Swedish Dental Journal

Scientific Journal of The Swedish Dental Association

No. 3/11
Vol.35 Pages 101-168

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Swedish Dental Journal

Scientific journal
of the Swedish Dental Association
and the Swedish Dental Society
ISSN: 0347-9994

Production
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Bank: Skandinaviska Enskilda Banken
Bankgiro: 404-4699 Postgiro: 45 86 34-3

Subscriptions
Sweden: SEK 925 Others: SEK 1 230
(Supplements are not included.)
For subscriptions delivered to adresses within the European Union. Please notice: If you have a VAT registration number you must provide this. Otherwise, please add your local VAT to the above price in SEK.

Printing office
Ljungbergs Tryckeri AB
264 22 Klippan

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Body weight maintenance and levels of mutans streptococci and lactobacilli in a group of Swedish women seven years after completion of a Weight Watchers' diet

BIRGITTA KÖHLER[1], INGRID ANDREÉN[2]

Abstract

◎ The long-term effect of the WW programme on weight and oral cariogenic bacteria was evaluated after 7 yr. All WW who completed the 8-wk dietary regimen in an earlier study (n=33) and the persons in the reference group (REF) (n=27) were invited to participate. The salivary secretion rate, numbers of mutans streptococci (MS) and lactobacilli (lbc) were determined. The WW were weighed. Sustaining a 5% weight loss from the initial weight was regarded as successful weight maintenance. An interview according to a standardised questionnaire was conducted on medication, the intake of antimicrobial agents, dietary changes and experience of dental caries during the last 7 yr. 25 WW and 21 REF qualified to participate. On a group basis, weight, salivary MS and lbc displayed pre-diet levels after 7 yr. 15 of the WW (60 %) were below their initial weight. Successful weight maintenance was achieved by 32%. Reported changes in the intake of fat-rich products differed significantly between the WW and the REF. Nine WW reported fewer carious lesions after joining the WW. Ninety per cent of REF did not regard caries as a problem.

Comparisons of pre- and post-diet data and 7 yr data indicated short-term compliance and varying outcome in terms of long-term compliance. No association was found between salivary levels of bacteria and long-term weight maintenance on a group basis. However, further well-designed longitudinal studies are required to confirm whether salivary MS could be used on an individual basis to validate reported sucrose intake in a dietary regimen.

Key words

Diet restriction, long-term follow up, lactobacilli, mutans streptococci, Strep. sobrinus, weight maintenance, Weight Watchers' diet

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Viktändring och salivnivå av mutansstreptokocker och lactobaciller på en grupp svenska kvinnor sju år efter avslutad kostregim med viktväktarna

BIRGITTA KÖHLER, INGRID ANDREÉN

Sammanfattning

◎ Långtidseffekten efter deltagande i ViktVäktarna (VV) på vikt och bakterier associerade med utveckling av karies utvärderades efter 7 år. Alla VV (n=33) som fullföljde 8 veckors program och referenspersonerna (REF) (n=27) bjöds in att deltaga. Salivprov insamlades för bestämning av salivsekretion, antal mutansstreptokocker (MS) och lactobaciller (lbc) per ml saliv. VV vägdes på kliniken. Upprätthållande av 5 % viktminskning av ursprungsvikten bedömdes som lyckat långtidsresultat. Samtliga personer intervjuades utifrån ett standardformulär om medicinering, användning av antimikrobiella substanser, koständringar och kariesutveckling under de senaste 7 åren. REF rapporterade själva eventuell viktändring. 25 VV och 21 REF deltog i uppföljningen. På gruppbasis observerades en återgång till ursprungsnivå för såväl vikt som salivvärden. 15 VV (60 %) var fortfarande under sin ursprungsvikt. 32 % uppvisade mer än 5 % viktminskning. Rapporterade förändringar av intag av fettrika produkter visade signifikanta skillnader mellan VV-och REF-grupperna. Nio VV uppgav att de hade färre kariesangrepp efter att de genomgått VV programmet. 90 % av REF ansåg att karies inte var ett problem.

Jämförelser mellan pre- och postdata och resultat av 7-års uppföljning visade goda korttidsresultat av VV programmet (8 v) men varierande långtidsresultat (7 år). 7 års uppföljningen visade ingen association på gruppnivå mellan bakterienivåer och långtidseffekt på vikten. Emellertid behövs större välplanerade longitudinella studier för att kunna fastslå huruvida saliv MS kan utgöra ett redskap i samband med bantningsprogram för värdering av uppgivet intag av sockerrika produkter.

Introduction

Sugar and its possible impact on various diseases is currently the subject of discussion, often in association with the worldwide increase in overweight and the number of obese persons. It is well established that the aetiology of dental caries is related to dietary carbohydrates in the oral cavity and their subsequent metabolism by oral bacteria. Fermentable carbohydrates, especially sucrose, also favour the growth of aciduric and acidogenic bacteria, such as mutans streptococci (MS) and lactobacilli (lbc), which are regarded as potentially cariogenic (5,19). This implies that monitoring the level of cariogenic bacteria could assess changes in the intake of fermentable carbohydrates.

Weight Watchers (WW) is a widely available, commercial weight-loss programme, whose dietary regimen largely matches a non-cariogenic diet. Against this background, a study was performed on a group of WW in terms of weight loss and possible influence on salivary secretion rate and numbers of cariogenic bacteria (1). The controlled programme continued for 8 wk. The result showed an average weight loss of 1 kg/wk, indicating compliance with the programme, in conjunction with a significant decrease in salivary MS and lbc counts between baseline and post-dietary regimen values. No significant changes were found in terms of secretion rate and buffer effect in stimulated whole saliva. At that time, very little was known about the long-term maintenance of weight loss after the WW dietary regimen. Studies of caries-preventive measures aimed at the reduction of potentially cariogenic bacteria, including antimicrobial agents, and the restriction of sugar consumption have been successful on a short-term basis (13,15,21). However, the salivary level of the bacteria readily returns to baseline levels in the absence of intervention. We therefore felt it would be interesting to study the long-term maintenance of weight loss and the salivary changes reported in the earlier study in the group of non-selected women who had pursued the WW programme.

Material and methods

Subjects

All individuals joining WW in January 1988 in the district of Oskarshamn, Sweden, were asked to participate in the former study. Forty-nine subjects, all women (only 3 men joined and were excluded), were included in the earlier study after informed consent and their saliva was sampled (1). After sampling, 16 women were excluded; two subjects due to penicillin treatment and 14 due to leaving WW. As a result, thirty-three women completed the study. Seven years later, in 1995, they and the reference subjects (REF) were recalled to the Public Dental Service Clinic in Oskarshamn. They were sampled to determine their saliva secretion rate, the salivary MS and lbc. All former WW were weighed at the clinic.

Standardised questionnaire

The subjects were interviewed according to a standardised questionnaire. They were asked about medication and the recent intake of antimicrobial agents. Questions about a reduction in the consumption of fat- and sucrose-containing products and between-meal frequency during the last 7 yr were dichotomised (yes or no). They were also asked about additional dietary treatment during the follow-up period and changes in caries experience after joining WW. In addition, the REF group self-reported estimated weight change during the last seven years. One and the same person (IA) performed the whole procedure.

Weight Watchers' programme

The subjects had been monitored during an 8-wk period on the WW dietary regimen, as described earlier (1). The weight achieved after 8 wk on the programme will be called the goal weight in this paper.

Salivary sampling

Paraffin-wax-stimulated whole saliva was collected for a minimum of 3 min. The flow rate was determined (ml/min). One ml of the sample was transferred to 5.7 ml VMGII transport medium (18). The samples were mailed the following day to the Department of Cariology in Gothenburg. On arrival the next day, the samples were cultured on selective agar MSB (9) and Rogosa SL agar (Difco 0480) using the micropipette method described by *Westergren & Krasse* (22). The MSB agar plates were incubated for 2 d at 37°C in an atmosphere of 95% N_2 and 5% CO_2 and the Rogosa SL agar plates were incubated aerobically at 37°C for 3 d. The number of colony forming units (CFU) of MS and lbc per ml saliva was calculated. The species Streptococcus mutans (Strep. mutans) and Streptococcus sobrinus (Strep. sobrinus) were also enumerated and identified on the basis of colony morphology (8). The identification of typical and atypical colonies was confirmed by immunofluorescent identification (6).

Weight maintenance analyses

The cut-off point for successful weight-loss maintenance was set at sustaining a weight loss of at least 5% from the initial weight (16). The WW will be categorised into subjects with a weight loss of ≥ 5% from their initial weight, subjects with a weight loss or gain of < 5% and subjects with a weight gain of ≥ 5% from their initial weight. For comparisons of weight change between REF and WW based on categorical data, three groups were identfied; gain or loss ≥ 2 kg = no change, gain > 2kg = increase and loss > 2 kg = decrease.

Statistical analyses

Earlier data only include the persons participating in the present 7-yr review. Categorical data were analysed using χ^2 test and Fisher's exact test. Continuous data are presented as the mean, SD, median and range. Differences within groups were tested using t-test and a two-sample t-test was used for comparisons between groups. The difference between the means of the differences between the initial sample and the sample at 7 yr between the two groups was tested using a two-sample t-test. The bacterial data were transformed to $\log_{10}$ before the analysis. Statistical significance was set at $p < 0.05$.

Results

Twenty-one of the REF women (78%) were available. They were between 28 and 64 yr of age (mean; SD 45 ± 11.2). Two of the REF subjects rinsed with the antimicrobial agent chlorhexidine and their result for salivary MS was excluded.

In the WW group, 26 of 33 women (79%) were available. They were between 34 and 60 yr of age (44 ± 6.8). One of the WW was currently participating in a dietary regimen at hospital in order to reduce weight prior to knee surgery and she was excluded.

Dropouts

Six REF (age; 33 ± 14.5) and 7 WW women (age; 42 ± 11.3) failed to participate. In the REF group, one person had died, two had moved and three did not wish to participate, while, in the WW group, one person had moved and six persons did not wish to participate. The WW dropouts had a mean weight at baseline of 86 kg (± 12.4) and those who participated at the recall had a mean weight of 81 kg (± 13.3). The weight loss after eight weeks was 7.3 kg (± 2.7) in the dropouts, while, in the remaining WW group, it was 8.4 kg (± 1.9). None of the differences was statistically significant.

Standardised questionnaire

Seventeen of the WW (68%) reported a reduction in sucrose-rich products compared with 8 of the REF (38%) (χ^2; Fisher's exact test p= 0.0739). The reported reduction in the number of between-meal snacks was 60% for the WW (n=15) compared with 38% for the REF (n=8) (χ^2; Fisher's exact test p= 0.2364). Twenty-one of the WW (84%) reported a reduction in fat-rich products compared with 7 of the REF (33%). The difference between the groups reached statistical significance for fat-rich products (χ^2; Fisher's exact test p= 0.0007).

Nine WW reported that they had experienced fewer carious lesions after joining WW (36%). Five WW had few fillings or no cavities even before joining WW and 4 of those were still below their initial weight. Eleven persons did not experience any change in caries incidence (44%).

Most REF (90%) did not regard caries as a problem.

Weight maintenance

Table 1 shows the weight of the WW on a group basis at baseline, after 8 wk and at 7 yr. On a group basis, no statistically significant difference was found between the initial and present mean weight.

