (bite-wings) where a caries lesion had penetrated the enamel (D3) and was not adjacent to a dental filling or fixed partial denture.
- Secondary decayed surfaces (Sec-DS). Presence of secondary caries was registered clinically and from radiographs if the caries lesion was located adjacent to a dental filling or fixed partial denture.
- Decayed and filled teeth (DFT). Based on 28 teeth.
- Decayed and filled surfaces (DFS). Based on 28 teeth.
- Tooth surfaces restored with dental amalgam.
- Tooth surfaces restored with composite resins.
- Tooth surfaces restored with glass-ionomer cements.
- Presence of fixed partial dentures.

It was not possible to include periodontal registrations in the comparisons because of a very low number of such registrations found in the electronic dental records. Calculation of mean number of teeth was performed on all subjects with one or more teeth registered. Edentulous subjects were therefore excluded.

This study was approved by the Human Ethics Committee of the Faculty of Medicine, University of Umeå, Umeå, Sweden.

Statistical methods

The statistical analysis was done in SPSS, version 14.0 (SPSS Inc., Chicago, IL, USA). Since the controls was based on a stratified epidemiological sample, the figures were weighted for the total region before the anaysis. Comparison of mean values for the selected variables between cases and controls was done using Student's t-test for independent variables. Analysis of differences in distribution between cases and controls of variables with a skewed distribution (DS, Sec-DS, tooth surfaces filled with composite resins or glass-ionomer cement, and fixed partial dentures) was done using chi-square test after dichotomizing the variable. If the expected number of individuals was <5 the data were recoded into fewer categories. The null hypothesis was rejected if $p<0.05$.

Results

The prevalence of edentulousness among 65-year-olds in Västerbotten was 10.7%; however, only 0.2% of those who visited the PDS ($P < 0.001$) for a scheduled check-up were registered as edentulous. The prevalence of edentulousness among 75-year-olds was 24.3%, but prevalence of edentulousness was registered among only 0.5–1% of those who visited the PDS ($P < 0.001$).

The mean number of teeth in all age groups was statistically significantly higher in data drawn from the EDPRs compared with population data (Table 2). According to data taken from the EDPRs, the per-

centage of 65-year-old subjects with a complete set of teeth (i.e. 32 teeth) was 6–8%, and among 75-year-olds it was 10%. These prevalence figures were significantly higher than was expected based on the population data (<0.5%). The percentage distribution of number of teeth for the selected ages, according to the epidemiological survey and according to registrations drawn from the EDPRs, is shown in Figure 1.

No statistically significant difference was found between cases and controls in prevalence of DS (Table 2). Secondary decayed tooth surfaces were, however, registered significantly less often for all ages ($P < 0.001$) among patients in the PDS than among the controls. The percentage distribution of DS at the selected ages, according to the epidemiological survey and according to registrations drawn from the EDPRs, is shown in Figure 2.

Only minor differences were found in registered, previously performed dental therapies between the cases, based on dental records, and the individuals presented in the survey (Table 3). Presence of glass-ionomer cements was rarely registered but in all age groups this was significantly more frequently registered among the cases. No statistically significant difference was found between cases and controls for the mean value of restored surfaces or DFT except at the age of 75 where data drawn from the EDPRs in 2003 showed a significantly lower ($P<0.05$) prevalence than found in the population data. The distribution of DFT among the EDPR cases was, however, affected by a higher percentage of DFS = 0, especially among the elderly cases, compared with controls from the population survey.

Table 2. Mean values, standard deviation (SD) and lowest to highest value (min-max) of number of teeth, number of sound teeth (not decayed and not restored), primary decayed surfaces (DS), caries on a previously filled surface (Sec-DS), and decayed and filled teeth (DFT) and surfaces (DFS) among 35-, 50-, 65- and 75-year-olds, based on an epidemiological sample (EPI 2002) and electronic dental patient records (EDPRs) drawn from the Public Dental Service (PDS) in 2003 (EDPR 2003) and 2004 (EDPR 2004). Statistically significant differences between EPI 2002 and EDPRs are indicated in the Table.

	35-year-olds			50-year-olds			65-year-olds			75-year-old		
	EPI 2002	EDPR 2003	EDPR 2004	EPI 2002	EDPR 2003	EDPR 2004	EPI 2002	EDPR 2003	EDPR 2004	EPI 2002	EDPR 2003	EDPR 2004
Number of teeth												
Mean value	28.8	29.1	29.3*	26.8	27.5*	27.7*	19.2	23.6‡	23.5‡	16.5	21.6‡	21.5‡
SD	2.2	2.1	2.1	3.3	2.8	2.8	7.0	5.1	5.3	7.0	6.5	6.5
Min-max	21–32	20–32	19–32	9–32	9–32	7–32	2–32	5–32	3–32	2–31	1–32	2–32
Sound teeth												
Mean value	18.9	19.4	19.6	9.0	10.2	10.1	4.4	9.3‡	8.2‡	3.2	10.5‡	9.3‡
SD	5.3	5.1	5.2	4.8	6.2	5.8	4.1	8.0	7.4	3.2	9.3	9.2
Min-max	5–32	1–32	1–32	0–21	0–32	0–32	0–25	0–32	0–32	0–15	0–32	0–32
DS												
Mean value	1.2	0.7	0.7	0.3	0.4	0.4	0.3	0.2	0.2*	0.4	0.3	0.3
SD	2.0	1.3	1.1	0.7	1.5	1.6	0.7	0.9	0.6	0.9	0.8	0.9
Min-max	0–16	0–17	0–11	0–5	0–24	0–33	0–4	0–15	0–8	0–5	0–8	0–11
Sec-DS												
Mean value	0.6	0.1‡	0.1‡	1.2	0.2‡	0.3‡	1.4	0.2‡	0.2‡	2.2	0.3‡	0.2‡
SD	1.1	0.4	0.5	1.9	0.7	0.8	2.7	0.7	0.6	3.8	0.8	0.7
Max-min	0–7	0–4	0–3	0–10	0–7	0–8	0–21	0–10	0–5	0–20	0–7	0–6
DFT												
Mean value	9.9	9.2	9.2	17.8	16.7	16.8	14.8	14.1	15.1	13.3	11.1*	12.2
SD	4.5	4.4	4.4	4.5	5.5	5.2	6.0	6.7	6.4	5.9	6.7	6.8
Max-min	0–23	0–27	0–26	5–28	0–28	0–28	2–26	0–27	0–26	1–26	0–25	0–27
DFS												
Mean value	18.0	16.2	15.9	46.1	36.3‡	36.7‡	47.8	26.8‡	29.3‡	43.3	18.8‡	21.9‡
SD	12.0	11.2	10.9	17.0	16.5	16.2	22.8	17.9	18.0	20.1	15.0	16.2
Min-max	0–56	0–66	0–64	9–108	0–95	0–84	4–103	0–82	0–85	0–100	0–65	0–67

*P<0.05 and P≥0.01; †P<0.01 and P≥0.001; ‡P<0.001.

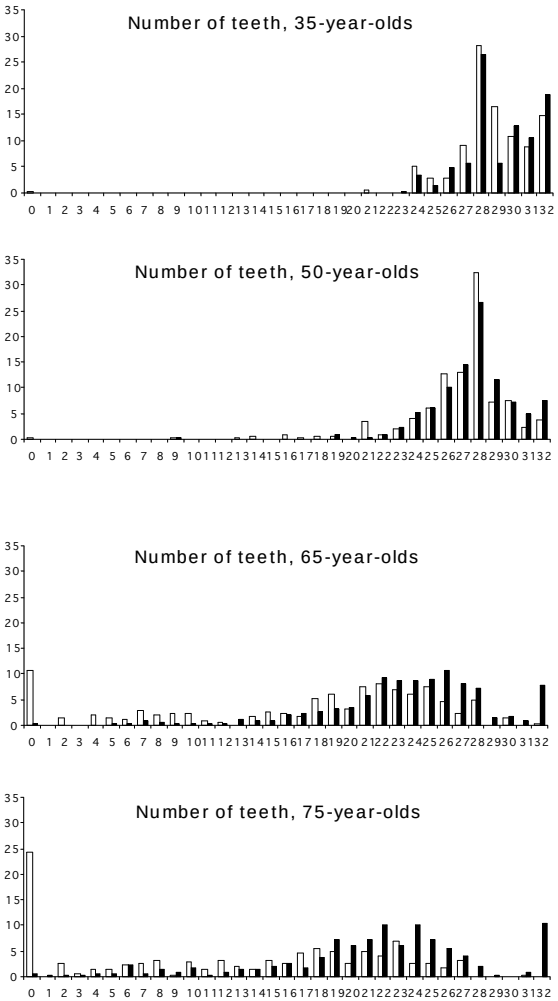

Figure 1. Percentage distribution of number of registered teeth among 35-, 50-, 65- and 75-year-olds, as registered in an epidemiological survey in Västerbotten, Sweden, in 2002 (open bars), and according to registration drawn from an electronic dental patient record (EDPR) system in 2003 (filled bars).

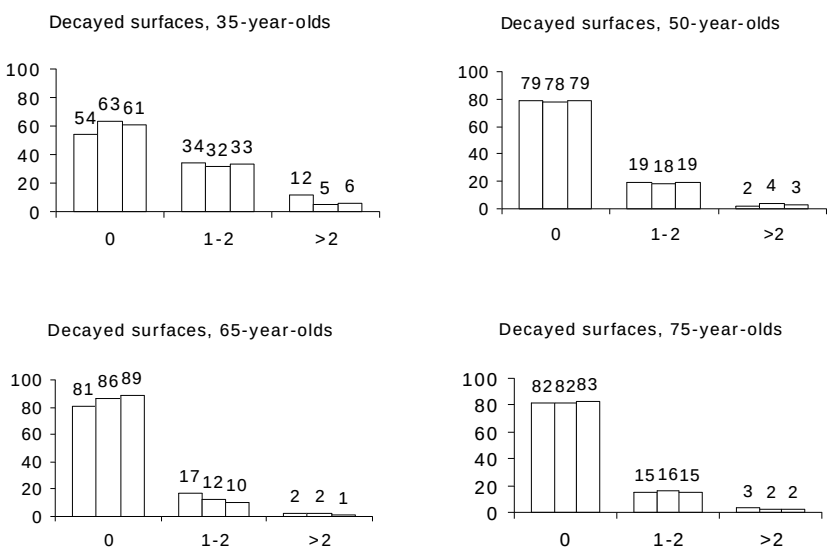

Figure 2. Percentage distribution of decayed surfaces (DS) among 35-, 50-, 65- and 75-year-olds, as registered in an epidemiological survey in Västerbotten, Sweden, in 2002 (open bars), and according to registration drawn from an electronic dental patient record (EDPR) system in 2003 (dotted bars) and 2004 (striped bars). 0 = no DS; 1-2 = one or two DS; >2 = more than two DS.