Within the group of WW at 7 yr, there were in-

Table 1. Weight (kg) at baseline, after 8 wk of dietary regimen and at the 7-yr recall

	na)	Mean	SD	Median	Range
WW group					
Baseline	25	80.9	13.6	78.5	60 - 123
8 wk	25	72.4*	12.9	70.4	54 - 114
7 yr	25	79,7	15,7	78,4	50-130

a) Number of WW

* Statistically significant lower p<0.0001 paired t-test

Table 3. Weight loss or gain of > 2 kg in the REF and WW groups after 7 yr compared with baseline

Groups	n[a]	No change loss or gain < 2 kg	Loss > 2 kg	Gain > 2 kg
REF [b]	21	13	3	5
WW	25	4	13	8

a) Number of subjects

b) Self-reported weight information

Significant difference between the groups χ^2 test $p < 0.01$ (p=0.003)

Table 2. WW participants listed in decreasing order of precedence according to % weight maintenance of initial weight. Initial weight, weight loss/gain after 8 wk and 7 yr, salivary MS at these points and secretion rate at 7 yr

ID	Initial age	Initial weight [a]	Weight loss after 8 wk		Weight at 7 yr	Weight loss/gain at 7 yr		Cat. [b]	MS log_{10} CFU/ml saliva			Secretion rate
			8 wk	kg % of initial weight		kg	% of initial weight		baseline	8 wk	7 yr	ml/min 7 yr
30	36	60	54	6.0 10.1	50	-10.1	-16.9	J	5.45	5.30	4.93	1.1
27	35	78	71	6.4 8.2	68	- 9.9	-12.7	J	6.58	5.99	6.56	1.2
32	27	72	65	6.2 8.7	63	- 8.3	-11.6	J	5.85	5.26	5.83	1.5
15	39	78	68	10.4 13.3	71	- 7.3	- 9.3	J	5.76	5.08	6.70	1.0
9	36	95	86	8.4 8.9	88	- 7,1	- 7.5	J	4.94	3.79	3.90	1.0
12	44	85	75	9.8 11.5	79	- 5.7	- 6.7	J	5.23	4.64	5.06	2.6
7	34	83	74	9.4 11.3	78	- 5.5	- 6.6	J	6.76	6.27	6.64	1.0
23	37	72	60	12.0 16.7	68	- 3.6	- 5.0	J	5.95	5.38	5.87	0.7
33	44	98	88	10.8 11.0	94	- 4.4	- 4.5	0	5.56	3.83	5.53	1.8
3	37	73	65	8.0 10.9	70	- 3.2	- 4.4	0	6.34	5.58	4.78	1.7
20	30	90	80	9.2 10.3	86	- 3.7	- 4.1	0	4.90	5.13	5.30	1.7
14	39	78	70	8.6 11.0	75	- 3.2	- 4.1	0	6.16	5.70	5.64	2.7
19	27	74	66	8.0 10.8	72	- 2.4	- 3.2	0	5.64	4.66	6.00	2.6
8	43	72	63	9.3 13.0	70	- 1.8	- 2.5	0	6.15	5.58	4.90	1.8
1	35	83	74	9.0 10.9	82	- 0.7	- 0.8	0	6.15	5.75	6.07	1.3
13	44	67	63	4.3 6.4	68	+ 1.0	+ 1.5	0	4.96	5.09	5.26	2.0
5	28	107	97	10.4 9.7	109	+ 1.8	+ 1.7	0	6.11	6.16	6.15	2.0
16	50	74	68	6.6 8.9	77	+ 2.4	+ 3.2	0	6.68	5.58	6.26	2.6
29	28	78	71	7.2 9.2	81	+ 2.7	+ 3.5	0	5.03	4.70	5.51	1.3
28	45	67	60	7.4 11.0	70	+ 2.5	+ 3,7	0	4.75	4.15	4.85	3.8
18	34	87	79	7.8 9.0	91	+ 4.0	+ 4.6	0	5.79	7.15	6.15	2.3
11	53	123	114	9,6 7.8	130	+ 6.9	+ 5.6	N	6.98	6.51	6.68	0.4
4	35	79	70	8.4 10.7	85	+ 6.3	+ 8.0	N	5.06	4.97	5.45	1.5
17	34	79	68	11.4 14.4	87	+ 7.7	+ 9.7	N	5.87	5.30	6.28	0.7
2	35	72	64	8.2 11.4	83	+ 10.8	+ 15.0	N	4.53	4.00	5.45	2.2

a) Weight in kg, b) Category J means weight loss ≥ 5% of initial weight, 0 means unchanged weight within 5% change and N means weight gain ≥ 5% of initial weight

Table 4. Percentage of subjects in REF and WW groups within a given range of salivary MS at baseline, after 8 wks of dietary regimen and at the 7-yr recall

	n	< 10^5	≥10^5 - 5x10^5	≥5x10^5 - 10^6	≥10^6
Reference group					
Baseline	19 a)	31.6 (6)	21.1 (4)	21.1 (4)	26.3 (5)
Sample II	19	36.8 (7)	31.6 (6)	5.3 (1)	26.3 (5)
At 7 yr	19	36.8 (7)	21.1 (4)	10.5 (2)	31.6 (6)
WW group					
Baseline	25	20.0 (5)	24.0 (6)	20.0 (5)	36.0 (9)
8 wks	25	32.0 (8)	40.0 (10)	12.0 (3)	16.0 (4)
At 7 yr	25	20.0 (5)	32.0 (8)	8.0 (2)	40.0 (10)

a) Two samples omitted due to chlorhexidine treatment

Table 5. Percentage of subjects within a given range of lactobacilli at baseline, after 8 wks of dietary regimen and at the 7-yr recall

	n	< 10^4	≥10^4 - 10^5	>10^5
Reference group				
Baseline	21	47.6 (10)	28.6 (6)	23.8 (5)
Sample II	21	47.6 (10)	23.8 (5)	28,6 (6)
At 7 yr	21	38.1 (8)	28.6 (6)	33.3 (7)
WW group				
Baseline	24 a)	50.0 (12)	37.5 (9)	12.5 (3)
8 wks	24	75.0 (18)	20.8 (5)	4.2 (1)
At 7 yr	24	33.3 (8)	41.7 (10)	25.0 (6)

a) One missing sample due to laboratory error

dividual differences regarding weight gain/loss. In Table 2, the WW are listed in decreasing order of precedence according to the percentage weight loss/gain from their initial weight. Fifteen of the WW had a lower weight than at baseline (60%). The WW were categorised into subjects who by definition had achieved successful weight-loss maintenance (Table 2), i.e. with a weight loss of ≥ 5% from their initial weight (J=32 %; n=8), subjects with a weight loss or gain of < 5% (O=52 %; n= 13) and subjects with a weight gain of ≥ 5% from their initial weight (N=16 %; n= 4). Only 3 subjects (Table 2: Id 30, 27, 32) weighed less than the achieved goal weight.

Table 2 also includes initial weight, weight loss after 8 wk, weight at 7 yr, $\log_{10}$ salivary level of MS at these points and stimulated secretion rate at 7 yr.

Table 3 shows a comparison between categorised data on weight change (gain or loss > 2 kg and < 2 kg unchanged) in the two groups. A significant difference was found between the groups (χ^2 test, p = 0.0033), suggesting higher volatility in the WW group.

Mutans streptococci, lactobacilli and salivary secretion rate

No statistical differences were found between the groups (WW and REF) regarding changes in bacterial count and salivary secretion rate between baseline and 7 yr (two-sample t-test; p>0.05%). The frequency distribution in given ranges of salivary MS and lactobacilli at baseline, after 8 wks and at 7 yr is given in Tables 4 and 5.

The WW who had a lower weight than at baseline showed a tendency towards a decrease in MS at 7 yr compared with those who had a higher weight at 7 yr than at baseline (unpaired t-test, p=0.0512). No statistical difference was found regarding change in lbc (p=0.1585).

A total of 6 subjects (3 WW and 3 REF) had a low secretion rate (≤ 0.7 ml/saliva) and 5 of them had high or very high levels of MS

No association between the weight-loss/gain categories J, O and N, based on the percentage of weight loss/gain from the initial weight (Table 2) and the change in salivary MS and lbc between baseline and 7 yr, was found (unpaired *t*-test; p=0.3278 and 0.7208 resp.).

Mutans streptococci – At 7 yr, ten WW had > 10^6 CFU of MS and, of these, six had had the same level at baseline (Table 2). Only two subjects had maintained the low value (< 10^5) achieved after 8 wk. Both of them (Table 2: ID 3, 8) were below their initial weight and, according to the questionnaire at 7 yr, they had reduced their sucrose intake. In contrast, three subjects had maintained the high level throughout the study and at 7 yr (ID 5, 7, 11) and all of them reported a high sucrose intake either on a daily basis or periodically.

Six subjects in the REF group had a high level of MS at 7 yr and two of them had a high level throug-

hout the study (Table 4). According to the questionnaire, none had either made any dietary changes or changed weight. Two subjects with very high levels of MS at baseline had very low values after 7 yr. According to the questionnaire they consumed less sucrose.

At the time of the interview the salivary data were not known.

Streptococcus sobrinus – At 7 yr, 16% (n=3) of the REF and 24% (n=6) of the WW had *Strep. sobrinus*, in addition to *Strep. mutans.* All the subjects with *Strep. sobrinus* had been positive at some of the earlier samplings. No association was found between weight maintenance and *Strep. sobrinus* carriers. The total MS were statistically significantly higher in the *Strep. sobrinus* carriers than the non-carriers (unpaired t-test log MS; p=0.0122).

Discussion

The present 7-yr review showed that 15 of the WW (60%) were still below their initial weight and 32% (n=8) had maintained a weight loss of 5% or more after 7 yrs. In the absence of weight-loss intervention, overweight individuals would be expected to gain weight over a 7 yr period and sustaining even a minor weight loss is therefore a noteworthy achievement and the long-term result is therefore encouraging.

A tendency towards a decrease in MS was found among the WW, who were still below their initial weight compared with those with a higher weight than at baseline. However, no association was found between the 3 weight-loss/gain categories (J, O and N) and the change in salivary MS and lactobacilli, which might not be expected considering the small number of persons in each group.

In both the REF and WW groups, more than 75% of the previous participants were available, which is satisfactory considering the long time span. At the same time, the size of the groups is small and much data is based on self-report, which has to be considered when interpreting the results. The dropouts in the WW group had a higher average initial mean weight and a lower weight loss at 8 wk than the review group. Even if the difference was not significant, it is possible to speculate that their failure to show up was due to their level of long-term compliance, indicating that the success rate was actually lower than reported.

The return to baseline levels for the salivary levels of bacteria on a long-term basis has been reported in several studies (15,21). However, the study by *Köhler & Andréen* (12,13) of mothers with $\geq 10^6$ MS/ml saliva at baseline showed that it is possible to maintain a lower level in the long term than the control group after a preventive programme including dietary recommendations. Even if more than 60% of the WW reported reducing their intake and frequency of sugar-rich products, there may be enough fermentable carbohydrates to promote bacterial growth. It is also possible that the WW know what they should eat and answered accordingly. Several of the WW also stressed at the interview that they knew how to eat but failed to comply to varying degrees. In the earlier study (1), written information about the association between the salivary parameters and dental caries was given, as well as the individual results for the saliva sampling. At the time of the present interview, the bacterial data were not analysed and they were therefore not used to challenge the likely under-reporting of sucrose-rich items. Some WW maintained a successful weight loss, despite reporting high sucrose consumption and maintaining high levels of MS. This illustrates the possibility that sugar-rich products might displace fat in the diet rather than more complex carbohydrate rich foods.

The initial study (1) was designed to assess the effect of the WW dietary regimen on salivary factors associated with the caries process. The long-term follow-up would definitely have benefited from clinical data on caries prevalence, present carious lesions and other confounding factors, such as the salivary secretion rate, medication and chronic diseases affecting the bacterial data results (19). As a matter of fact, the inspiration for our study of WW was observations from the dental clinic of improved dental health in patients after joining WW. The observation of a higher number of missing teeth with increasing BMI by *Zitzman et al.* (23) supports the concept of an association between nutritional status and dental health.

No data from Sweden and only limited data from North America are available on long-term weight maintenance in individuals after completing a WW weight-loss programme. The success rate, defined as sustaining at least 5% of the weight loss from the initial weight, was 32%. This is in close agreement with other studies (7,10). In the study by *Delprete et al.* (7), self-reported weight was found to be underestimated compared with measured weight. In those studies, a correction factor was therefore calculated for the self-reported weight, making their data comparable with the present findings. In the present study, the REF group reported more weight stability than WW. However, the data releating to the REF were self-reported and have to be intepreted with caution.

The problem of obtaining accurate assessments

of habitual intake has been reviewed by *Macdiarmed & Blundell* (17). Several studies of controlling dental caries by dietary counselling have been successfully monitored by microbiological examination (11,14). Recent studies have addressed the possible association between counts of cariogenic bacteria and sugar intake related to weight (4). *Barkeling et al.* (3) concluded that a successful dietary treatment programme for obese women with high intakes of sweet foods must focus on helping them with their craving for sweets. Food items with a negative health image, such as fermentable, energy-dense carbohydrates, are likely to be under-reported, especially by overweight persons (17). *Barkeling et al.* (3) suggest that salivary MS could be a simple tool for dealing with under-reporting. A literature review had been made to assess whether cariogenic bacteria can serve as an objective marker of sugar intake (20). The article concluded that lbc and MS counts might be used as a marker of sugar intake at group level. The present study was unable to provide conclusive support for this statement on a long-term basis and was only able to provide some anecdotal evidence. Our earlier study confirmed that a strict dietary regimen can affect the cariogenic bacteria in the short term. The interviews on an individual basis reported varying sucrose intake often reflected in the bacterial data although not necessarily in the degree of weight maintenance. The background to weight problems is strongly associated with genetic predisposition, in combination with the abundant availability of energy-dense, high-fat foods (2), but the abundance of sucrose-containing items as a replacement for fat foods still needs to be addressed and controlled in a weight-loss programme.

In conclusion, the present follow-up provides information on the long-term success rate of a weight-loss programme and the effect on bacteria associated with the caries process. Comparisons of pre- and post-diet data and data at 7 yr indicated short-term compliance but varying outcome in terms of long-term compliance. Both dental caries and overweight are multifactorial conditions and both are affected by dietary habits. Intervention programmes call for behavioural changes. Within the limits of this study, we suggest that the salivary MS might be a useful and simple tool in weight-loss interventions in individuals reporting a craving for "sweets". However, further well-designed longitudinal studies are required to confirm MS levels as a long-term tool in dietary regimens.

Acknowledgements

We thank Lilian Axelsson, Ann-Charlotte Gustavsson and Ann Karlsson for help in collecting the saliva samples and Ann-Britt Lundberg for skilful technical assistance.

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Clinical evaluation of fixed partial dentures made in Sweden and China

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Abstract

◎ The aim of this study was to compare the quality of fixed partial dentures (FPDs) made in a Chinese dental laboratory with corresponding FPDs made in Swedish dental laboratories.

Twenty-one patients were fitted with FPDs between March 2007 and December 2008. Single crowns and prostheses of up to seven units were made. All dentures, gold and CoCr alloys covered with ceramic, were produced in duplicate: one by a dental technician in China and the other by a dental technician in Sweden. The dentures were blind-tested with regard to marginal integrity, anatomic form and color, approximal and occlusal contacts, and time taken for adjustments. The composition of dentures was analyzed, and the material used, framework weight, compliance of the laboratories, and costs (material and labour) were recorded.

There was no difference in the quality of marginal integrity, anatomic form, color, approximal and occlusal contacts, or in the time taken for adjustments. The bridge frameworks made in China were thinner and lighter ($p<0.01$) than those made in Sweden. Three FPDs from China showed elastic deformation when tested clinically and were considered too thin for clinical use. In 11 out of 14 orders from the Chinese laboratory, the gold alloy specified was not delivered and the cobalt-chromium alloy contained small amounts (0.19%) of nickel. The prostheses with gold-alloy frameworks from China cost 47% of those from Sweden ($p<0.01$) and those with cobalt/chromium frameworks 44% ($p<0.01$).

In conclusion, the quality of the FPDs made in Sweden and China was comparable, with the exception of the dimension of the Chinese bridges, which in some cases was considered too weak. The gold alloy ordered from the Chinese laboratory was often not the alloy delivered and the CoCr alloy contained small amounts of nickel. FPDs from China cost less than half the price of those from Sweden.

Key words

Quality, fixed partial dentures, clinical evaluation

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Klinisk utvärdering av fast protetik utförd i Sverige och Kina

KARIN EKBLOM, JAN-IVAN SMEDBERG, LARS-ERIK MOBERG

Sammanfattning

◎ Syftet med den här studien var att utvärdera kvaliteten på konventionell kron- och broprotetik som framställts vid tandteknikerlaboratorier i Kina och Sverige.

Tjugoen patienter erhöll enstaka kronor och broar upp till sju led mellan mars 2007 och december 2008. För varje patient gjordes en konstruktion av en tandtekniker i Kina och en annan av en tandtekniker i Sverige. Konstruktionerna bedömdes blint med avseende på marginal kantanslutning, färg och form, approximala och ocklusala kontakter och tid för justeringar. Göten vägdes och materialanalys med avseende på grundämnesinnehåll gjordes. Avvikelser i laboratoriernas utförande av arbetet enligt specifikation på beställningssedel, materialet som användes och kostnader (material och arbete) registrerades.

Det var inga kvalitetsskillnader beträffande kantanslutning, anatomisk utformning, färg och approximal- och ocklusionskontakter. Det var inte heller någon skillnad beträffande justeringstiderna för kronorna/broarna från Kina respektive Sverige. De kinesiska arbetena, både de i guld och koboltkrom, var tunnare och lättare ($p<0.01$) än de svenska. Tre av de kinesiska broarna uppvisade elastisk deformation vid provning och bedömdes för tunna för kliniskt bruk. I 11 av 14 beställningar av guldlegering erhölls annan legering än den beställda från det här kinesiska laboratoriet och koboltkrom-legeringen innehöll små mängder nickel (0,19%). Totalkostnaden för de kinesiska kronorna/broarna i guld var 47% av de svenska ($p<0.01$), och för koboltkrom 44 % ($p<0.01$).

Sammanfattningsvis var kvaliteten på kronorna/broarna som framställdes i de båda länderna jämförbara med undantag av dimensionering, som hos flera av de kinesiska broarna bedömdes vara sämre. Den guldlegering som beställdes från det kinesiska laboratoriet var ofta inte den som levererades och koboltkromlegeringen innehöll små mängder nickel. Totalkostnaden för de kinesiska kronorna och broarna var mindre än hälften av den svenska.

Introduction

In the last decade, dental prosthetic treatments in Sweden have become more advanced and expensive. Fixed partial dentures have also been more common as people increasingly keep their teeth into advanced age. Financial compensation from The Swedish Social Insurance Agency, Försäkringskassan, reduces the cost of prosthetic treatments, but advanced prosthetic rehabilitation could still be too expensive for many patients. Because the technical components of prostheses represent a considerable part of the cost of fixed partial denture treatment, some dental laboratories in Sweden have recently started collaborating with Chinese dental laboratories to reduce the cost of the technical part of the treatment. Although this could be advantageous from an economic point of view, the quality of these imported dental appliances have not been evaluated and made public. Further, there are global media reports of toxic – and thus not biologically suitable – heavy metals such as lead, nickel, cadmium, and beryllium in prostheses made in Asian countries.

Because Sweden is a member of the European Union (EU), the Swedish Public Dental Health Service (Folktandvården) must follow EU procurement regulations when purchasing dental technician services. Significantly, although price competition among suppliers highlights the need for standardized evaluation of the quality of dental appliances, no such system has yet been adopted. To clarify, the term quality here is a measure of clinical biological acceptance, and longevity of service in the oral cavity. Further, even if an appliance is in itself inexpensive to purchase, this may be false economy as the post-purchase time spent adjusting it to make it clinically acceptable may result in a high overall cost.

Several clinical studies have evaluated the quality of dental appliances after varying amounts of time in service (5,6,10,15). But to our knowledge, there are no published studies that evaluate the quality of fixed prostheses when received from a laboratory, before adjustments, and in ordinary clinical use. Further, no published study has compared the quality between such prostheses in the same patient and on the same teeth. Looking forward, both dental professionals and patients alike may benefit from this type of quality evaluation of dental appliances in a standardized form.

This study aimed at comparing the quality of fixed partial dentures made in a Chinese dental laboratory with those made in Swedish dental laboratories. The dentures were tested with regard to clinical marginal fit, anatomic form and color, approximal and occlusal contacts, and time taken for adjustments. The null hypothesis was that there was no difference in clinical quality between the dentures tested. For each patient, two copies of each FPD were made, one at a Chinese dental laboratory and the other at a Swedish facility. The FPDs were then simultaneously evaluated and compared with each other. We analyzed the dimensions of the FPDs, the composition of the dental alloys used, the laboratories' compliance in terms of fulfilling the specified orders, and the labor and material costs of the appliances.

Materials and Methods

The study included 21 patients referred for prosthetic treatment to the Department of Prosthetic Dentistry, St Erik Hospital, Stockholm, Sweden. The mean age was 64.7 years (range 33-85); 62% women and 38% men (Table 1). Each patient was informed of the purpose of the study and agreed to participate. All patients asked took part in the study. The treatments were carried out by six dentists at the clinic.

Two impressions with silicone (Provil, Bayer Dental, Leverhausen, Germany) or polyether (Impregum, 3M ESPE A6, Dental Products, Seefeld, Germany) were made for each patient. Alginate impressions were made of the opposite jaw and the interocclusal relationships were registered with wax, both in duplicate. The impressions and registrations were arranged by the dental nurse, in two packages. They were sent blindly to the Chinese and to the Swedish dental laboratories. One large Chinese laboratory (180 technicians) and 5 Swedish laboratories (a total of 32 technicians) were used; the choice of Swedish laboratory depending on the dentist. Written instructions, including color selection, on the order forms were identical for all of the dental laboratories in the study. Alloys ordered from the Chinese laboratory were selected from a list on the laboratory's order form. Alloys ordered from the Swedish laboratories were written de novo on the order form. The study coordinator unpacked the castings and completed restorations, and coded them to keep the test blind.