Table 3. Mean values, standard deviation (SD) and lowest to highest value (min-max) of fixed partial dentures, and number of surfaces with type of restoration material among 35-, 50-, 65- and 75-year-olds, based on an epidemiological sample (EPI 2002) and electronic dental patient records (EDPRs) drawn from the Public Dental Service (PDS) in Västerbotten, Sweden, in 2003 (EDPR 2003) and 2004 (EDPR 2004). Statistically significant differences between EPI 2002 and the EDPRs are indicated in the Table.

	35-year-olds			50-year-olds			65-year-olds			75-year-old		
	EPI 2002	EDPR 2003	EDPR 2004	EPI 2002	EDPR 2003	EDPR 2004	EPI 2002	EDPR 2003	EDPR 2004	EPI 2002	EDPR 2003	EDPR 2004
Number of fixed partial dentures												
Mean value	0.1	0.1	0.1	1.7	1.2*	1.1*	4.8	3.7	3.9	5.0	3.7*	4.1*
SD	0.5	0.5	0.5	2.7	2.4	2.1	4.5	4.1	4.2	4.2	3.8	4.2
Min-max	0–5	0–7	0–6	0–21	0–27	0–13	0–21	0–23	0–24	0–17	0–17	0–20
Surfaces restored dental amalgam												
Mean value	11.5	10.8	9.9*	25.4	25.1	25.3	16.6	15.8	17.5	13.4	9.8*	11.9
SD	8.7	8.2	7.5	14.0	13.4	13.1	15.3	13.7	13.9	15.1	10,3	11.6
Min-max	0–38	0–55	0–45	0–65	0–67	0–67	0–73	0–59	0–59	0–91	0–43	0–52
Surfaces restored composite resins												
Mean value	5.5	5.4	6.1	14.3	11.6	12.6	11.3	10.2	11.6	9.4	7.4	8.7
SD	6.2	6.4	7.1	10.3	9.7	10.1	10.2	8.3	8.7	8.2	7,2	7.9
Min-max	0–43	0–44	0–57	0–53	0–58	0–56	0–63	0–48	0–41	0–40	0–43	0–43
Surfaces restored glass-ionomer cements												
Mean value	0.1	0.4‡	0.5‡	0.1	0.6‡	0.7‡	0.1	0.8‡	0.8‡	0.1	1.1‡	1.0‡
SD	0.4	1.1	1.3	0.3	1.8	1.7	0.3	1.7	1.5	0.5	2.3	1.9
Max-min	0–3	0–13	0–13	0–2	0–17	0–14	0–2	0–14	0–10	0–6	0–15	0–12

*P<0.05 and P≥0.01; †P<0.01 and P≥0.001; ‡P<0.001.

Discussion

This study shows that clinical registrations drawn from the EDPRs at present do not accurately present basic oral health indicators among adults in a community.

The county of Västerbotten has a total population of approximately 250,000 inhabitants, 190,000 of whom are adults (≥20 years old). The PDS in Västerbotten offers regular dental care to all children and adolescents up to 19 years of age and to approximately half of all adults. The PDS is therefore the major provider of dental care in Västerbotten. In order to control for selection bias (dental status among PDS patients versus dental status in those in the private dental sector) we performed an analysis of the selected variables in the population sample between those who received their dental care in the PDS and those in the private dental sector, and found no systematic statistically significant differences. The clinical registrations collected from the EDPRs had been done during normal treatment and as part of daily PDS routines. Neither the dentists nor the chair-side assistants had any prior knowledge about the present study. The outcome can therefore be considered to represent normal processes in dental record registrations in the PDS. The equal distribution between men and women among patients in both the PDS and the population survey indicates that there was no bias related to gender in the analysed study populations.

In studies of this nature, drop-outs can severely affect interpretation of the results. Since there was reason to believe that subjects with complete removable dentures may have been over-represented among those who did not participate in the clinical examination in the epidemiological survey an analysis was done based on reported presence of removable dentures in the questionnaire. The comparison was done between the 768 subjects with both a complete clinical examination and a completed questionnaire and the 219 subjects who had only answered the questionnaire. No statistically significant difference was found for reported presence of removable dentures between the two samples at any age. The results

drawn from the epidemiological sample can therefore be considered to be representative of the oral health in the selected indicator age groups.

One advantage with well-planned, well-conducted and well-controlled epidemiological surveys is that the examiners are calibrated to the variables selected, and able to depict health patterns in a population. A study that compared trained dental examiners with general dental practitioners found a more consistent pattern in classifying teeth as decayed among the trained examiners, but concluded that it would be feasible to gather dental epidemiological information for adults with the aid of examiners in general dental practice (10). In one study in children, examinations by epidemiologists following recommendations of the British Association for the Study of Community Dentistry and by dental officers not following these recommendations showed a very high level of agreement and it was concluded that data collected at routine dental inspections on large samples may be adequate for the studied age group (15).

Studies on the quality of dental records have reported several weaknesses and presence of inadequate information in dental records (3, 9, 11). In this study we found that even though the Swedish version T4 of the Dental Practice Management System includes the possibility to register periodontal conditions such as pocket depth, this information was generally not provided and could consequently not be used for comparisons. Assessments of temporomandibular disorders, muscle pain and jaw mobility are important health indicators but are not included in the T4 system and could therefore not be compared with the results in the survey. Despite several factors that can influence the results in the EDPRs, it is our opinion that a major factor for the statistically significant differences found between the population sample and the dental record sample was registration of number of teeth. Where the dentist/chair-side assistant did not mark lost teeth the program automatically gave the subject 32 teeth. The study strongly indicates that the dentist's general choice was to skip this registration in patients with partial or complete dentures. Minor adjustments in the software programs to enable easy registration of edentulous jaws, and feed-back reports serving as controls would significantly improve these EDPR systems to be used for monitoring dental health patterns among those who attend dental clinics for examination and treatment. This quality improvement seems to be within reach in the near future and at a reasonable cost.

The significantly lower prevalence of registrations of Sec-DS in the EDPRs as compared with the epidemiological sample is interesting. The result may suggest that the dentists' registrations in the PDS have involved not only an observation but also, clinical decision-making over whether to restore the observed defect or not, while the research teams have merely reported the observation. These types of conscious processes may skew measurements based on digital records, presenting a more dentally healthy population. For matters of health planning and related allocations of resources, results based on general practitioners' registrations may be relevant, but not to determining oral health. A change in financing systems, from fee-for-service payment to capitation, may also involve difficulties in interpreting changes over time, based on registrations in the EDPRs, since these symptoms seem to affect the dentist's clinical decision-making (4).

Tooth mortality, number of sound teeth, DFS and DS are all very basic indicators of oral health. Electronic dental patient record systems may be used to follow changes in a population and they are cost-effective. The present study, however, shows that these systems can at present not be used for such purposes since the quality of registered data is not good enough. Steps should be taken to improve the control of registered data so that these data could be used to monitor and follow changes in oral health patterns among patients. It should be emphasized that the requirement for high quality of registrations in digital journals involves costs related to the time needed to assure accuracy.

Acknowledgements

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References

1. Bäckman B, Crossner CG, HolmAK. Reduction of caries in 8-year-old Swedish children between 1967 and 1979. Community Dent Oral Epidemiol 1982; 10: 178–81.
2. Clarkson JE, Worthington HV, Holloway PJ. Adult dental surveys: a different approach. Community Dent Health 1995; 12: 65–9
3. Helminen SE, Vehkalahti M, Murtomaa H, Kekki P, Ketomaki TM. Quality evaluation of oral health record-keeping for Finnish young adults. Acta Odontol Scand 1998; 56: 288–92.
4. Johansson V, Axtelius B, Söderfeldt B, Sampogna F, Lannerud M, Sondell K. Financial systems' impact on dental care; a review of fee-for-service and capitation systems. Community Dent Health 2007; 24: 12–20.

5. Kelly K, Gelbier S, Gibbons D. A comparison between the findings of a routine school dental inspection and epidemiological data from the same five year old children. Communit Dent Health 1989; 6: 233–8.
6. Källestål C, Holm AK, Ollinen P. Dental health in 13-year-olds in Västerbotten County, Sweden. Changes over twenty years. Swed Dent J 1990; 14: 193–200.
7. Leake JL, Werneck RI. The use of administrative databases to assess oral health care. J Public Health Dent 2005; 65: 21–35.
8. Melfi CA. Using databases for studying and comparing health care costs and resource use. Pharmacoepidemiol Drug Saf 2001; 10: 399–402.
9. Morgan RG. Quality evaluation of clinical records of a group of general dental practitioners entering a quality assurance programme. Br Dent J 2001; 191: 436–41.
10. Nuttall NM, Clarkson JE. Can dental epidemiological information be gathered during routine dental examinations by general dental practitioners? Community Dent Health 2005; 22: 101–5.
11. Osborn JB, Stoltenberg JL, Newell KJ, Osborn SC. Adequacy of dental records in clinical practice: a survey of dentists. J Dent Hyg 2000; 74: 297–306.
12. Stecksen-Blicks C, Holm AK, Mayanagi H. Dental caries in Swedish 4-year-old children. Changes between 1967 and 1987. Swed Dent J 1989; 13: 39–44.
13. Wänman A, Wigren L. Need and demand for dental treatment. A comparison between an evaluation based on an epidemiologic study of 35-, 50-, and 65-year-olds and performed dental treatment of matched age groups. Acta Odontol Scand 1995; 53: 318–24.
14. Wänman A. The relationship between muscle tenderness and craniomandibular disorders: a study of 35-year-olds from the general population. J Orofac Pain 1995; 9: 235–43.

Address:
Dr Anders Wänman
Department of Odontology/Clinical Oral Physiology
Faculty of Medicine, Umeå University, Umeå, Sweden
E-mail: anders.wanman@odont.umu.se

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Psychosocial work environment related health in Swedish oral and maxillofacial surgery in comparison with other human service workers

GÖRAN PILGÅRD[1,2,3], BJÖRN SÖDERFELDT[2], KARIN HJALMERS[2], JAN ROSENQUIST[2]

Abstract

◎ The aims of this study were: to describe how the employees of OMFS clinics in Sweden perceive their health, to compare with female unpromoted general practice dentists and other human service groups and to explore the dimensionality of the health measure.

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

The results showed that employees of OMFS clinics in Sweden perceived their health as rather problematic. In comparison, the present study group placed itself between general practice dentists and other human service groups as to their health.

Three factors explained more than half of the variance of symptoms. They were interpreted as: (1) psychosomatic troubles, (2) somatic troubles, and (3) muscle and joint troubles. These factors were almost the same as previously reported, confirming the basic dimensionality of the question battery.

This study has shown that OMFS employees are feeling unhealthy, but no worse than other high-risk-groups in human service working situation and better than female general practice dentists. The women among OMFS employees felt worse than the men. Three factors of symptoms could be established, i.e. psychosomatic troubles, somatic troubles, and muscle and joint troubles.

Key words

Physical and social work environment, psychosocial work environment, maxillofacial surgery.