Patients were treated with crowns and bridges of up to seven units. The frameworks were in gold (14 cases, 28 crowns) and cobalt-chromium (7 cases, 14 crowns). For the Chinese frameworks, the gold alloy used in 11 cases was DDA10-MK/PFM (The Argen Corporation, San Diego, USA). In three cases, the gold alloy used was not known. The gold alloys ordered from Sweden were: Sjödings M2 (K.A. Rasmussen as, Hamar, Norway; 6 cases, 13 crowns), Alfa

Table 1. Distribution of fixed partial dentures, patient age, and materials used.

Pat. nr	Age	Restorations	Material
1	55	25(26)27	Gold-Ceramic
2	77	45	Cobalt/Chromium-Ceramic
3	40	34, 36	Gold-Ceramic
4	77	33	Cobalt/Chromium-Ceramic
5	85	45, 44	Gold-Ceramic
6	68	33 34(35)(36)37 38	Gold-Ceramic
7	58	47(46)(45)44	Gold-Ceramic
8	40	35, 17	Gold-Ceramic
9	85	34, 35	Gold-Ceramic
10	70	36	Gold-Ceramic
11	76	24(25)26 27	Gold-Ceramic
12	40	16	Gold-Ceramic
13	73	11(12)13 14(15)(16)17	Cobalt/Chromium-Ceramic
14	68	47(46)45	Cobalt/Chromium-Ceramic
15	67	14(15)16	Cobalt/Chromium-Ceramic
16	33	13(14)(15)16	Cobalt/Chromium-Ceramic
17	72	22	Gold-Ceramic
18	75	45	Gold-Ceramic
19	68	13(14)15	Gold-Ceramic
20	70	13(14)15	Cobalt/Chromium-Ceramic
21	61	33(34)35(36)37	Gold-Ceramic

Ceramic 11 (Alldental, Stockholm, Sweden; 5 cases, 9 crowns) and Sjödings Bio 2001 (K.A. Rasmussen as, Hamar, Norway; 3 cases, 6 crowns). The CoCr alloy from China was Extreme-bond PC NP SP (The Argen Corporation, San Diego, U.S.A) and from Sweden Wirobond®C (BEGO Bremer Goldschlägerei Wilh. Herbst GmbH & Co, Bremen, Germany).

Quality evaluation

In all cases, quality was recorded by two examiners, using CDA criteria (4, 13). The two examiners were either one of the authors (KE) and the dentist conducting the treatment, or two of the authors (KE and LEM), when treatment was carried out by one of the other authors. All examiners were calibrated with other examiners at the clinic using CDA criteria. When initial ratings differed, an agreement was reached after discussion.

In crown therapy cases, the completed crown covered with ceramic was evaluated clinically. For bridges, the marginal integrity of the frameworks was evaluated before completion with ceramics.

Marginal integrity

The restoration was seated on the abutments and assessed for stability on prepared teeth by finger pressure. That is, it should not rock or rotate when force was applied. Marginal integrity was assessed according to slightly modified CDA criteria (4), using an explorer (tip diameter of 0.6 mm) and by X-ray taken approximally using a paralleling technique. It was evaluated as follows:

- excellent, when the margin was smooth and even, with no visible evidence of a crevice along the margin into which the explorer could penetrate.
- acceptable, when there was a slight marginal discrepancy that was not considered necessary to adjust.
- correct, when there was a rough, irregular, or "stepped" junction, or a marginal overhang, which could be adjusted to a smooth and even margin.
- replace, when a crevice along the margin into which the explorer could penetrate was present and could not be corrected.

Anatomic form was estimated according to CDA criteria as:

- excellent, when the restoration contour was in harmony with adjacent teeth and soft tissues, with good individual anatomic form.
- acceptable, when the restoration was slightly over- or undercontoured, or differed slightly from surrounding teeth, but was not considered necessary to adjust.
- correct, when the restoration was slightly over-or undercontoured, or differed slightly from surrounding teeth, but was considered possible to adjust to an acceptable appearance.
- replace, when the restoration was over- or under contoured, or differed from surrounding teeth in a way not possible to adjust to an acceptable appearance.

Color was estimated according to the CDA criteria as:

- excellent, when the restoration color was in full harmony with the adjacent teeth.
- acceptable, when the restoration differed slightly from surrounding teeth, but was considered not necessary to adjust.
- correct, when the restoration differed slightly from surrounding teeth and was considered possible to adjust to an acceptable appearance.
- replace, when the restoration differed from surrounding teeth to an extent not possible to adjust to an acceptable appearance.

Approximal contacts were estimated as:
- good, when dental floss (Johnson & Johnson, Reach dentotape, waxed ribbon floss, Skillman, NJ, USA) could be passed through the contact with only slight pressure.
- hard, when the crown could not be seated completely, when the patient experienced pain during seating, or when dental floss could not, or only with great effort, be passed through the contact area.
- insufficient, when no resistance was felt when passing the floss, or when no contact was observed visually.

Occlusal contact was estimated as
- good, when occlusion was recorded as equal to the crown or bridge and the surrounding teeth, as evaluated with a thin plastic foil (Hanel, Occlusion foil, Coltène/Whaledent, Langenau, Germany, 2x12µm) and only a slight occlusal adjustment was made to reach optimal occlusion.
- hard, when contact was recorded only on the appliance tested and no contact occurred on the surrounding teeth.
- insufficient, when no contact was recorded for a crown, or an abutment or pontic of a bridge.

The time used for FPD adjustments was measured and estimated to the nearest minute. Additional appointments were made when restorations had to be returned to the laboratory for adjustments. The length of time set for the appointment was then recorded.

Weights of the bridge frameworks were recorded in grams (g).

Alloy composition was analyzed in six samples of FPDs chosen by lot from the Chinese laboratory, three with gold alloys and three with CoCr alloys. Five samples chosen by lot from the Swedish laboratories, one for each gold alloy (Sjödings M2, Alfa Ceramic 11, and Sjödings Bio 2001) and two for the CoCr alloys (Wirobond®C). All samples were coated with porcelain. The alloys were analyzed using ICP-EOS (Inductive Coupled Plasma-Optical Emission Spectroscopy; Sheffield Analytical Services Ltd, UK) at the Nordic Institute of Dental Materials (Oslo, Norway).

Compliance of the laboratories was recorded in terms of fulfillment of order specifications, type of appliance and material delivered, and conformity of the delivery note and invoice.

Costs – labor and materials – of the fixed partial dentures were recorded in SEK.

The prosthesis best fulfilling the clinical requirements was chosen for cementation after discussion between the dentist and the patient. The price was the same regardless of which appliance was selected.

Statistical analysis
Wilcoxon's rank sum test was used for paired comparisons of qualitative data, and Student's t-test was used for comparing time taken, weights and costs.

Results
The FPD distribution is listed in Table 1. Six patients were treated with one single crown and the remaining 15 patients received FPDs of up to seven units each. Fourteen frameworks were made in gold alloy, and seven in CoCr alloy. All samples were coated with porcelain.

Marginal integrity
The total number of abutment teeth was 42. Marginal integrity was rated lower for the Chinese crowns, with 79% scoring satisfactory (excellent or acceptable), compared with 88% for the Swedish ones (Table 2). The remaining crowns were rated as not acceptable (correct or replace). Pairwise statistical comparisons showed no statistically significant difference in marginal integrity between the Chinese and Swedish crowns.

It was noted that increased finger pressure of 30-50 Newton (N) on three out of 11 bridge frameworks made in China (patient no. 6, 11, and 13; Table 1) produced distortions and gaps at the cervical margins of end abutments. This was not seen for the Swedish frameworks.

Anatomic form
Anatomic form was rated as satisfactory (excellent or acceptable) in 80% of the FPDs from China and in 81% of the FPDs from Sweden (Table 2). This difference was not statistically significant.

Color
Color was rated as satisfactory (excellent or acceptable) for 85% of the FPDs from China and for 95% of the FPDs from Sweden (Table 2). This difference was not statistically significant.

Approximal contacts

Approximal contacts were rated "good" in 40% of FPDs from China, compared with 48% for their Swedish counterparts (Table 3). Hard contacts were corrected by grinding. One Chinese and one Swedish approximal contact were recorded as "insufficient" and were corrected at the respective laboratories. No statistically significant difference was found between the Chinese and Swedish FPDs.

Table 2. Evaluation of marginal integrity of the crowns, anatomic form, and restoration color for each patient, according to CDA criteria.

	Marginal integrity		Anatomic form		Color	
	China	Sweden	China	Sweden	China	Sweden
Satisfactory						
Excellent	22	27	11	11	8	7
Acceptable	11	10	5	6	9	13
Unacceptable						
Correct	5	2	3	4	3	1
Replace	4	3	1	0	0	0
Total	42	42	20*	21	20*	21
Statistical analysis	ns		ns		ns	

* one registration record was missing for the Chinese restorations; statistical analysis was conducted for 20 pairs.

Occlusal contacts

Occlusal contacts were judged as "good" for 39% of the Chinese FPDs, compared with 15% for the Swedish FPDs (ns; Table 3). There are no registration records for three FPDs from China and one from Sweden. The reasons for this were an incomplete temporary bridge in the opposite jaw in the first unit, the second unit could not be properly seated on the abutment, and there were logistical difficulties with the third.

Collective comparison of qualitative parameters (marginal integrity, anatomic form and color, approximal and occlusal contacts) found no statistically significant difference between the FPDs from China and Sweden.

Table 3. Recorded approximal and occlusal contacts.

	Approximal contacts		Occlusal contacts	
	China	Sweden	China	Sweden
Good	8	10	7	3
Hard	11	10	5	10
Insufficient	1	1	6	7
Total	20*	21*	18**	20**
Statistical analysis	ns		ns	

* one Chinese registration record was missing; statistical analysis was conducted for 20 pairs.
** three Chinese and one Swedish registration records were missing; statistical analysis was conducted for 18 pairs.

Time taken for adjustments

There was no statistically significant difference in the total time used for adjustments between the FPDs from China and from Sweden. The mean time for adjustments was 39 minutes for Chinese FPDs (SD +/-37), and 38 minutes for Swedish FPDs (SD +/-27). The most common cause for adjustment was correction of hard approximal (No. 21) and occlusal (No. 15) contacts. The second most common reason was missing occlusal contacts (No. 13), which caused additional porcelain build-up. These restorations were returned to the laboratories and additional appointments were made with the patients. In four cases, restorations were returned to the technician for adjustment of anatomic form and color. In three cases from China, new impressions were made due to unacceptable marginal integrity and overly thin frameworks.

Bridge framework weight

All bridge frameworks made in China were lighter than those made in Sweden ($p<0.01$). The mean weight of the gold alloy frameworks made in China was 7.0 g, while those from Sweden weighed 10.6 g (Table 4). A comparison of gold alloy framework pairs (one Swedish and one Chinese framework made for each patient) found that the Chinese frameworks were 34% (mean; range 25-43%) lighter than those made in Sweden.

The mean weight of the CoCr alloy frameworks from China was 4.1 g, while those from Sweden were heavier at 5.7 g. Paired comparison of the CoCr alloy frameworks made for the same patient revealed that the Chinese frameworks were 22% (mean; range 7-50%) lighter than the Swedish counterparts.

The three Chinese castings that showed distortion and poor fit weighed 43% (patient no. 6), 32% (patient no. 11), and 50% (patient no.13; Fig. 1 and 2) less than the corresponding Swedish ones.

Composition of the alloys

The composition of the gold alloys according to the manufacturers, and the analysis of the Chinese and Swedish frameworks are presented in Table 5. Analysis of the Chinese gold alloy frameworks revealed a composition in accordance with DDA10-MK/PFM, with the exception of silver, which was not found. The analyses of gold alloys from the Swedish laboratories were in accordance with the manufacturer's

Figure 1. Patient no. 13. Upper FPD from Sweden and lower from China.

Figure 2. Patient no.13. FPD framework from China on the working cast. The framework was underdimensioned and showed flexibility when tested clinically, and gaps occurred at the crowns' margins.

Table 4. Mean weight and range of the bridge frameworks made in China and in Sweden in grams (g).

Alloy	China		Sweden	
	Mean	Range	Mean	Range
Gold (n=6)	7.0	4.8-9.4	10.6	7.4-15.4
Cobalt/Chromium (n=5)	4.1	2.2-5.1	5.7	2.8-10.2

Table 5. Composition of the gold alloys in the frameworks in percentage weight (%) according to the manufacturer and analysis (in parenthesis).

Framework	Element	China	Sweden		
		DDA10-MK/PFM	Sjödings M2	Alfa Ceramic 11	Sjödings Bio 2001
Gold alloy	Au	75 (74.9)	84 (85.2)	75 (74.9)	86.1 (85.6)
	Pd	17.9 (17.9)	5 (5.0)	11.0 (10.8)	
	In	4.5 (4.4)	1 (1.0)	1.0 (0.9)	
	Sn	1.0 (1.1)	0.5 (0.4)	1.0 (1.2)	
	Co	<1 (0.2)			
	Pt		7.9 (7.8)	3.0 (3.0)	11.4 (11.5)
	Ir		0.1	0.1	<2 (0.27)
	Ag	1.3	0.9	8.9 (9.5)	
	Cu		0.3 (0.3)		
	Zn		0.1 (0.09)		<2 (1.1)
	Fe		0.2 (0.17)		
	Ru				<2 (1.0)
	Ta				<2 (0.48)
	Mn				<2

documentation, with the exception of Sjödings M2, for which no silver content was found. No lead (detection limit 0.01% by weight), nickel, beryllium, or cadmium (detection limits 0.005% by weight) was found in the analyses.

Analysis of the CoCr alloy, Extreme-bond PC NP SP, from China showed less cobalt and chromium, and almost 20% more molybdenum, than that declared by the manufacturer (Table 6). A small amount of Ni (0.19%) was also found in the Chinese CoCr frameworks. According to the manufacturer, the CoCr alloy from China should not contain nickel. No lead, beryllium, and cadmium were found (detection limits 0.01% by weight). Analysis of the two CoCr alloy frameworks from Swedish laboratories corresponded well with the composition stated for Wirobond®C.

Compliance

All laboratories delivered the type of appliance that had been ordered. However, one Chinese bridge was made in two parts with an attachment connection, without any comment on this in the delivery documentation (Fig. 3).

For 11 Chinese frameworks, the gold alloy DDA12-MK/PFM (The Argen Corporation, San Diego, USA) was ordered. But when the 11 frameworks were delivered, the accompanying delivery documentation specified that nine contained DDA10-MK/PFM, and two CoCr Extreme-bond PC NP SP. However, judging by the appearance and weight of these last two frameworks, they were also made of gold alloy. For the corresponding Swedish situation, the gold alloys that had been ordered were also delivered, according to the delivery documentation.

For the seven cases where CoCr alloy was specified in the order, this alloy was delivered from both the Chinese laboratory and the Swedish laboratories, according to the invoices.

Costs of the fixed partial dentures

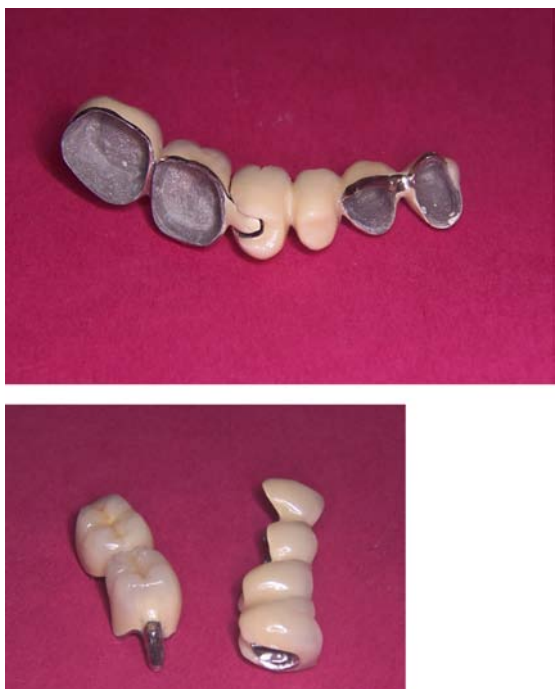
The gold alloys used in the Chinese FPDs were cheaper than those used in the Swedish FPDs (Table 7) ($p<0.01$). The labor costs for the Chinese restorations (mean SEK 1774; range SEK 690–4140) were 52% lower than the Swedish ones (mean SEK 3662; range SEK 1329–8910). Pairwise comparison of the FPDs revealed that the total cost (material plus labor cost) of the Chinese restorations was 53% (SD 9%) lower than the Swedish ones ($p<0.01$) (Table 8).

The total costs for the gold and CoCr alloy prostheses are presented in Table 8. Some Swedish technicians did not charge for the CoCr alloy itself, but charged extra for time-consuming work with the CoCr alloys. Therefore, only the total cost for material and work together is presented for CoCr alloy prostheses. The CoCr alloy FPDs from China cost less, SEK

Table 6. Composition of the CoCr alloys in the frameworks in percentage weight (%) according to the manufacturer and analysis (in parenthesis).

Framework	Element	China Extreme-bond PC NP SP	Sweden Wirobond® C
Cobalt/ Chromium-alloy	Co	59.5 (49.5)	61 (64.8)
	Cr	31.5 (25.8)	26 (24.7)
	Mo	5 (24.4)	6 (5.0)
	W		5 (5.4)
	Si	2	
	Mn	1	
	Other	<1	
	Ni	(0.19)	(<0.01)

Figure 3. Patient no.6. FPD from China made in two parts.



2354 (mean; range SEK 780–5460), than those from Sweden, SEK 5587 (mean; range SEK 1470–13399). A comparison of the two FPD CoCr restorations made for the same patient found that the Chinese version was 56% (mean; SD 4%) cheaper than the Swedish one ($p<0.01$).

Discussion

In dentistry, it is desirable to minimize costs for patients without lowering quality. But no previously published study has compared quality vs cost of two fixed prostheses made on the same teeth in a patient, using standardized criteria. So, the present study aimed to clinically compare the quality of fixed partial dentures made in Sweden with samples from China, where prices are considerably lower.

The dental laboratories used in the study were not aware of their participation. From a Swedish perspective, the Chinese laboratory is large, with 180 technicians. It was not possible to ascertain exactly how many dental technicians were involved in producing the dentures. However, according to personal communication with the laboratory, 10–15 technicians are involved in the production of the Swedish gold alloy frameworks, 10–15 other technicians work with CoCr, and yet another group of 10-15 conducts the porcelain part of the work. In the Swedish laboratories, 32 technicians were involved, with 5–10 technicians involved in the casting process of the gold and CoCr alloy frameworks, while the porcelain build up involved a further 5–7 technicians.

The CDA evaluation system for assessing the clinical quality of dental care has been used since 1977 (4, 13). It was used in this study to evaluate marginal integrity, anatomy, and color. The marginal integrity of the Chinese FPDs was of lower quality, with 79% rated as satisfactory compared to 88% of the Swedish FPDs. When the marginal integrity of the FPDs was recorded as "unacceptable", the main reasons were poor fit and deficient margins. Form was rated as satisfactory in 80% and 81% for the Chinese and Swedish restorations, respectively, and color as satisfactory in 85% and 95%, respectively. When the lowest rating from the three characteristics marginal integrity, color, and anatomic form was used to determine the overall rating for the restoration, 57% of the Chinese FPDs and 62% of the Swedish counterparts were judged as satisfactory. However, the differences between the quality parameters above were not statistically significant. These frequencies are low compared to those shown in other clinical studies, when fixed prostheses have been evaluated retrospectively after different periods of time in the mouth (6, 10, 15). The present study evaluated restorations after delivery from the laboratories, but before any adjustments had been made. When the restorations were ready for cementation, they all had been corrected to a satisfactory quality, i.e. were "satisfactory" to a level of 100%.

No difference was found when approximal and occlusal contacts were compared. The occlusal contacts were judged as good in 39% of the FPDs from China and 15% of the FPDs from Sweden. These frequencies seem relatively low and hard contacts were the most common reason for a poor rating, especially for the occlusal contacts of the Swedish FPDs. Adjusting these contacts is routine clinical

Table 7. The costs in SEK of gold alloy per gram and labor for FPDs made in Chinese and Swedish dental laboratories (Mean; Range).

	Material (SEK/g)		Labor (SEK)	
	China Mean (Range)	Sweden Mean (Range)	China Mean (Range)	Sweden Mean (Range)
Gold alloy	227 (159–330)	334* (223–423)	1774 (690–4140)	3662* (1329–8910)

* Statistically significant $p<0.01$.

Table 8. The total cost (SEK) for material and labor (Mean; Range), for FPDs made in gold alloy and CoCr alloy in the Chinese and Swedish dental laboratories, and the cost of the Chinese prostheses as a percentage of the Swedish counterparts when compared in pairs.

	Total cost (SEK)		Relation %
	China Mean (Range)	Sweden Mean (Range)	Mean SD
Gold alloy/ ceramics	2771 (780–7243)	5831 (2255–14531)	47*9
Cobalt-Chromium alloy/ ceramics	2354 (780–5460)	5587 (1470–13399)	44*4

* statistically significant $p<0.01$.

procedure when an FPD is tested on a patient, but the quality of occlusion will differ between dental laboratories. We have not found any other study with which to compare our results.

It has been shown that the deformation of a bridge may take place in directions that deviate largely from the axial one (8). The straining pattern in a bridge under pressure in a clinical situation has been shown to be very complex. Thus, the dimensions should be large not only vertically but also horizontally (7). In this study, as the two appliances compared were made on the same teeth, the weight was considered to well reflect the differences in overall dimension. All frameworks made in China, both those of gold alloy and of CoCr alloy, were lighter than those made in Sweden. The weight range of the Chinese frameworks was 50-93% of their Swedish counterparts. Only a fraction of this difference could be due to variations in alloy density, as the appliance pairs compared were made of an alloy in the same composition range (2). The difference in weight indicated that the Chinese and Swedish framework designs differed considerably. The Chinese bridges seemed designed for a larger porcelain coat and in three cases were judged as being too weak for clinical use. The leverage effect of pontics caused crowns in the FPDs to lift from end abutments with finger pressure only (30-50N). These frameworks weighed 43% (6 units, gold alloy), 32% (4 units, gold alloy), and 50% (7 units, CoCr alloy) less than the corresponding Swedish ones. This elastic deformation was regarded as unacceptable as occlusal forces during chewing could well reach these levels and during hard biting reach forces of 200–300N and even higher levels (9, 12). In such a situation, retention of the prosthesis will rely only on the cement, which would not be regarded as satisfactory.