[1]Department of Oral Public Health, Faculty of Odontology, Malmö University, Sweden
[2]Department of Oral Surgery, Faculty of Odontology, Malmö University, Sweden
[3]Department of Oral and Maxillofacial Surgery, Borås hospital, Sweden

Psykosocial arbetsmiljörelaterad hälsa bland svenska käkkirurgiska kliniker i jämförelse med andra anställda med liknande arbetssituation

GÖRAN PILGÅRD, BJÖRN SÖDERFELDT, KARIN HJALMERS, JAN ROSENQUIST

Sammanfattning

◎ Frågeställningen i denna studie var att beskriva hur medarbetarna på käkkirurgiska kliniker i Sverige upplevde sin hälsa jämfört med kvinnliga obefordrade distriktstandläkare och andra human service grupper.

Frågeformuläret innehöll 67 frågor. De avsåg kvalitetsarbete på kliniken, hälsa, arbete, arbetsklimat, arbetssituation, professionen, frågor om innebörden av det goda arbetet, sambandet mellan arbetsmiljö och hälsa, vikten av arbetsmiljön, hälsa och stöd. Huvuddelen av frågorna var hämtade från andra undersökningar men det fanns också några originalfrågor. 22 kliniker med 297 medarbetare svarade vilket innebar 65 % av klinikerna och 86 % av medarbetarna.

Resultatet visade att medarbetare på käkkirurgiska kliniker i Sverige upplever sin hälsa som ganska problematisk. I jämförelse med andra grupper placerar man sina besvär mellan kvinnliga distriktstandläkare och andra human service grupper.

Tre faktorer förklarar mer än hälften av skillnaden av symptomen. Faktorerna tolkades som (1) psykosomatiska besvär, (2) somatiska besvär, och (3) muskel- och ledbesvär. Dessa faktorer var samma som andra författare rapporterat vilket bekräftar frågebatteriet.

Till dessa resultat kan läggas frågor om sjukskrivning, ergonomiska problem, utbildning i ergonomi och psykosociala arbetsmiljön.

Denna studie har visat att medarbetare på käkkirurgiska kliniker inte mår helt bra, dock inte sämre än andra högriskgrupper inom human service arbeten och bättre än kvinnliga distriktstandläkare. Kvinnorna på käkkirurgiska kliniker mår sämre än männen. Tre faktorer av symptom kunde definieras nämligen psykosomatiska besvär, somatiska besvär och muskel- och ledbesvär.

Introduction

It is important for most employees to have a good work environment. There are many different aspects of work affecting the employee physically and mentally [23]. They include, for example, noise, air quality, chemical hazards and machinery, as well as organizational conditions such as work load, working hours, leadership, social contacts, variation, and the possibility of "rest and recovery". A good work environment contributes to good health and means more than the absence of illness and accidents [15]. A good work environment is also characterized by the possibility of influence, freedom of action and development, variety, cooperation, and social contacts [15].

Quality development usually includes both physical and social work environment as well as general environment. Satisfied patients and clients (quality), happy co-workers (social environment), and resource economy are intended to be the results of quality development. There is also a relationship between several work environment related factors and quality [3]. To be able to perform good work, the employees must feel engagement, responsibility and pride in their profession.

Psychosocial work environment is a central area of interest in social and behavioural sciences, mirroring the importance of work for the well-being of people. However, this research has mainly been done with regard to industrial labour. There is another major type of labour, human services, where there is a lack of studies of psychosocial work environment and health.

The basic characteristic of human service work is that it receives and deals with individual human beings. The core of the work is human contact. This holds both for the health and the educational systems as well as for social services in general [9].

Human service organizations, HSOs, often have vague and varying practices in relatively loose structures:

> "Structural elements are only loosely linked to each other and to activities, rules are often violated, decisions are often unimplemented, or if implemented they have uncertain consequences, technologies are of problematic efficiency and so vague as to provide little coordination" [17].

It is plausible that the looseness and role conflicts in HSO:s in themselves may lead to stress, detrimental for health. In case studies, health problems in HSO contexts have been documented [1, 2, 6, 8, 10, 12 – 14].

Dental work involves high psychological stress [20]. *Hjalmers et al* [10] reported that female unpromoted general practice dentists in Public Dental Health Service (PDHS) suffered from many physical and mental troubles linked to the working situation. Several reports have shown that dentists [5, 7, 10, 11], have a difficult work situation. Only one study has investigated specialist dentists in this respect [21]

Oral and Maxillofacial Surgery (OMFS) is a dental speciality; the surgical treatment of pathological lesions and malformations of the jaws and surrounding tissues. It comprises minor procedures such as dentoalveolar surgery, and major procedures such as orthognatic surgery, temporo-mandibular joint surgery, traumatology and reconstructive surgery [22].

A previous study was performed analysing ideals and reality concerning the content of healthy work. The employees of OMFS clinics in Sweden emphasized free, influential, and intellectually stimulating work, but the perceived discrepancy between ideal and reality was rather wide, even if this discrepancy was generally wider among unpromoted female general practice dentists than among OMFS employees [19].

Aims

The aims of this study were: (i) to describe how the employees of OMFS clinics in Sweden perceive their health, (ii) to compare with female unpromoted general practice dentists and other human service groups and (iii) to explore the dimensionality of the health measure.

Methods

Study base

The material has previously been described by *Pilgård et al.* [18]. A letter explaining the study was sent (January 2002) to all 34 heads of the hospital based OMFS clinics in Sweden (including one prosthetic clinic). If the heads agreed to participate, they were asked to acknowledge their participation by returning a list of names of their staff. Then a questionnaire was distributed to each individual staff member during April 2003. All employees at the clinics were involved. After completion of the questionnaire, the employees returned their response directly to the Department of Oral Public Health, Malmö University. The study was approved by the Research Ethics Committees (March 2003). The study design is reported in detail elsewhere [18].

Of the 34 clinics, four clinics never responded and another five declined participation. Three addi-

tional clinics declined participation when the questionnaires were sent out. Altogether 22 clinics (65 %) participated in the study. Questionnaires were distributed to 453 persons at the 25 clinics. 40 persons had either left the clinic or had other duties and 66 worked at clinics that later declined participation. Of the remaining 347 persons, the net sample, 50 did not return the questionnaires and thus 297 persons responded, i.e. 86 % [18].

For comparisons, personnel in two other organizations, namely the Social Insurance Organization, (SIO), [25, 27] and highly specialized Children's Clinics in the public general health care, (CC), [26] have been used in this study. Data were available there with exactly the same questions as in the present study. These organizations have the human service orientation in common with the OMFS clinics. Another comparison has been made with unpromoted female dentists [10]. By courtesy of FSF Metod Inc., a reference material consisting of 12128 persons in various occupations was also made available. This material represents a relatively average population of working Swedes, although with a tendency towards overrepresentation of symptoms since the data have been accumulated in various series of occupational health service studies. FSF Metod data refer to the time period 1996 – 2000 [10].

Questionnaire

The questionnaire consisted of 67 questions. They concerned quality management at the clinic, health, work, working climate, working situation, profession, questions about the content of healthy work, the connection between physical environment and health, emphasis on physical environment, health and support. The main part of the questionnaire was from the SIO-study [25, 27], the *Bejerot-study* [4], and *Hjalmers et al* [10] but there were also some original questions.

A battery of questions related to psychosomatic health aspects was included. The formulation of the questions can be found in the tables, where relevant comparisons with SIO, CC and *Hjalmers et al* [10] were made when the questions were identical. There were five frequency oriented response alternatives ranging from 1 (almost never) to 5 (almost always). Marking 3 or more would be interpreted as having troubles.

Statistical methods

The data were first presented in frequency tables. Principal components analysis (PCA) was then used on the raw scores of the questions using the *Kaiser* criterion and inspection of screen plots for determination of the number of factors. The factor solution was varimax rotated [16]. For some statistical analyses t-test was used. All data were processed in the statistics programme SPSS 11.0.

Results

The responses for all employees of OMFS clinics in Sweden are shown in Tables 1-6.

In Tables 1-3, the percentages of persons with reported troublesome symptoms are shown item for item for OMFS personnel, Table 1 concerns all employees, Table 2 only maxillo-facial surgeons and Table 3 only dental nurses and assistant nurses. Tables 1-3 include comparison values to the unpromoted female dentists [10].

A principal components analysis was performed on the raw scores and is presented in Table 4. Three

Table 1. Reported symptoms in percent (%) for OFMS personnel (295 ≤ n ≤ 296). In brackets unpromoted female dentists (167 ≤ n ≤ 170) [10].

How often do you ...	Almost never				Almost always	
	1	2	3	4	5	3-5
feel tired without reason?	23 (7)	37 (23)	30 (36)	10 (28)	1 (7)	41 (70)
suffer from headache?	36 (24)	39 (37)	20 (26)	3 (13)	1 (1)	24 (40)
suffer from eye-tiredness?	34 (33)	33 (28)	19 (22)	11 (15)	3 (3)	33 (40)
have sleep disturbances?	31 (29)	36 (20)	22 (28)	8 (16)	3 (7)	23 (51)
feel anxious, worried or nervous?	34 (17)	45 (37)	19 (28)	2 (15)	0 (3)	21 (46)
feel low-spirited, uneasy or sad?	31 (16)	46 (38)	22 (32)	1 (11)	0 (3)	23 (46)
have troubles from the stomach?	47 (39)	33 (25)	14 (20)	5 (11)	2 (5)	21 (36)
suffer from back, neck or shoulder pain?	17 (7)	28 (18)	30 (28)	18 (20)	8 (28)	56 (76)
suffer from pain from other joints?	44 (29)	29 (24)	14 (24)	10 (15)	4 (8)	28 (47)
suffer from numbness in the hands?	59 (46)	21 (21)	13 (21)	5 (9)	2 (2)	20 (32)
suffer from "white fingers"?	74 (62)	17 (16)	5 (16)	3 (6)	2 (1)1	0 (23)

Table 2. Reported symptoms in percent (%) for *maxillo-facial surgeons* (n = 95). In brackets unpromoted female dentists (167 ≤ n ≤ 170) [10].

How often do you ...	Almost never			Almost always		
	1	2	3	4	5	3-5
feel tired without reason?	23 (7)	35 (23)	31 (36)	11 (28)	1 (7)	43 (70)
suffer from headache?	39 (24)	45 (37)	14 (26)	0 (13)	2 (1)	16 (40)
suffer from eye-tiredness?	43 (33)	32 (28)	10 (22)	15 (15)	1 (3)	26 (40)
have sleep disturbances?	26 (29)	35 (20)	24 (28)	10 (16)	5 (7)	39 (51)
feel anxious, worried or nervous?	31 (17)	48 (37)	16 (28)	5 (15)	0 (3)	21 (46)
feel low-spirited, uneasy or sad?	32 (16)	43 (38)	22 (32)	3 (11)	0 (3)	25 (46)
have troubles from the stomach?	53 (39)	28 (25)	15 (20)	3 (11)	1 (5)	19 (36)
suffer from back, neck or shoulder pain?	18 (7)	37 (18)	22 (28)	16 (20)	7 (28)	45 (76)
suffer from pain from other joints?	48 (29)	31 (24)	8 (24)	12 (15)	1 (8)	21 (47)
suffer from numbness in the hands?	66 (46)2	0 (21)	10 (21)	3 (9)	1 (2)	14 (32)
suffer from “white fingers”?	82 (62)	14 (16)	1 (16)	3 (6)	0 (1)	4 (23)

Table 3. Reported symptoms in percent (%) for *dental nurses and assistant nurses* (159 ≤ n ≤ 160). In brackets unpromoted female dentists (167 ≤ n ≤ 170) [10].