For economic reasons, not all appliances in the study were analyzed. Eleven FPDs were selected at random, six Chinese and five Swedish. Analysis of the gold alloys indicated that they were nearly in accordance with the composition stated by the laboratories and manufacturers. Analysis of the Chinese CoCr alloy found that it differed considerably from the composition declared and also contained small amounts (0.19%) of nickel.

As regards the compliance of the Chinese and Swedish laboratories, the main deviation was the material delivered from the Chinese laboratory. On the order sheet, two types of high noble gold alloys for metal-ceramic prostheses could be chosen. However, only one of them, that with a lower gold content (75%), was delivered. For two orders of gold alloy, the invoice declared that the FPDs delivered were made in another type of alloy, a CoCr alloy. However, these appliances were probably made in a gold alloy. In this context, it should be kept in mind that only one Chinese laboratory was used in the study.

Contact allergy to metals present in dental alloys and its relevance in the oral environment is not clear and the concentrations needed for sensitization to metals released from appliances are not known (1, 11, 14). However, published reports do indicate a relationship between allergy to metals present in dental alloys and the presence of these metals in the mouth (1, 3). It is therefore of the utmost concern that the material indicated on the invoice is in fact the material delivered. It is the responsibility of the dentist to know which alloy is used and that it is biologically acceptable for the patient.

FPDs from China, regardless of material, cost much less than Swedish FPDs, and Chinese labor costs were less than half of those in Sweden. The gold alloy from China (DDA10-MK/PFM) contained less gold than two of the gold alloys from the Swedish laboratories (Sjödings M2 and Sjödings Bio 2001). This reduced the total cost, as did the smaller amount of material used.

To evaluate quality from a long-term perspective, the restorations must be tracked and studied frequently over several years. The warranty from the Chinese laboratory is six years compared to two years for the FPDs from the Swedish laboratories. However, these warranties cover the cost of the technical work only, not the cost for the dental work in the clinic and the expense and inconvenience for the patient.

We believe that the methods used to evaluate the clinical quality of FPDs in the present study well reflect the demands of the dentist in the clinical setting, and that the comparisons of quality between the dental laboratories are satisfactory. This study may be improved by more samples and more advanced methods, both of which we hope will be available in the future.

Conclusions

- There was no difference in quality of marginal fit, color, form, and approximal and occlusal contacts between the FPDs from China and Sweden.
- The bridge frameworks made in the Chinese

dental laboratory were thinner and lighter than those made in Swedish laboratories.
- Three out of eleven Chinese bridges were unacceptable due to unsatisfactory dimensions.
- There was no difference in time taken for adjustments.
- Analysis of the CoCr alloy from China revealed both a different composition than that stated by the manufacturer, and the presence of a small amount of nickel.
- In terms of total cost, the FPDs from China were about 50% cheaper than those from Sweden.
- In 11 out of 14 orders of gold alloy prostheses from China, a different alloy was delivered.

Acknowledgements
We thank study coordinator Gunnel Enoksson for practical help and Folktandvården Stockholm AB for financial support.

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Frequent jaw-face pain in chronic Whiplash-Associated Disorders

Birgitta Häggman-Henrikson, Johan Grönqvist, Per-Olof Eriksson

Abstract

◎ Chronic Whiplash-Associated Disorders (WAD) present with frequent pain in the neck, head and shoulder regions but the presence of frequent jaw-face pain is unclear. The aim of the study was to investigate the frequency of jaw-face pain, pain in other regions, and general symptoms in chronic WAD patients. Fifty whiplash-patients and 50 healthy age- and sex-matched controls were examined by questionnaire for pain in the jaw-face, pain in other regions and other symptoms.

In contrast to healthy, a majority of the WAD patients (88%) reported frequent pain in the jaw-face, in addition to frequent pain in the neck (100%), shoulders (94%), head (90%) and back (72%). The WAD patients also reported stiffness and numbness in the jaw-face region, and frequent general symptoms such as balance problems, stress and sleep disturbances.

The result suggests that frequent pain in the jaw-face can be part of the spectrum of symptoms in chronic WAD. The finding of self-reported numbness in the jaw-face indicates disturbed trigeminal nerve function and merits further investigation. We conclude that assessment of WAD should include pain in the jaw-face region. A multidisciplinary rehabilitation program including dentists, preferably specialized in the area of orofacial pain, should be advocated after whiplash injury.

Key words

Face, jaw, neck, pain, whiplash injuries.

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Frekvent smärta i ansikte-käkar vid kroniska whiplashbesvär

Birgitta Häggman-Henrikson, Johan Grönqvist, Per-Olof Eriksson

Sammanfattning

◎ Patienter med kroniska besvär efter whiplashskada rapporterar vanligen frekvent smärta i nacke, huvud och axlar. Det är oklart i vilken utsträckning de även har frekvent smärta i käk- och ansiktsregionen.

Syftet med denna undersökning var att studera förekomst och frekvens av smärta i käk- och ansiktsregionen, smärta i andra regioner och övriga symptom hos patienter med kroniska besvär efter whiplashskada. Femtio whiplashpatienter och 50 friska köns- och åldersmatchade individer undersöktes med en enkät innehållande frågor om förekomst och frekvens av smärta i käk- ansiktsregionen, smärta i andra regioner samt övriga typiska symtom efter whiplashskada.

I motsats till friska, rapporterade en majoritet av WAD-patienterna frekvent smärta, inte bara i nacke (100 %), huvud (90 %) och rygg (72 %) utan även i käk- och ansiktsregionen (88 %). Dessutom rapporterade patienterna stelhet och domningar i käk-ansiktsregionen och frekventa generella symtom såsom balansstörningar, stress och sömnsvårigheter. Resultaten visade att frekvent smärta i käk- och ansiktsregionen är vanligt förekommande bland patienter med kroniska besvär efter whiplashskada. Fynden av domningar i käkar-ansikte tyder på neurologiska störningar i trigeminusregionen vilket bör undersökas i ytterligare studier. Slutsatsen från dessa resultat är att bedömning av nackskadade patienter bör inkludera förekomst av smärta i käk-ansiktsregionen. Rehabilitering av whiplashpatienter bör baseras på ett multidisciplinärt omhändertagande, vilket bör inkludera tandläkare.

Introduction

The term whiplash describes a hyperextension-flexion injury to the neck. The incidence in Sweden is about 1-2 per 1000 inhabitants, mostly from traffic injuries but also from other traumas such as falls (6). The most common signs and symptoms after whiplash injury are neck pain, impaired neck movements and headaches (36, 39). A range of other symptoms such as vertigo, disturbances in memory, concentration, sleep, hearing and vision functions are also reported (19, 37, 39). The variety of symptoms, including neck pain and dysfunction, are embraced in the term Whiplash Associated Disorders, WAD. Although most individuals recover from an acute whiplash injury (36), a substantial number of individuals will develop chronic WAD (17). This patient group cause significant demands on the health care system and costs for the society in terms of sick leave, rehabilitation and disability pensions (7).

WAD embraces pain in other body regions than the neck, such as shoulders and back, but varying prevalence of jaw-face pain is reported (9, 28, 33, 44). Furthermore, pain during eating and chewing has been reported in chronic WAD (18, 22), and a recent study on cardio-vascular and jaw muscle activity during chewing shows widely distributed pain in all body regions, including the jaw-face (27). However, with a few exceptions, reports in medical journals on typical symptoms and signs in WAD generally have scarce information about pain and dysfunction in the jaw-face. Thus, currently there seems to be a gap in the body of knowledge of jaw-face pain in WAD, and specifically in relation to pain in other body regions.

Jaw movements are the result of coordinated activation of jaw and neck muscles, with simultaneous movements in three joint systems, the temporomandibular, atlanto-occipital and cervical spine joints (15). Head-neck movements are an integral part of jaw activities, with head extension in jaw opening and head flexion in jaw closing (13). Actually, in jaw opening, the head starts to move simultaneously with, or even before, the lower jaw, which indicates recruitment of neck muscle motoneurons in a feed-forward mode (23). Consequently, as jaw function comprises the integrated control of movements of both the lower jaw and the upper jaw, i.e. the head-neck, jaw behaviours such as mouth opening, biting and chewing rely on linked motor control of the jaw and neck motor systems. Pain is a significant cause of a disturbed neuromuscular control, so also for the jaw motor system (40, 41). Thus, neck pain and dysfunction following whiplash injury may impair jaw function. In fact, in chronic WAD an association has been shown between neck pain and dysfunction and deranged jaw function (16). The findings include reduced amplitude for both lower jaw and head-neck movements, disturbed coordination of jaw and head-neck movements (14, 20, 47), and reduced endurance during chewing (22).

Successful treatment of disease, WAD included, requires profound knowledge and understanding of symptoms and signs of the disease. Therefore, knowledge whether the typical spectrum of symptoms embracing WAD can include also frequent pain in the jaw-face would benefit assessment and management of these patients. In the present study, we investigated in a group of 50 chronic WAD patients the frequency of jaw-face pain, pain in other body regions and frequency of other symptoms typical for chronic WAD. The results were compared with data from a control group of 50 age- and sex-matched healthy subjects without a history of neck injury.

Materials and Methods

WAD patients and healthy subjects

Eleven male and 39 female chronic WAD patients, (aged 20-68) with a mean age of 39 years, (SD: 11), with pain and impaired movements in the neck of more than 6 months, were compared with 50 age- and sex-matched healthy subjects, mean age 39 years, (SD: 11). The WAD group consisted of consecutive patients referred to the department of Clinical Oral Physiology, University Hospital of Umeå Sweden, for assessment and management of jaw and neck pain and dysfunction that had developed following head-neck trauma, mostly in motor vehicle accidents. The duration between trauma and examination was 1 to 7 yrs (median, 3 years). They had been diagnosed and classified by physicians as WAD class II or III according to the Quebec classification (36), in which grade I denotes neck pain, grade II neck pain with musculoskeletal signs, grade III neck pain with neurological signs, and grade IV neck pain with fracture. Exclusion criteria for the healthy subjects were history of neck trauma and joint and muscle diseases. All participants gave informed consent according to the World Medical Association's declaration of Helsinki. The Ethics committee of the University of Umeå approved the investigation.

Questionnaire

Symptoms in both healthy subjects and WAD patients were assessed by means of a questionnaire

containing 22 items about frequency of pain in different body regions, frequency of symptoms in the jaw-face-head region, and frequency of general symptoms. Each question had five options: (0) No, never; (1) Yes, seldom, every year; (2) Yes, often, every month; (3) Yes, very often, every week; and (4) Yes, always, every day.

Analysis

In the analysis, scores 1 or 2 were classified as "low frequency", and 3 or 4 as "frequent". The questions were grouped in three sections:

A. Pain (9 items; throat, ears, mouth, jaw-face, head, neck, shoulders, back and hip)
B. Symptoms in the jaw-face-head region (8 items; stiffness jaw/face/tongue, numbness jaw/face/tongue, nose/throat/sinus problems, tinnitus, hearing problems, balance problems, vertigo and visual problems)
C. General symptoms (5 items; stress/tension, depression, problems concentration/memory, sleeping problems and digestive problems)

Statistics

Differences between the groups were tested with Chi-square test, with Bonferroni adjustment for multiple tests. A probability level of 0.05 was considered as statistically significant.

Results

The frequency of symptoms was scored, as low (yearly/monthly) and high frequent (weekly, daily). Compared to healthy, the WAD patients reported a higher frequency of pain for all regions, and a higher frequency of head-neck symptoms and general symptoms (Table 1).

Total number of reported symptoms

The average number of reported symptoms was summarized for all individuals. Compared to healthy, the WAD patients reported a higher number of symptoms, especially for frequent symptoms (Fig.1). The highest number of frequent symptoms reported was for pain, with the average WAD patient reporting frequent pain in six locations (Table 2).

Frequent (weekly and daily) pain

In addition to the frequent neck pain that all WAD patients reported, a majority also reported frequent pain in the shoulders, head, jaw-face and back. Many patients also reported frequent pain in the mouth, ear, hip and throat regions (Fig.2). Of the WAD pa-

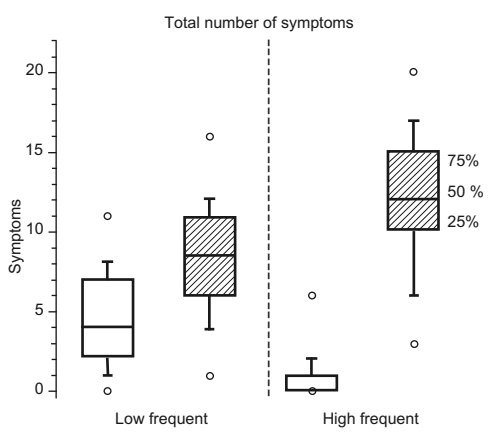
Table 1. Frequency of symptoms for healthy and WAD groups.

Symptoms	Healthy (n=50)		WAD (n=50)	
	Median [a]	(Min-Max)	Median [b]	(Min-Max)
Pain				
Throat	0	(0 – 1)	1	(0 – 4)
Ears	0	(0 – 1)	3	(0 – 4)
Mouth	0	(0 – 1)	3	(0 – 4)
Jaw-face	0	(0 – 2)	3	(0 – 4)
Head	1	(0 – 3)	4	(2 – 4)
Neck	1	(0 – 3)	4	(3 – 4)
Shoulders	1	(0 – 3)	4	(0 – 4)
Back	1	(0 – 3)	3	(0 – 4)
Hip	0	(0 – 3)	2	(0 – 4)
Symptoms head				
Stiffness jaw/face/tongue	0	(0 – 3)	3	(0 – 4)
Numbness jaw/face/tongue	0	(0 – 1)	2	(0 – 4)
Nose/throat/sinus	1	(0 – 2)	2	(0 – 4)
Tinnitus	0	(0 – 4)	3	(0 – 4)
Hearing	0	(0 – 3)	2	(0 – 4)
Balance	0	(0 – 1)	3	(0 – 4)
Vertigo	0	(0 – 3)	3	(0 – 4)
Vision	0	(0 – 3)	3	(0 – 4)
General symptoms				
Stress, tension	1	(0 - 3)	3	(0 – 4)
Depression	1	(0 – 2)	1	(0 – 4)
Concentration, memory	1	(0 – 2)	3	(0 – 4)
Sleep	1	(0 – 4)	3	(0 – 4)
Digestive	1	(0 - 3)	2	(0 – 4)

[a] Median values indicate frequency of reported symptoms for the groups: (0) No, never; (1) Yes, seldom, every year; (2) Yes, often, every month; (3) Yes, very often, every week; and (4) Yes, always, every day

b $p < 0.01$ for all comparisons between healthy and WAD.

Figure 1. The average number (0-22) of low (yearly/monthly) and high frequent (weekly/daily) symptoms for the healthy (unfilled boxes, n=50) and WAD (hatched boxes, n=50) groups.



tients who did not report frequent jaw-face pain (12%), all but one individual reported low frequent jaw-face pain. A minority of the healthy subjects reported any frequent pain, mainly in the shoulder and head-neck regions.

Frequent (weekly and daily) symptoms head region

Many WAD patients reported frequent problems also with balance, tinnitus, vertigo and vision, in addition to stiffness and numbness in the jaw-face region. A few healthy individuals reported frequent problems with vision and tinnitus (Fig. 3).

Frequent (weekly and daily) general symptoms

Frequent general symptoms commonly reported in the WAD group were stress, sleep disturbances and digestive problems (Fig. 4). Some individuals in the healthy group reported frequent sleep disturbances and stress.

Table2 Average number of low (yearly/monthly), and high frequent (weekly/daily) pain, symptoms head region and general symptoms.

Symptoms	Healthy (n=50)		WAD (n=50)	
	Mean	(SD)	Mean	(SD)
Pain [a]				
Low	3.1	(1.9)	1.7	(1.5)
High	0.3	(0.7)	6.3	(2.0)
Head [b]				
Low	2.0	(1.5)	2.6	(1.5)
High	0.2	(0.4)	4.6	(2.1)
General [c]				
Low	3.3	(1.2)	1.6	(1.1)
High	0.3	(0.6)	2.9	(1.3)

[a] 9 items; throat, ears, mouth, jaw-face, head, neck, shoulders, back and hip

[b] 8 items; stiffness and numbness jaw/face/tongue, nose/throat/sinus problems, tinnitus, problems hearing, balance, vertigo and visual problems

[c] 5 items; stress/tension, depression, problems concentration/memory, sleeping problems and digestive problems.

Figure 2. Percentage of individuals reporting frequent pain (weekly/daily: score 3-4) in the healthy (unfilled boxes, n=50) and WAD (hatched boxes, n=50) groups.

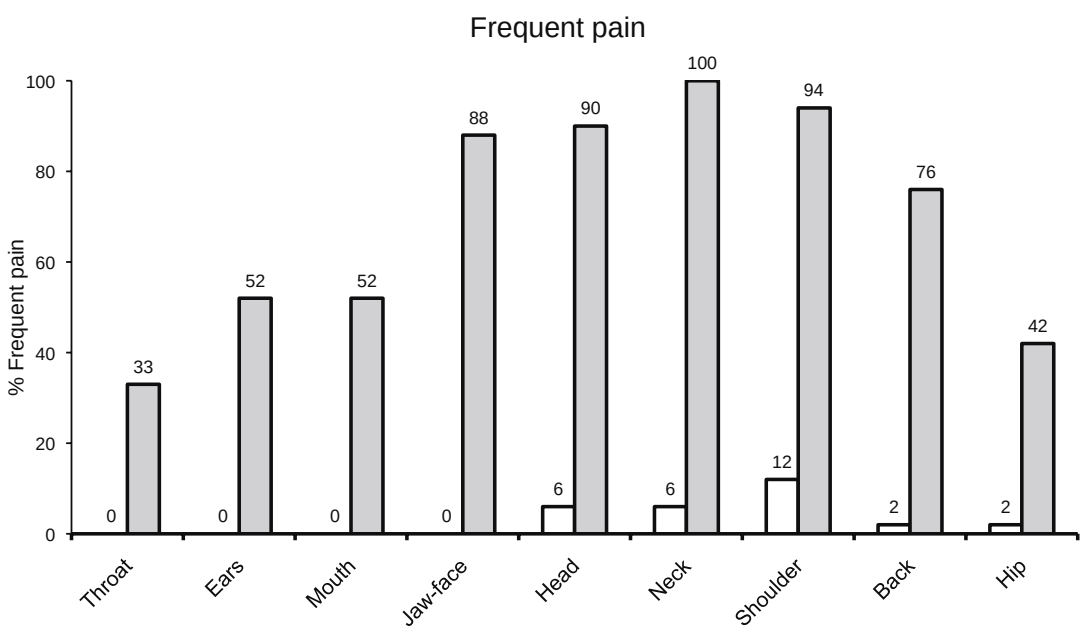


Figure 3. Percentage of individuals reporting frequent symptoms head (weekly/daily; score 3-4) in the healthy (unfilled, n=50) and WAD (filled, n=50) groups.

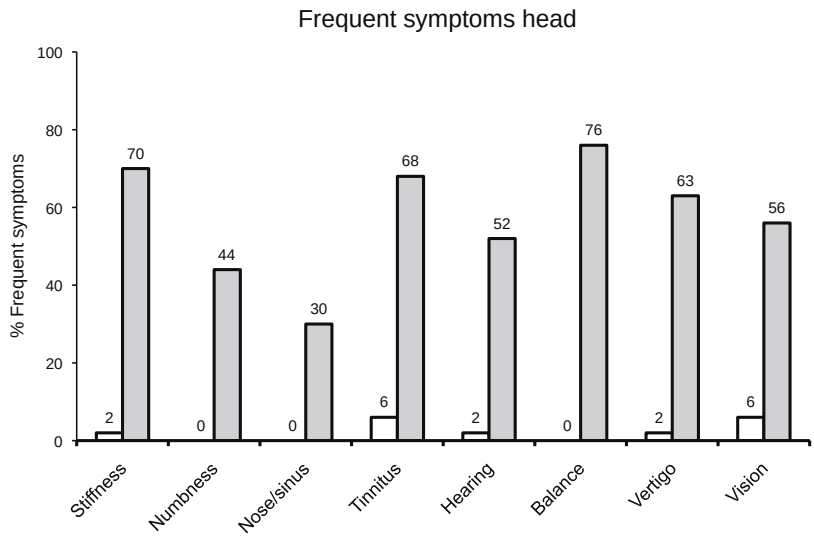
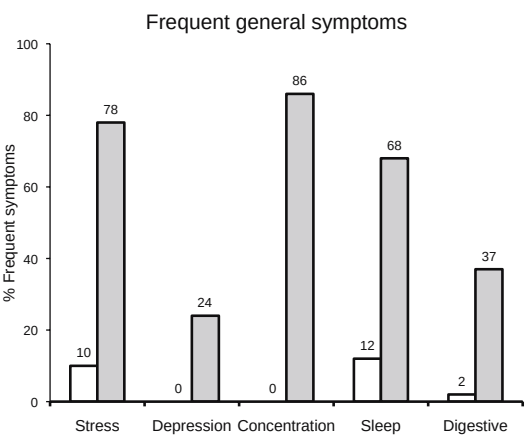


Figure 4. Percentage of individuals reporting frequent general symptoms (weekly/daily; score 3-4) in the healthy (unfilled, n=50) and WAD (filled, n=50) groups.



Discussion

The variety of symptoms in the present study group was in accordance with previous findings in chronic WAD (19, 30, 31, 39), indicating that our WAD group was representative of chronic WAD. The main finding in the present investigation was that jaw-face pain was almost as frequent as neck pain and as frequent as pain in the head and shoulders. These results suggest that the typical spectrum of symptoms following a whiplash injury can also include frequent pain in the jaw-face. The result has implications concerning assessment and rehabilitation of chronic WAD, discussed below, and for evaluating the patophysiology in chronic WAD. More longitudinal studies are needed to determine the time-scale and incidence for development of jaw-face pain after neck injury.