How often do you ...	Almost never			Almost always		
	1	2	3	4	5	3-5
feel tired without reason?	21 (7)	38 (23)	30 (36)	9 (28)	1 (7)	40 (70)
suffer from headache?	35 (24)	35 (37)	24 (26)	5 (13)	1 (1)	30 (40)
suffer from eye-tiredness?	33 (33)	32 (28)	23 (22)	8 (15)	5 (3)	36 (40)
have sleep disturbances?	34 (29)	37 (20)	19 (28)	8 (16)	2 (7)	29 (51)
feel anxious, worried or nervous?	38 (17)	44 (37)	18 (28)	1 (15)	0 (3)	19 (46)
feel low-spirited, uneasy or sad?	30 (16)	49 (38)	20 (32)	1 (11)	0 (3)	21 (46)
have troubles from the stomach?	47 (39)	35 (25)	12 (20)	4 (11)	2 (5)	18 (36)
suffer from back, neck or shoulder pain?	18 (7)	22 (18)	36 (28)	18 (20)	7 (28)	61 (76)
suffer from pain from other joints?	41 (29)	28 (24)	18 (24)	8 (15)	6 (8)	32 (47)
suffer from numbness in the hands?	54 (46)	21 (21)	16 (21)	6 (9)	2 (2)	24 (32)
suffer from “white fingers”?	68 (62)	19 (16)	8 (16)	2 (6)	3 (1)	13 (23)

Table 4. PCA of reported symptoms. Factor loadings >0.30. Major loadings in boldface type.

Communalities	Variables	F1	F2	F3
0.71	feel anxious, worried or nervous	**0.84**		
0.71	feel low-spirited, uneasy or sad	**0.81**		
0.55	have sleep disturbances	**0.72**		
0.54	feel tired without reason	**0.59**	0.45	
0.48	suffer from eye-tiredness	**0.46**	0.41	0.32
0.60	suffer from headache		**0.73**	
0.70	suffer from back, neck or shoulder pain		**0.71**	0.45
0.47	have troubles from the stomach		**0.65**	
0.65	suffer from numbness in the hands			**0.80**
0.65	suffer from “white fingers”			**0.65**
0.54	suffer from pain from other joints		0.36	**0.63**
	Variance explanation (%)			
	Total 58.3 %			

factors (F1, F2 and F3) explained more than half of the variance (58 %). In loading plots they formed three well-defined vector clusters. The factors are arranged in order in Table 4.

In the interpretation of the factors, the items for Fl were regarded as psychosomatic troubles. Five questions were included, feel anxious, worried or nervous, feel low-spirited, uneasy or sad, have sleep disturbances, feel tired without reason, and suffering from eye-tiredness.

F2 was defined as a factor for somatic troubles. This factor included three questions. The variables contained aspects of suffering from headache, from back, neck, or shoulder pain and having troubles from the stomach.

F3 was defined as a factor for muscle and joint troubles. This factor also included three questions. Here the variables contained suffering from numbness in the hands, suffering from "white fingers" and from pain from other joints.

With t-test, the differences between maxillofacial surgeons and dental nurses and assistant nurses were significant as to muscle and joint trouble ($p<0.05$). The differences were also significant between men and women both as to muscle and joint trouble and somatic troubles ($p<0.05$).

There were also data about feeling sick in the questionnaires. In Table 5, a comparison was made between the three samples that were available, i.e. the employees of OMFS clinics, maxillofacial surgeons, dental nurses and assistant nurses, female dentists [10], the SIO personnel [25, 27] and the Children's Clinic personnel [26].

In addition to these results, there were also questions about the sick-listing, ergonomic troubles, education in ergonomics and psychosocial work

Table 5. Reported frequency of answers of the question "has it any time during the last three months happened that you have gone to work although you have felt ill/sick?", for OMFS personnel, for dentists [10], for personnel in SIO [26] and for personnel in Children's Clinics in the Public Health Care (CC) [25]. For OMFS personnel the question asked for the last 12 months.

	OMFS (n=287)	OMFS Maxillo-facial surgeons (n=95)	OMFS Dental nurses and assistant nurses (n=160)	Unpromoted female dentists (%) (n=170)	SIO (%) (n=3158)	CC (%) (n=352)
Yes, many times	14	17	13	22	10	10
Yes, several times	22	22	19	20	19	22
Yes, once in a while	48	49	50	37	39	49
No	16	12	18	21	32	20

Table 6. Reported differences in troublesome symptoms in percent (%) for OFMS personnel, dentists, personnel in SIO, personnel in Children's Clinics in the Public Health CC versus a normal population FSF.

Symptom item:	OMFS personnel (%) 295 ≤ n ≤ 296	Maxillo-facial surgeons (%) n=95	Dental nurses and assistant nurses (%) 159 ≤ n ≤ 160	Dentists (%) 168 ≤ n ≤ 170	SIO (%) 3150 ≤ n ≤ 3164	CC (%) 341 ≤ n ≤ 343	FSF (%) 5429 ≤ n ≤ 5547
Tired without reason	41	43	40	70	52	45	28
Headache	24	16	30	40	35	31	19
Sleep disturbances	23	39	29	51	43	43	23
Anxious, worried or nervous	21	21	19	46	36	24	12
Low-spirited, uneasy or sad	23	25	21	46	37	31	13
Back, neck or shoulder pain	56	45	61	76	57	51	44
Pain from other joints	28	21	32	47	28	26	22

environment. To the question "Have you been sick-listed at any time during the last 12 months?", 7 % of the maxillo-facial surgeons answered affirmatively. The dental nurses and assistant nurses answered similarly. As to ergonomic troubles during the last 12 months, 15 % of the maxillo-facial surgeons answered affirmatively, and 28 % of the dental nurses and assistant nurses. Only 13 % of the maxillo-facial surgeons and 18 % of the dental nurses and assistant nurses had had any education on ergonomics. To the question concerning how the psychosocial work environment had changed during the last three years, 16 % of the maxillo-facial surgeons answered "much better", 15 % "slightly better", 46 % "neither better or worse", 18 % "rather worse" and 4 % "much worse". For the dental nurses and assistant nurses the results were "much better" 11 %, "slightly better" 15 %, "neither better or worse" 42 %, "rather worse" 27 % and "much worse" 4 %.

In Table 6, responses are stated for the frequency of troubles as defined in the questionnaire. A comparison was made between the seven samples that were available, i.e. the OMFS personnel, maxillo-facial surgeons, dental nurses and assistant nurses, the female dentists [10], the SIO personnel [25, 27], the Children's Clinics personnel [26] and the reference "normal" population (FSF) [10].

Discussion

The results showed that employees of OMFS clinics in Sweden perceived their health as rather problematic. In comparison, the present study group placed itself between general practice dentists and other human service groups as to their health. It was also found that the various health aspects could be reduced to three factors, psychosomatic troubles, somatic troubles, and muscle and joint troubles.

The study group here was employees of OMFS, both maxillo-facial surgeons and dental nurses and assistant nurses. Bejerot showed that gender plays a role in psycho-social work environment [4]. However, gender does not offer an obvious explanation to the noted differences, since two of the comparison populations – SIO and CC – had about 80% women [10]. In this study, out of the 297 respondents, three fourths were women and one fourth men, one third were maxillo-facial surgeons and more than half were dental nurses, with the other groups constituting 16 % [18].

It has previously been shown that self reported psycho-vegetative and musculo-skeletal health may be especially problematic in the SIO organization [25, 27]. Also, personnel in Children's Clinics showed problems of the same character [26], but the health problems among female dentists were many more and displayed also more severe symptoms than the other groups (10). In this study, high prevalences were found for "back- neck- or shoulder-pain" (56%) and for "tiredness without reason" (41%). The dental nurses experienced suffering from "back, neck or shoulder pain" much more than maxillo-facial surgeons, but less than female dentists [10]. The maxillo-facial surgeons' and the dental nurses' experiences of "tiredness without reason" were similar. One fourth of the employees of OMFS suffered from numbness in the hands but only a few from "white fingers". The last two symptoms were not compared to the other groups as SIO and CC, and might be more typical for dentists, who are exposed to high frequency vibrations in their work.

Three factors explained more than half of the variance of symptoms. They were interpreted as: (1) psychosomatic troubles, (2) somatic troubles, and (3) muscle and joint troubles. These factors were almost the same as previously reported [24], confirming the dimensionality of the question battery.

A basic idea of this study was that there are special circumstances concerning work in HSOs that can have adversary effects on health. Still, the differences in reported health held also in relation to the other human service organizations, namely SIO and CC. A possible reason for the special situation for the dentists might be that the focus for the working dentist is efficiency and that the production is imagined to be easily measurable. In a human service organization where you take care of patients, the medical staff is educated, above all, to give care with quality and not to give the economy a priority. In the PDHS today the organizational philosophy is human resource management which focuses on economy, and the dentist's work is measured on a minute level. This reporting system with productivity per minute is dearly bought for the dentists who pay with their health, while they want to fulfil the demands of both the patients and the employers. In Swedish OMFS clinics today this situation is real.

Conclusions

In conclusion, we have shown that OMFS employees are feeling unhealthy, but no worse than other high-risk-groups in human service working situation and better than female general practice dentists. It appears that OMFS is a dental speciality and the work is not quite as stressing as the work of female general

practice dentists. The women of OMFS employees feel worse than the men. Three factors of symptoms could be established.

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References

1. Appels A, Shouten E. Burnout as a risk factor for coronary heart disease. Behav Med 1991, 17:53-9
2. Arnetz BB. White collar stress: What studies of physicians can teach us. Psychother Psychosom 1991, 55:197-200
3. Axelsson JRC. Quality and Ergonomics. Towards successful integration. Linköpings Universitet nr 616, 2000 (Thesis)
4. Bejerot E. Dentistry in Sweden – Healthy work or ruthless efficiency? National Institute for Working Life, Stockholm. Arbete och Hälsa, vetenskaplig skriftserie 1998, 14. Lund University: Department of Dental Public, 1998:14 (Thesis)
5. Bejerot E, Söderfeldt B, Aronsson G, Härenstam A, Söderfeldt M. Perceived control systems, work conditions and efficiency among Swedish: interaction between two sides of human resource management. Acta Odontol Scand 1999, 57:46-54
6. Belcastro PA, Gold RS. Teacher stress and burnout: Implications for school health personnel. JOSH 1983, 53:404-7
7. Bourassa M, des Ormeaux J-M, Desormeaux M, Thanh Thi Dao T. Identification of stress factors in dentistry and suggested coping methods. J Dent Que 1984, 21:11-3
8. Burke RJ. Work-family stress, conflict, coping, and burnout in police officers. Stress Med 1993, 9:171-80
9. Hasenfeld Y. Human service organizations. New Jersey. Prentice Hall inc., Englewood Cliffs, 1983
10. Hjalmers K, Söderfeldt B, Axtelius B. Psychosomatic symptoms among female unprompted general practice dentists. Swed Dent J 2003, 27:35-41
11. Hjalmers K, Söderfeldt B, Axtelius B. Healthy work for female unpromoted general practice dentists; Acta Odontol Scand 2004, 62:107-10
12. Härenstam A. Prison personnel - working conditions, stress, and health. Stockholm: Karolinska Institute, 1989 (Thesis)
13. Landsbergis PA. Occupational stress among health care workers: A test of the job demands - control model. J Org Behav 1988, 9:217-39
14. Lewis SL, Becktell PJ, Bonner PN, Campbell MA, Cooper CL, Hunt WC. Work stress, burnout, and sense of coherence among dialysis nurses. ANNA 1992, 19:545-53
15. Karasek R, Theorell T. Healthy work. Stress, productivity and the reconstruction of working life. New York: Basic Book, inc., Publishers, 1990
16. Kim J-O, Mueller CW. Introduction to factor analysis: What it is and how to do it. Beverly Hills: Sage; 1978
17. Meyer J, Rowan B. Institutionalized organizations: formal structure as myth and ceremony. Am J So 1977, 83:340-63
18. Pilgård G, Rosenquist J, Söderfeldt B. Quality managements in oral and maxillofacial surgery in Sweden. Swed Dent J 2006, 30:117-22
19. Pilgård G, Söderfeldt B, Hjalmers K, Rosenquist J. Dimensions of healthy work for employees in oral and maxillofacial surgery in Sweden. Swed Dent J 2007, 31:147-54
20. Reitemeier B. Psychophysiological and Epidemiological Investigations on the Dentist. Rev Environ Health 1996, 11:57-63
21. Rundcrantz BL. Pain and discomfort in the musculoskeletal system among dentists. Swed Dent J Suppl. 1991, 76:1-102
22. Socialstyrelsens föreskrifter och allmänna råd; Tandläkarnas specialiseringstjänstgöring. SOSFS 1993:4
23. Swedish Work Environment . Systematic work environment management, AFS 2001:1. Swedish Work Environment Authority, Stockholm 2001 (ändrad 2003)
24. Söderfeldt B, Söderfeldt M, Ohlson C-G, Warg L-E. Psychosomatic symptoms in human service work. A study on Swedish Social Workers and Social Insurance Personnel. Scand J Soc Med, 1996, 24:43-9
25. Söderfeldt B. Pers. comm. 2006
26. Söderfeldt M. Undersökning av den psykosociala arbetsmiljön vid barn- och ungdomscentrum, Lunds Universitetssjukhus. Pers. comm. AMI, Danmark, 2001
27. Söderfeldt M, Axtelius B, Söderfeldt B, Unell L. Demand and control in human service work in relation to selfrated oral health. Community Dent Health, 2002, 19:180-85

Address
Dr Göran Pilgård
Public Dental Health Service, Västra Götaland
Ekenäsgatan 15, Plan 7
SE-504 55 Borås, Sweden
E-mail: goran.pilgard@vgregion.se

Bond strength between different bonding systems and densely sintered alumina with sandblasted surfaces or as produced

EVAGGELIA PAPIA, PER VULT VON STEYERN

Abstract

◎ The traditional zinc phosphate cementation technique for crowns and fixed partial dentures (FPDs) is based on mechanical retention where the geometry of the prepared tooth provides retention for the restoration. In clinical situations where mechanical retention is compromised or regarded insufficient, a bonding system can be used to provide retention.

This study investigates whether bond strengths of different bonding systems to densely sintered high-strength alumina ceramics are sufficient. One hundred twenty pairs of industrially manufactured specimens – one block and one cylinder-shaped disc of densely sintered alumina – were used. The cementation surfaces of the blocks were sandblasted with 110-µm aluminium oxide while the cementation surfaces of the discs were left untreated, as produced. The pairs were then bonded with one of six different bonding systems. Each bonding group of 20 samples was randomly divided into thermocycled and non-thermocycled subgroups (n=10). Both subgroups were stored 1 week in distilled water (37°C). During this week, the thermocycled subgroup underwent 5000 thermocycles (5°C –55°C). Following pre-treatment, the specimens were loaded until fracture in a universal testing machine to determine shear bond strength. Data were analysed using student's t-test and a one-way ANOVA. Fractured interfaces were examined under a light microscope to classify the failure mode of the debonded area as adhesive, cohesive, or a combination of the two. The highest bond strengths, achieved with two of the bonding systems, were significantly higher than the remaining bonding systems, irrespective of pre-treatment – ($p>0.001$). The predominant failure mode for both treated and untreated surfaces was adhesive.

Two of the six tested bonding systems achieved sufficient shear bond strength to densely sintered alumina. Furthermore, recommendations on whether to use surface-treated or as produced densely sintered alumina must be based on which bonding system is being used.

Key words

Dental ceramics, aluminium oxide, resin cement, shear strength, surface treatment

[1]Department of Prosthetic Dentistry, Faculty of Odontology, Malmö University, Malmö, Sweden

Bindningsstyrkan mellan olika adhesiva cement och sandblästrad respektive obehandlad aluminiumoxid

EVAGGELIA PAPIA, PER VULT VON STEYERN

Sammanfattning

◎ Traditionella cementeringstekniker förutsätter att makromekanisk retention kan uppnås mellan den preparerade tanden och rekonstruktionen. I kliniska situationer där den mekaniska retentionen är otillräcklig kan det emellertid vara nödvändigt att använda sig av adhesiv cementeringsteknik. Syftet med denna studie var att i en simulerad oral miljö undersöka om en tillräcklig och hållbar bindningsstyrka kan uppnås mellan olika adhesiva cementsystem och en tätsintrad aluminiumoxidbaserad oxidkeram.

Industriellt framställda provkroppar (120 stycken par), block och cylinder av tätsintrad alumina användes i studien. Samtliga block sandblästrades med 110µm Al2O3 medan tillhörande cylinder bevarades så som de levererats från fabrikanten. Sex cementsystem som rekommenderades av olika fabrikanter för adhesiv cementering av oxidkeramer valdes ut. Varje grupp bestod av 20 stycken provkroppar som i sin tur var indelade i två undergrupper, icke termocyklade (n=10) och termocyklade (n=10). Provkropparna i båda undergrupper förvarades efter cementering i destillerat vatten (37oC) i en vecka. Under denna vecka utsattes provkropparna i termocyklingsgruppen för termocyklisk belastning, 5000 termocykler (5oC -55oC). Efter förvaring utsattes respektive grupp för skjuvkraftstest för att fastställa bindningsstyrkan. Erhållen data analyserades med student´s t-test och one-way ANOVA. Brottytorna undersöktes med mikroskop för att fastställa typ av brott; adhesivt, kohesivt eller en kombination av dem båda.

Bindningsstyrkan för de två cement som uppvisade högst värden var signifikant högre än bindningsstyrkan för övriga cement oavsett termocykling eller ej (p>0.001). Den huvudsakliga typen av brott för både sandblästrade och icke behandlade ytorna var adhesivt.
Två av sex undersökta adhesiva cement uppvisade kliniskt acceptabel bindning till tätsintrad aluminiumoxid. Rekommendationer om huruvida blästring skall föregå cementering, eller om ytan skall lämnas obehandlad, bör emellertid baseras på vilket cementsystem som skall användas.

Introduction

All-ceramic restorations have become increasingly popular in recent decades. Some reasons are the introduction of high-strength core materials that can be used for both anterior and posterior restorations (2,10,18,19,23,30,31,44). Development of various all-ceramic systems based on polycrystalline oxide ceramics and special manufacturing technologies have maximised strength while the development of superior aesthetics by veneering with feldspathic porcelain has been maintained (10,18,19,21,23). Densely sintered alumina (Al_2O_3) is one of these high-strength ceramics with significantly improved mechanical properties compared to silica-based ceramics and glass-ceramics (31,44). Studies of Al_2O_3-based systems have shown clinical results similar to those of porcelain fused to metal (PFM) (19,31,39,44).One system that is based on densely sintered high-purity Al_2O_3 is produced by computer-aided design/computer-aided manufacturing (CAD-CAM) techniques (Procera® Alumina, Nobel Biocare, Gothenburg, Sweden) (1,10,31,44). Cores for crowns and fixed partial dentures (FPDs) made of this material are subsequently veneered with a specially developed feldspathic porcelain (Procera®Rondo Alumina, Nobel Biocare, Gothenburg, Sweden).

Bonding techniques are generally recommended for all-ceramic restorations and can provide the restoration higher strength compared with zinc phosphate cemented restorations (5,14). For the bond to be sufficiently strong, the seating surface of the restoration must be enlarged. Such surface enlargement is generally created by etching with solutions of hydrofluoric acid. The surface roughness created by the etching promotes mechanical interlocking of the luting agent to the treated surfaces. Another factor that influences adhesion between the resin and the ceramic surface is the chemical bond created by silanisation. This technique using acid etching and silane coupling agents was primarily designed for silica-based ceramics (8,9,36,37). The composition and physical properties of polycrystalline oxide ceramics differ, however, substantially from those of silica-based ceramics as acid etching does not enlarge oxide ceramic surfaces (2,7,8,40). Furthermore, it is generally acknowledged that because pure crystalline alumina ceramics lack a silica-containing matrix, chemical bonds cannot be established between such ceramics and silane (2,4,5). For this reason traditionally cementation techniques, relying on macromechanical retention gained from the geometry of the preparation, have been recommended for oxide ceramics (1,19,34,43,44).

In some cases of compromised retention, such as short clinical crowns or ceramic veneer reconstructions, it might be beneficial to adapt adhesive bonding (4,7,15). Hence, contemporary research has focused on obtaining a durable bond to oxide ceramics with adhesive cements. Different bonding systems contain a variety of monomers and oligomers such as dimethacrylate (Bis-GMA) and 2-hydroxyethyl methacrylate (HEMA). Bonding systems vary in:

- composition (one-paste or two-paste system)
- curing (chemical-cured, light-cured, or dual-cured)
- type and amount of filler (e.g., nano, micro, and hybrid)
- viscosity (low, medium, or high) (5,12,29)

Other differences include the physical and chemical properties of the cement, which in turn depend upon degree of conversion, that is, how many of the reactive sites on the polymer chains were utilised in the setting reaction (12,13,29).

Newly developed techniques have promoted mechanical interlocking by sandblasting the seating surfaces (4,5) or by silica coating (22,25,32) in combination with phosphate monomer-based cements (10-methacryloyloxydecyl dihydrogen phosphate, MDP) (4,10,19,40). The durability of such bonds, and the underlying mechanisms, are, however, unclear (4,7). Hence further investigations are needed into techniques for obtaining durable bonding between oxide ceramics and different bonding systems.

Aim

The aim of the present study was to investigate, in a way that reflects the clinical situation regarding environmental influence, whether sufficient and durable shear bond strengths (>20MPa) (16,29) can be established between different bonding systems and densely sintered alumina as produced (untreated) or sandblasted. The null hypothesis was that there is no difference between the shear bond strength achieved with the different bonding systems or different surfaces used in the study.

Materials and Methods

In this study, 120 pairs of industrially manufactured specimens – one block (9.6 x 9.6 x 5.0 mm) and one cylinder disc (diameter: 6.0 mm; thickness: 2.0 mm) of densely sintered Al_2O_3 (PROCERA® Alumina, Nobel Biocare AB, Göteborg, Sweden) – were used (Fig 1).

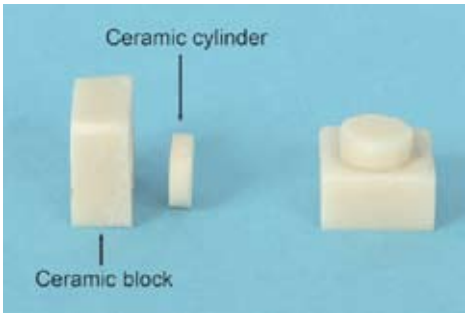

Figure 1. The specimen, a block and cylinder of densely sintered alumina.

The cementation surface of all the blocks were cleaned with acetone (Apoteksbolaget AB, Göteborg, Sweden) and then sandblasted with 110-µm Al_2O_3 particles (Aloxcobra, Renfert GmbH, Hilzingen, Germany) for 10 seconds with an air pressure of 5 bars and a distance of 100 mm between the surface of the sample and the blasting tip. The tip of the blaster was gently moved in circles at about a 70° angle to the surface. After sandblasting, the samples were ultrasonically cleaned in 96% isopropanol (Apoteksbolaget AB, Göteborg, Sweden) for 5 minutes. The cylinder-shaped samples were not sandblasted but were stored as when they were received from the manufacturer and subsequently cleaned in

Table 1. Bonding systems.

System with belonging components	Abbreviation	Type	Manufacturer	BatchNo./LOT
VARIOLINK® II	**VA**	Bis-GMA based resin*	Ivoclar Vivadent AG/ FL-9494 Schaan/ Lichtenstein	
Monobond-S, primer agent		Dual-cured		D51336
Heliobond, porcelain primer		Two-paste system		D68417
Varolink® II, Base + Catalyst, (T)			D20542 + D17352	
Liquid Strip				D50843
BISCO CHOICE™	**BC**	Bis-GMA based resin	Bisco Inc/ Schaumburg, IL 60193/ USA	
BISCO PORCELAIN PRIMER		Dual-cured		0200007636
ONE-STEP® Univ. dental adhesive		Two-paste system		0100012867
CHOICE™ Porcelain Adhesive Paste Base (translucent) + Catalyst			0100014108	0100014106 +
BISCO ILLUSIONTM	**BI**	Bis-GMA based resin	Bisco Inc/ Schaumburg, IL 60193/ USA	
BISCO PORCELAIN PRIMER		Dual-cured		0200007636
ONE-STEP® Univ. dental adhesive		Two-paste system		0100012867
ILLUSION™ Porcelain Adhesive Paste Clear Base + Clear Catalyst				0100014248 + 0100013914
NEXUS 2™	**NE**	Bis-GMA based resin	Kerr Corporation/ Orange, CA 92867/ USA	
Silane Primer		Dual-cured		010381
NEXUS 2™ Base Clear + Catalyst		Two-paste system		010435 + 010440
3M™ ESPETM RelyX™ Veneer Cement	**RV**	TEGDMA**/ Bis-GMA based resin	3M ESPE/ St. Paul, MN 55144/ USA	
3M™ RelyX™ Ceramic Primer		Light-cured		20020716
3M™ Scotchbond™ 1, adhesive		One-paste system		20020620
3M™ ESPE™ RelyX™ Veneer Cement (TR)				20011019
PANAVIA™ F	PF	Phosphatemonomer based resin (MDP)***	KURARAY MEDICAL INC/ Okayama 710-8622/ Japan	
CLEARFIL™ PORCELAIN SE BOND ACTIVATOR				0563B
CLEARFIL™ SE BOND PRIMER		Dual-cured		00120B
PANAVIA™ F A Paste		Two-paste system		00050A
PANAVIA™ F B Paste (TC)				00029A
PANAVIA™ F OXYGUARD II				00433A

* Bis-GMA= Bisphenol-A-diglycidylmethacrylate **TEGDMA =***MDP =10-methacryloloyloxydecyl-dihydrogenphosphate

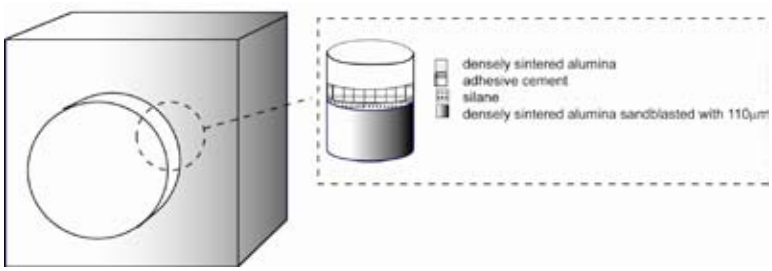

Figure 2. Schematic figure of the specimen and a close-up of the different surfaces and layers in the bonding system.

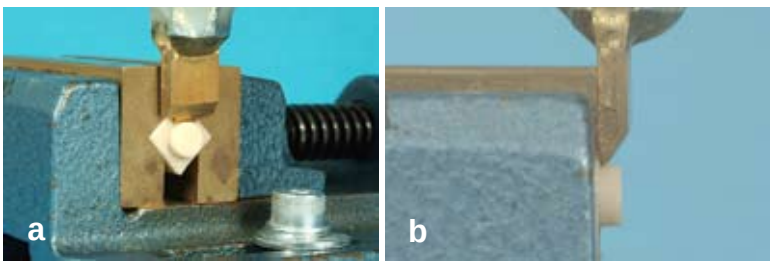

Figure 3.
a. The specimen in the brass holder during the shear bond test with a knife-edged blade operating parallel to the bonded surfaces.
b. Close-up.

two steps: first with acetone and then ultrasonically in 96% isopropanol for 5 minutes.

Six different bonding systems, which at the time for the study had been recommended by different cement manufactures for adhesive bonding to oxide ceramics, were selected and tested. Table 1 lists the different systems and their characteristics.

The untreated cylinder discs were luted to the prepared blocks with an alignment apparatus that applied a seating load of 15 N during polymerisation. The apparatus ensured a standardised seating load and that the axes of the cylinder-shaped discs were perpendicular to the surface of the block. The cementation procedures were carried out according to the manufacturers' instructions. All materials were mixed and applied by the same operator (Fig 2).

Excess resin was removed from the margin using disposable brushes (Top Dent, DAB Dental AB, Sweden). An oxygen-blocking gel was used according to the manufacturers' instructions if it was part of the bonding system (Table 1). The resin cements were light-cured with a dental curing lamp (Optilux 400, Model VCL 401, Demetron Research Corporation, Danbury, CT, USA) – mean light intensity 300 mW/cm2 – for 40 seconds from four directions 90° apart. The seating load was removed, and light-curing was continued for 60 seconds. Any excess resin was removed with a surgical blade (AESCULAP® no. 12, AESCULAP AG & CO, Tuttlingen, Germany) after polymerisation was complete. In a final step, samples were rinsed with water for one minute to remove oxygen-blocking gel remnants.

Each bonding group of 20 samples was randomly divided into two subgroups (n=10). Both subgroups, non-thermocycled and thermocycled, were stored in 37°C distilled water for 1 week. During this week, the samples in the thermocycled subgroup underwent 5000 thermocycles in a specially constructed thermocycling device. The samples were cycled in two water baths, one at 5°C and one at 55°C. Each cycle lasted 60 seconds: 20 seconds in each bath and 10 seconds for transferring between the baths. Following pre-treatment, shear bond strength was determined in a universal testing machine (Instron model 4465, Instron® Canton, MA, USA) with a knife-edged blade parallel to the bonded surfaces according to previous studies (2,15). The ceramic blocks were placed in a brass holder fixated in the testing machine to maintain their position during testing.

The cross-head speed was 0.5 mm/min. The load at the point of debonding was recorded, and shear bond strength was calculated:

$$C = \frac{F}{\varpi r2}$$

where C is the bond strength (MPa), F is the load (N) at debonding, and r is the radian in mm of the cemented area in mm2. From these data, mean and standard deviation for each group were calculated.

Student's *t*-test and one-way ANOVA were used to determine within-group and between-group differences. The level of significance was set to $\alpha = 0.05$.

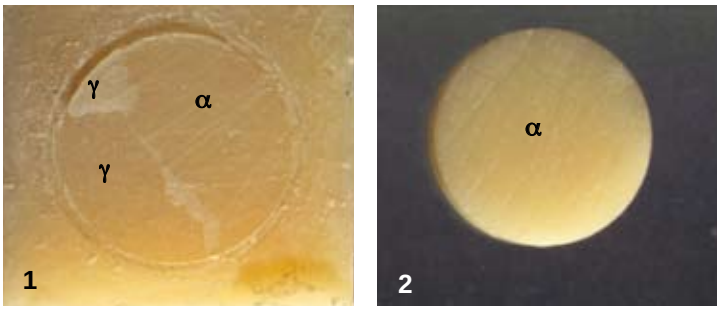

Figure 4. Representative illustration of failure modes α and γ (specimen RelyX™ Veneer, thermocycled subgroup).
1 = treated surface (block),
2 = untreated surface (cylinder)
α = Adhesive failure at the untreated surface, only
γ = Adhesive failure at both the untreated and treated surfaces

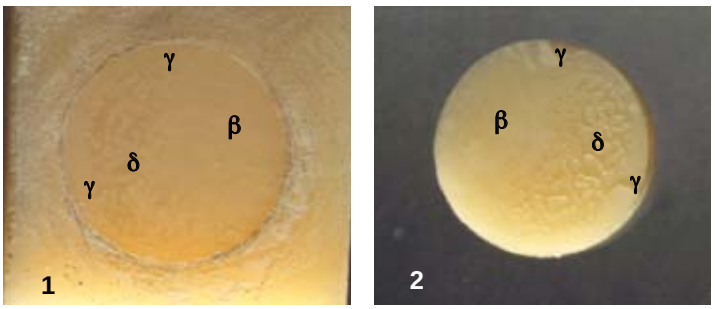

Figure 5. Representative, illustration of failure modes β, γ, and δ (specimen Panavia™ F, non-thermocycled subgroup).
1 = treated surface (block),
2 = untreated surface (cylinder)
β = Adhesive failure at the treated surface, only
γ = Adhesive failure at both the untreated and treated surfaces
δ = Complex cohesive failure at between the two surfaces

The fractured surfaces were examined in a light microscope (WILD M3, WILD HEERBRUGG, Heerbrugg, Switzerland) at x6.4 magnification and photographed with a digital camera (Olympus DP12, Tokyo, Japan) to classify the failure mode of the debonded area: adhesive, cohesive, or a combination of the two. One photo of each specimen was interpreted with an analysis function program, Image Tool for Windows Version 3.00 (UTHSCSA, The University of Texas Health Science Center in San Antonio, TX, USA).

Each specimen – block and corresponding cylinder – with visible areas of a resin-free ceramic surface was classified as adhesive failure. Adhesive failure could occur either at the untreated surface, that is, the surface of the cylinder (α) or at the treated surface, that is, the surface of the block (β). Adhesive failure could also occur at both surfaces. For instance, the untreated surface could be totally resin-free and the corresponding treated surface, the block, could have both resin-free areas and areas that were covered with resin. Resin-covered areas with distinct fractures in the resin and a gap between the residual resin and the underlying ceramic surface were classified as adhesive failure at both surfaces (γ). When both the untreated and the treated surfaces were covered with resin, the failure was classified as complex (cohesive [δ]) (Fig 4,5).

Table 2. Mean shear bond strengths in the non-thermocycled and thermocycled subgroups of each bonding system. The significance of the difference between the subgroups in each system was determined with Student's *t*-test.

Bonding groups	Non-thermocycled Mean bond strength (+SD)	Thermocycled Mean bond strength (+SD)	Statistical significance between the subgroups within the bonding group
Variolink II	27 MPa (+7.0)	34 MPa (+5.0)	0.0141 (P<0.05)
Bisco Chioce	14 MPa (+5.5)	11 MPa (+7.6)	0.4192 (P>0.05)
Bisco Illusion	10 MPa (+3.9)	9 MPa (+4.4)	0.4921 (P>0.05)
Nexus 2	10 MPa (+4.4)	5 MPa (+3.6)	0.0335 (P<0.05)
RelyX Veneer	4 MPa (+1.7)	2 MPa (+1.4)	0.0352 (P<0.05)

Table 3. The different bonding groups:
Differences in mean shear bond strengths between the non-thermocycled and thermocycled subgroups. The significance of the differences was determined with a one-way ANOVA.

Non-thermocycled / Thermocycled	BC	BI	NE	RV	Panavia F
Variolink II	*** / ***	*** / ***	*** / ***	*** / ***	NS / NS
Bisco Choise (BC)		NS / NS	NS / NS	*** / *	*** / ***
Bisco Illusion (BI)			NS / NS	NS / NS	*** / ***
Nexus 2 (NE)				NS / NS	*** / ***
RelyX Veneer (RV)					*** / ***

NS= Non-statistical significance
***P<0.001, ** P<0.01, *P<0.05
Upper /Lower = Non-thermocycled /Thermocycled

Results

Bond strength

Variolink® II and Panavia™ F showed significantly ($p<0.001$) higher bond strengths compared to Bisco Choice™, Bisco Illusion™, Nexus™ 2, and RelyX™ Veneer, irrespective of treatment. Differences between the non-thermocycled and thermocycled subgroups in the Variolink® II group ($p<0.05$) were significant, with the latter having higher bond strengths. Table 2 summarises shear bond strengths and significant differences between the two subgroups in each bonding group.

Differences between Variolink® II and Panavia™ F were non-significant ($p>0.05$). Bisco Choice™ had significantly higher bond strengths than RelyX™ Veneer ($p<0.01$ for the non-thermocycled subgroup, $p<0.05$ for the thermocycled subgroup). Differences between Bisco Choice™, Bisco Illusion™ and Nexus™ 2 and between Bisco Illusion™, Nexus™ 2, and RelyX™ Veneer were non-significant.

Analysis of debonded surfaces

Failure modes in the debonded areas in each group are described in Table 4.

The failure mode in the Variolink® II and Bisco Illusion™ bonding groups, irrespective of storage condition, and for the non-thermocycled subgroup in the RelyX™ Veneer group was predominantly adhesive at the untreated surface of the cylinder (α). The thermocycled subgroup in the RelyX™ Veneer bonding group underwent adhesive failure at both untreated and treated surfaces ($\gamma = 50\%$). In the remaining groups, irrespective of storage condition, the failure mode was predominantly adhesive at the treated surface (β). All bonding groups, irrespective of pre-treatment, had some indications of complex failure (δ), but no group had more than 9% (mean) of such failures.

Discussion

To achieve a sufficient and durable bond between a cement and a ceramic restoration, enlargement of the seating surface (micromechanical retention) is required (5,8,9,22,36,37). Such enhanced retention is generally achieved using etching or sandblasting techniques. With oxide ceramics, however, available etching techniques are insufficient, and surface enlargement is often restricted to sandblasting (2,7,8,40). Sandblasting with Al_2O_3 particles is thought to be an effective method of achieving micromechanical retention on high-strength oxide ceramics (4,5,7,36,37). Two main retentive mechanisms for this stronger bond between core ceramics and adhesive cements after sandblasting have been described. First, if a pore is close to the surface, the bridge of material separating the pore from the surface may break during sandblasting, creating a surface pore and enhancing mechanical interlocking (9,7). Second, sandblasting removes contaminations from the surface (9,18,22,25). One disadvantage, on

Table 4. Mean percentage of the various failure modes in each bonding group according to storage conditions

Bonding groups Non-thermocycled	Failure modes (Mean percentage) Thermocycled	Failure modes (Mean percentage)
Variolink II	α 93% β 1% γ 5% δ 1%	α 92% β 2% γ 4% δ 2%
Bisco Choise	α 5% β 50% γ 42% δ 0%	α 3% β 56% γ 41% δ 0%
Bisco Illusion	α 95% β 0% γ 1% δ 4%	α 91% β 2% γ 2% δ 5%
Nexus 2	α 21% β 60% γ 19% δ 0%	α 31% β 53% γ 10% δ 6%
RelyX Veneer	α 74% β 4% γ 20% δ 2%	α 44% β 3% γ 50% δ 3%
Panavia F	α 35% β 46% γ 10% δ 9%	α 28% β 65% γ 6% δ 1%

Non-Thermocycled (storage condition 37°C H_2O)
Thermocycled (storage condition 37°C H_2O incl. thermocycling)
α= Adhesive failure from the untreated surface, only
β= Adhesive failure from the treated surface, only
γ= Adhesive failure from both the untreated and treated surfaces,
δ= Complex cohesive failure mode

the other hand, is that sandblasting may tear the surface and induce surface cracks, which might cause an insidious weakening of the ceramic (9,35).

In the present study, the ceramic surfaces of the blocks were blasted with 110-µm Al2O3 particles for 10 seconds according to the manufacturer's recommendations. Other studies have suggested that blasting ceramic surfaces with 50-µm Al2O3 particles for 13 seconds would be adequate to obtain sufficient micromechanical retention (2,4,5,22,30,37). Results from still other studies, however, indicate that a smaller particle size such as 50 µm polishes rather than enlarges the surface (11,27).

Several investigations have used an air pressure between 2.5 and 2.8 bars with a distance of 10 mm between the blasting tip and the object during sandblasting (2,4,5,22,30,37). In this study, an air pressure of 5 bars and a distance of 100 mm were used according to the manufacturer's instructions. This, together with the angle of incidence, may have influenced the results by creating a rougher surface and a larger area and thereby, possibly, improving bond strength (25,38).

The use of a silane coupling agent appears to have improved bond strength in this study (9,37). A silane agent consists of bifunctional molecules that function as coupling agents between the inorganic ceramic surface and the organic polymer matrix of the resin (3,8,37). The exact bonding mechanisms of silane to high-strength oxide ceramic are still unclear (2,5,31,37). In cases of high-strength oxide ceramics, a durable bond between densely sintered alumina and bonding systems can be achieved with adhesive cements containing phosphate groups like 4-methacryloxyethyltrimellitic acid anhydride (4-Meta) or MDPs, combined with their corresponding coupling agents (4,6,18,22,24,26,42). Bonding systems based on MDP bond chemically to metal oxides such as alumina and zirconia (5,6,24,26,37,42). Some authors recommend that adhesive cements containing MDP components can be used without silane, whilst others suggest that use of a coupling agent enhances surface wettability (4,5,6,24,25,26,37,42).

In preparation for the present study, a pilot study conducted on the bond strength of an MDP-containing adhesive cement with and without the silane coupling agent. Differences between the two groups were non-significant. Based on this, a silane coupling agent was applied to the sandblasted ceramic surfaces according to the manufacturers' instructions. The silane may have acted as a wetting agent for the adhesive cement and promoted adhesion between the two surfaces (2,4,5,7,22). This may explain some results in the present study where the MDP-containing cement, Panavia™ F, and Variolink® II, a Bis-GMA-based cement had the highest bond strengths, irrespective of treatment.

In addition, for optimal cementation, different cements probably require different mixing procedures depending on the viscosity of the adhesive cement and the content of the filler, which in turn determine the film thickness of the adhesive cement (7,9). The use of an alignment apparatus with an applied seating load of 15 N during polymerisation ensured that the axes of the cylindrical samples were perpendicular to the surface of the cubic samples. It also ensured a standardized load for all specimens during polymerisation. As mentioned previously,

cement thickness was determined by filler particle size and viscosity of the adhesive cement (7,9). No measurements of the thickness of the cement on the samples were made, which means that this is an unknown variable. It has been discussed that differences in flexural strength between cement thicknesses of 60 µm and 120 µm are irrelevant for resin cement, while for zinc phosphate and glass ionomer cements, fracture resistance decreased as cement thickness increased from 60 µm to 120 µm (17,23).

It is generally acknowledged that different environmental influences in the oral cavity can affect the durability of a bonding system's bond strength (24,41,45). Thermocycling at temperatures between 5°C and 55°C is an accepted method for simulating aging, by stressing the bond interface, and for evaluating long-term bond strength (5,7,8,24,36,41). It has been shown that bond strength decreases after thermocycling (5,6,41). Previous investigations found that the bond strength of the MDP-containing resin cement Panavia™ F differed non-significantly before and after thermocycling compared to other investigated cements. The results of the present study agree with these findings (4,22,41). Of the six different bonding systems, only two, Nexus™ 2 and RelyX™ Veneer, decreased significantly ($p<0.05$) in bond strength after thermocycling. Student's t-test also found a significant difference ($p<0.05$) between the Variolink® II subgroups where the thermocycled subgroup maintained a higher bond strength than the non-thermocycled subgroup. Thermocycling may have acted as a catalyst and promoted a continuing curing of the adhesive cement.

The blocks and the cylinders that constituted the specimen pairs in this study were made of the same material – densely sintered Al_2O_3. Previous studies have used different materials such as composite cylinders bonded to aluminium oxide blocks (2,11,15,18). The fracture pattern is most probably dependent on the test method used because stress is unequally distributed along the cementation surfaces when loaded with a knife-edged blade (4,6,16,28,33,45). Which method to use for studying bond strengths has been disputed, and a commonly used approach in the study of shear bond strength is to use a low-modulus composite cylinder bonded to a ceramic surface (4,6,18,22,28,36,37,38). A bending moment is introduced with a knife-edge, and a typical failure start is at the load site in the composite cylinder (5,18,28,45). The cementation interface does not deform plastically to any great extent during such tests (16,28). In the present study, where the cylinder is made of a high modulus ceramic material, there will also be a bending moment, but deformation during loading will occur in the cement and at the cementation interfaces (28).

During water storage and thermocycling, however, when the specimens are exposed to water, the composite material will absorb more water than the ceramic and thus expand. This expansion will induce stresses along the interface, which may influence bond strength (4,22). Concerning RelyX™ Veneer, the only cement in this study that is solely light cured and the only one-paste system, a possible explanation for its low bond strength could lie in the conversion (12,13). If it is assumed the alumina discs were opacious and partly hindered light from reaching the cement, there might have been poorly cured areas in the deeper portions of the cement. But alumina is a highly light-dispersing material rather than an opacious, which allows for light transmittance (20,21). Still, the quality of the transmitted light could have influenced the conversion and, consequently, bond strength (13). Furthermore, differences in compositions between the various cements such as filler particles, colour, and other chemical additives could have influenced the level of conversion (12,13).

The failure mode of the debonded areas, that is, whether it was adhesive or complex (cohesive), was determined by whether or not the ceramic surface was resin free. The predominant failure mode of Variolink® II, Bisco Illusion™, and to a certain degree RelyX™ Veneer was adhesive at the untreated surface (α), irrespective of storage conditions. It is possible that higher bond strengths could have been achieved if the untreated surface of the cylinder had been treated with silane, as had the surface of the block. For the remaining groups, Bisco Choice™, Nexus™ 2, and Panavia™ F, the failure mode was adhesive, but at the treated surface (β), irrespective of storage conditions. In this case, it might be that current bonding systems require no more surface treatment than the retention that is achieved during the manufacture of the restoration. In the thermocycled subgroup of the RelyX™ Veneer group, a mean of 50% of the adhesive failures occurred at both surfaces (γ). Results for Bisco Choice™, irrespective of storage conditions, were similar: failure mode γ was 42% in the non-thermocycled subgroup and 41% in the thermocycled subgroup. These findings indicate that the use of a treated or untreated surface is irrelevant with some cement systems while it is important with others. Complex failures (δ) occurred in 9% or less (mean) of the specimens, regardless of bonding

system. This percentage might have been higher if the examination had been made under greater magnification, revealing remnants that are undetectable under the magnification used in the present study.

The variation in bond strengths is large, and previous studies have shown that mean bond strengths between 10 MPa and 20 MPa, or even above 30 MPa, can be obtained with different bonding systems depending on the chosen test method (16,28,33,45). It has been suggested that a bond strength of 20 MPa is needed to cement dental reconstructions (16,29): the values achieved for Panavia™ F and Variolink® II in the present study might be sufficient. Clinical studies, however, are needed to confirm the findings of *in-vitro* studies such as this study.

Conclusion

Within the limitations of this *in-vitro* study, these conclusions can be drawn:

- Only two of the six tested bonding systems, Panavia™ F and Variolink® II, achieved sufficient shear bond strength to densely sintered alumina.
- No general recommendation can be made whether to use surface treated or as produced densely sintered alumina because bond strength seems to depend on the bonding system used. Hence, such recommendations must be based on which bonding system is being used.

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References

1. Andersson M, Odén A. A new all-ceramic crown. A dense-sintered, high-purity alumina coping with porcelain. Acta Odontol Scand 1993;51(1):59-64.
2. Awliya W, Odén A, Yaman P, Dennison JB, Razzoog ME Shear bond strength of a resin cement to densely sintered high-purity alumina with various surface conditions. Acta Odontol Scand 1998;56(1):9-13.
3. Barghi N. To silanate or not to silanate: Making a clinical decision. Compend Contin Educ 2000;21:659-64.
4. Blatz MB, Sadan A, Arch GH, Lang BR. In vitro evaluation of long-term bonding of Procera AllCeram alumina restorations with a modified resin luting agent. J Prosthet Dent 2003;89:381-7.
5. Blatz MB, Sadan A, Kern M. Resin-ceramic bonding: a review of the literature. J Prosthet Dent 2003;89(3):268-74.
6. Blatz MB, Sadan A, Martin J, Lang B. In vitro evaluation of shear bond strengths of resin to densely-sintered high-purity zirconium-oxide ceramic after long-term storage and thermal cycling. J Prosthet Dent 2004;91:356-62.
7. Blatz MB, Sadan A, Soignet D, Blatz U, Mercante D, Chiche G. Long-term resin bond to densely sintered aluminum oxide ceramic. J Esthet Restor Dent 2003;15(6):362-8;discussion 369.
8. Blatz MB, Sadan A, Kern M. Bonding to silica-based ceramics: clinical and laboratory guidelines. Quintessence Int 2002;25:54-62.
9. Blatz MB. Long-term clinical success of all-ceramic posterior restorations. Quintessence Int 2002;33:415-26.
10. Blixt M, Adamczak E, Linden LA, Oden A, Arvidson K. Bonding to densely sintered alumina surfaces: effect of sandblasting and silica coating on shear bond strength of luting cements. Int J Prosthodont. 2000;13(3):221-6.
11. Borges GA, Sophr AM, de Goes MF, Sobrinho LC, Chan DC. Effect of etching and airborne particle abrasion on the microstructure of different dental ceramics. J Prosthet Dent 2003;89(5):479-88.
12. Burke FJ. Trends in Indirect Dentistry: conclusions. Dent Update. 2005;32(10):574.
13. Darr AH, Jacobsen PH. Conversion of dual cure luting cements. J Oral Rehabil. 1995;22(1):43-7.
14. Dawn A, Yaman P, Razzoog ME, Wang RF. Effect of Cement on Fracture Resistance of All-Ceramic Crowns. (Abstract #2136) J Dent Res 1996;75(1):284.
15. Dérand P, Dérand T. Bond strength of luting cements to zirconium oxide ceramics. Int J Prosthodont 2000;13(2):131-5.
16. Dunn WJ, Söderholm KJ. Comparison of shear and flexural bond strength tests versus failure modes of dentin bonding systems. Am J Dent. 2001;14(5):297-303.
17. El Abrashi S, Lang BR, Razoog ME, Yaman P, May K. Fracture resistance of ceramic crowns influenced by coping/die fit. (Abstract #2938) J Dent Res 1999;78:473
18. Friederich R, Kern M. Resin bond strength to densely sintered alumina ceramic. Int J Prosthodont 2002;15(4):333-8.
19. Haag P, Andersson M, Vult von Steyern P, Odén A. 15 Years of Clinical Experience with Procera Alumina. A Review. Appl. Osseoint. Res 2004;4:7-12.
20. Heffernan MJ, Aquilino SA, Diaz-Arnold AM, Haselton DR, Stanford CM, Vargas MA. Relative translucency of six all-ceramic systems. Part I: core materials. J Prosthet Dent. 2002;88(1):4-9.
21. Heffernan MJ, Aquilino SA, Diaz-Arnold AM, Haselton DR, Stanford CM, Vargas MA. Relative translucency of six all-ceramic systems. Part II: core and veneer materials. J Prosthet Dent. 2002;88(1):10-5.
22. Hummel M, Kern M. Durability of the resin bond strength to the alumina ceramic Procera. Dent Mater 2004;20(5):498-508.
23. Kelly JR, Nishimura I, Campbell SD. Ceramics in dentistry: historical roots and current perspectives. J Prosthet Dent. 1996;75(1):18-32.
24. Kern M, Thompson VP. Bonding to glass infiltrated alumina ceramic: Adhesive methods and their durability. J Prosthet Dent 1995;73:240-9.
25. Kern M, Thompson VP. Sandblasting and silica coating of glass-infiltrated alumina ceramic: volume loss, morphology, and changes in the surface composition. J Prosthet Dent 1994;71-453-61.
26. Kern M, Wegner SM. Bonding to zirconia ceramic: adhesion methods and their durability. Dent Mater

1998;14:64-71.
27. Kim BK, Bae HE, Shim JS, Lee KW. The influence of ceramic surface treatment on the tensile bond strength of composite resin to all-ceramic coping materials. J Prosthet Dent 2005;94:357-62.
28. Kinloch AJ. The Science of adhesion. Part 2 Mechanics and mechanisms of failure. J Mater Sci 1982;17:617-51.
29. Lambrechts P, Inokoshi S, van Meerbeek B, William G, Braem M, Vanherle G, Classification and potential of composite luting materials. In: Morman W, editor. International Symposium on Computer Restorations. Berlin: Quintessence Publishing Co.; 1991 p. 61-90.
30. Madani M, Chu FC, McDonald AV, Smales RJ. Effects of surface treatments on shear bond strengths between a resin cement and an alumina core. J Prosthet Dent 2000;83(6):644-7.
31. Odén A, Andersson M, Krystek-Ondracek I, Magnusson D. Five-year clinical evaluation of Procera AllCeram crowns. J Prosthet Dent 1998;80(4):450-6.
32. Ozcan M, Akkaya A. New approach to bonding all-ceramic adhesive fixed partial dentures: A clinical report. J Prosthet Dent 2002;88:252-4.
33. Pecora N, Yaman P, Dennison J, Herrero A. Comparison of shear bond strength relative to two testing devices. J Prosthet Dent. 2002;88(5):511-5.
34. Probster L. Survival rate of In-Ceram restorations. Int J Prosthodont 1993;6(3):259-63.
35. Richerson DW. Mechanical behavior and measurement. In: Richerson DW, editor. Modern ceramic engineering properties, processing, and use in design. New York: Taylor & Francis Group 2006.
36. Roulet JF, Soderholm KJ, Longmate J. Effects of treatment and storage conditions on ceramic/composite bond strength. J Dent Res 1995;74(1):381-7.
37. Sadan A, Blatz MB, Soignet D. Influence of silanization on early bond strength to sandblasted densely sintered alumina. Quintessence Int 2003;34:172-6.
38. Sen D, Poyrazoglu E, Tuncelli B, Goller G. Shear bond strength of resin luting cement to glass-infiltrated porous aluminum oxide cores. J Prosthet Dent 2000;83:210-5.
39. Tan K, Pjetursson BE, Lang NP, Chan ESY. A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. Clin Oral Implants Res. 2004;15(6):654-66.
40. Valandro LF, Leite FP, Scotti R, Bottino MA, Niesser MP. Effect of ceramic surface treatment on the microtensile bond strength between a resin cement and an alumina-based ceramic. J Adhes Dent 2004;6(4):327-32.
41. Wegner SM, Gerdes W, Kern M. Effect of different artificial aging conditions on ceramic-composite bond strength. Int J Prosthodont 2002;15(3):267-72.
42. Wegner SM, Kern M. Long-term resin bond strength to zirconia ceramic. J Adhesive Dent 200;2:139-47.
43. Vult von Steyern P, Jönsson O, Nilner K. Five-year evaluation of posterior all-ceramic three-unit (In-Ceram) FPDs. Int J Prosthodont 2001;14(4):379-84.
44. Ödman P, Andersson B. Procera AllCeram crowns followed for 5 to 10.5 years: a prospective clinical study. Int J Prosthodont 2001;14(6):504-9.
45. Ølio G. Bond strength testing--what does it mean? Int Dent J 1993;43(5):492-8.

Address:
Dr Per Vult von Steyern
Department of Prosthetic Dentistry
Faculty of Odontology
Malmö University
SE-205 06 Malmö, Sweden
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