Is the finding of frequent jaw-face pain in chronic WAD remarkable? We believe not. Previous experimental and clinical studies have shown a close relationship and functional linkage between the jaw and neck regions (1-3, 13, 15, 16, 21, 23, 46). Thus, a wide range of head-neck movements are influenced or initiated by input from oro-facial structures, indicating that movement of the head is an integral part of normal jaw function. In fact, the trigeminal input has been suggested to be one of the strongest to those neck motoneurons involved in head movement (2). This is supported by findings in healthy subjects

of impaired jaw function after experimental restriction of head-neck mobility (23), and in patients with restricted head-neck mobility due to pain from neck injury (20). Previous studies have reported an association between pain in the jaw-face and pain in the neck region (10, 12, 43, 45). In addition, evidence from experimental studies support the existence of intersegmental nociceptive connections between the cervical spine and the trigeminal regions (42). Experimental studies have also shown that reflex connections between chemosensitive muscle afferents and the fusimotor system exist intersegmentally, i.e. between the jaw muscles and the cervical muscles (24). Moreover, it has been proposed that the fusimotor muscle spindle system plays an important role in the onset, spread and perpetuation of chronic muscle pain (26), and that such a mechanism seems to exist also in the jaw system (8, 32). Taken together, these findings indicate a connection between the jaw and the neck regions in the spread of pain. Hence, our present findings of frequent pain in the jaw-face in WAD patients are in line with previous clinical and experimental findings.

The nociceptive system and the autonomic nervous systems, both of which are critical for survival, interact at both peripheral and central levels (4, 5, 11, 34). Chronic pain is proposed to be a manifestation of plasticity within central and peripheral nociceptive pathways, involving a variety of control mechanisms and effects on the cardiovascular system, the neuroendocrine system and the brain (41). Furthermore, muscle metabolites released during muscle pain, ischemia and sustained static muscle contraction, may cause excitatory influences on the sympathetic system via chemosensitive muscle afferents. Increased sympathetic activity leads to increased muscle stiffness and decreased blood flow, resulting in more metabolites and further increased sympathetic activity, and as a result, disturbances in proprioception, stiffness regulation and motor control via effects on the gamma muscle spindle system (25, 26). In fact, a recent study in chronic WAD (27) shows that natural chewing evoked an increased autonomic response exhibited as a higher increase in heart rate compared to healthy controls. The study also reports pressure pain in widespread body regions not directly subjected to the whiplash trauma, in line with the knowledge that autonomic activation may lead to lowered sensory and pain thresholds (42). Moreover, widespread sensory hypersensitivity reported in WAD, contrasts localised cervical hypersensitivity in idiopathic neck and shoulder pain (35). From experiments and clinical observations *Passatore & Roatta* (29) concluded that increased sympathetic activation affects muscle microcirculation, muscle contractile properties and muscle spindle function, leading to central sensitisation, which might contribute to the development of chronic pain. The finding in our present study of frequent pain in the jaw-face in chronic WAD may reflect spread of pain related to close sensory and motor linkage between the jaw and neck, as well as to lowered sensory and pain thresholds due to sensitisation of the central nervous system.

The high frequency of numbness in the jaw-face region found in the present study, indicates neurological signs in the trigeminal nerve region, and has not been reported previously in chronic WAD. This matter should be further explored since it may contain knowledge of importance for a better understanding of the patophysiology and assessment and management of chronic WAD. Furthermore, this finding together with previous data in chronic WAD on impaired sensory function in the facial skin (38), can have implications for the classification of WAD grade III. The present grade III classification includes neurological signs but excludes the trigeminal nerve region (36). Therefore, the WAD classification could be improved if data from examination of the trigeminal nervous system was included. In fact, a recent study in chronic WAD reports that based on findings also of disturbed trigeminal nerve sensory function, all patients fulfilled the criteria for WAD grade III (27).

Knowledge about pain in the jaw-face region in relation to pain in other body regions could provide further insight into mechanisms behind development of widespread pain, and benefit the clinical approach for chronic WAD. Including the jaw-face region in routine investigation could also facilitate a more individualized rehabilitation regimen. Thus, from the present results we suggest that jaw-face pain should be recognized as a typical symptom in chronic WAD, and be included in the assessment. A multidisciplinary rehabilitation program including dentists, preferably specialized in the area of orofacial pain, should be advocated after whiplash injury.

Acknowledgements

Supported by the Faculty of Medicine, Umeå University, and RTP (The Swedish Association for Survivors of Accident and Injury).

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Patients' adherence to hard acrylic interocclusal appliance treatment in general dental practice in Sweden

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

Abstract

◎ The aims of the present study were to investigate patient adherence to treatment with hard acrylic interocclusal appliance in general dentistry in Sweden and to see if some general factors could predict patient adherence or non-adherence.

During the period January - May 2009 a postal questionnaire was sent to all adult patients (≥20 years of age) that had received a hard acrylic interocclusal appliance from the public dental health service in the County of Uppsala during 2007 (n=388). The same questionnaire was also sent to all adult patients that had received a hard acrylic interocclusal appliance at a specialist clinic during the same year (n=69).

The response rate in general dental practice was 71 % and at the specialist clinic the response rate was 91 %. In general dental practice, 97 % of the hard acrylic interocclusal appliances were stabilisation appliances. At the specialist clinic other types of interocclusal appliances was used to a greater extent. A vast majority of patients in both general dental practice and at the specialist clinic experienced that the interocclusal appliance had a positive treatment effect. In general dental practice, 73 % of the patients still used their interocclusal appliances 1½-2 years after they had received them. The corresponding figure at the specialist clinic was 54 %. The main reasons for not using the interocclusal appliance, besides disappearance/reduction of TMD symptoms, were different kinds of comfort problems.

From the results of this study it is concluded that the patient adherence to hard acrylic stabilisation appliances made in general dental practice in Sweden is good. It can also be concluded that a perceived good treatment effect, as well as treatment of more long-term conditions, predicted a better patient adherence to hard acrylic stabilisation appliances. More studies concerning factors affecting patient adherence in TMD therapy are warranted.

Key words

Temporomandibular disorders; splint; dentistry; compliance; concordance; adherence

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Följsamhet till behandling med bettskena i hård akrylat inom allmäntandvården i Sverige

ERIK LINDFORS, MARTTI HELKIMO, TOMAS MAGNUSSON

Sammanfattning

◎ I över ett sekel har bettskenor använts vid behandling av käkfunktionsstörningar (eng. temporomandibular disorders, TMD). En förutsättning för att en behandling skall vara effektiv är att patienten följer de råd och rekommendationer som ges av vårdgivaren, d.v.s. uppvisar en god följsamhet.

Målsättningen med studien var att analysera grad av följsamhet vid behandling med bettskena i hård akrylat inom allmäntandvården i Sverige samt att utröna om vissa generella faktorer påverkar följsamheten.

En enkät skickades per post till samtliga vuxna patienter (≥20 år) som erhållit bettskena i hård akrylat inom Folktandvården i Uppsala län under 2007 (n=388). Samma enkät skickades även till samtliga vuxna patienter som under samma år fått en bettskena i hårt akrylat vid avdelningen för Klinisk Bettfysiologi vid Odontologiska Institutionen i Jönköping (n=69). Enkäten var uppdelad i 9 flervalsfrågor med följande kategorier: typ av bettskena, indikation, behandlingseffekt, frekvens av användning, orsak till att man slutat använda bettskenan. Fyra av frågorna gav möjlighet att lämna ett öppet skriftligt svar.

Svarsfrekvensen inom allmäntandvårdsmaterialet var 71 % och i specialistmaterialet var motsvarande siffra 91 %. Den vanligaste förekommande bettskenan inom allmäntandvården var stabiliseringsskenan (97 %). Inom specialisttandvården gjordes ett större antal andra bettskenetyper. En majoritet av de patienter som svarade på enkäten upplevde en viss alternativt god behandlingseffekt av bettskenebehandlingen. Inom allmäntandvården använde 73 % av patienterna sin bettskena 1½-2 år efter att bettskenan lämnats ut. Motsvarande siffra inom specialisttandvården var 54 %. Både inom allmän- och specialisttandvård var den huvudsakliga orsaken till att patienterna inte fortsatte använda sin bettskena förutom att de bettfysiologiska symtomen hade avklingat/reducerats, bristande komfort.

Från studien kan man konkludera att följsamheten till behandling med stabiliseringsskena inom allmäntandvården i Sverige är god. Studien visar även att en stor majoritet av patienter som erhåller stabiliseringsskena upplever viss alternativt god behandlingseffekt. En god behandlingseffekt och behandling av mer långvariga symtom verkar prediktera en bättre följsamhet. Fler studier som undersöker vilka faktorer som styr följsamheten vid behandling av TMD behövs.

Introduction

Temporomandibular disorders (TMD) is a group of conditions affecting the temporomandibular joints (TMJ) and masticatory muscles. The most common symptom of TMD is pain, usually localized in the muscles of mastication, the preauricular area and/or the TMJs. TMD is frequently accompanied by headache, restricted mouth opening capacity, and pain in connection to chewing or other jaw functions, and thus reduces the patients' quality of life (32).

For more than a century, different kinds of interocclusal appliances have been used for treatment of e.g. bruxism and TMD (17, 20). The most commonly used appliances in Sweden are the stabilisation appliance made in hard acrylic (Fig. 1a) and the soft/resilient appliance (Fig. 1b) (22). It has been estimated that approximately 30 000 - 40 000 interocclusal appliances are made every year in Sweden (23), making an incidence per year of approximately 0.42% to 0.57% in adult individuals.

Figure 1a. Example of a hard acrylic stabilisation appliance, Michigan type.

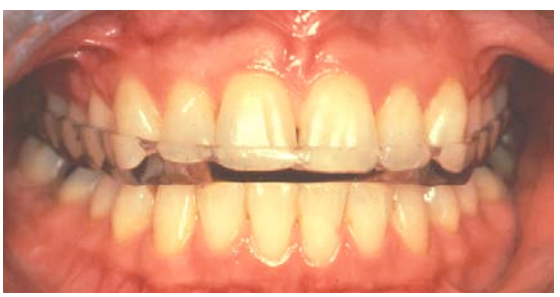
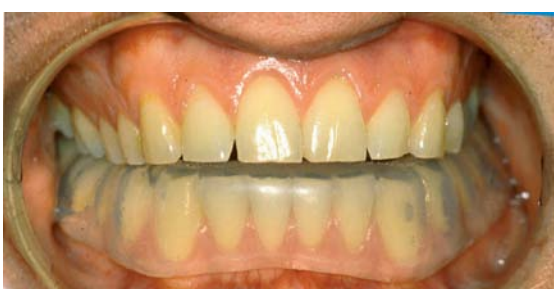


Figure 1b. Example of a soft/resilient appliance.



The stabilisation appliance is the appliance which has the best scientific support for efficacy and effectiveness. *Ekberg et al* (9-11, 13-15) have in a number of randomised, controlled short- and long-term trials shown that stabilisation appliances have a favourable effect on TMD of both myogenous and arthrogenous origin. Other studies (25, 26) have reported a correlation between tension-type headache and TMD and recommend TMD-treatment in patients with TMD and recurrent headache. *Ekberg et al* (12) reported a positive effect on tension-type headache after treatment with stabilisation appliances, both in short- and long-term, in patients with TMD of mainly arthrogenous origin. Several studies have shown that treatment with stabilisation appliances reduce symptoms and clinical findings in more than 80 % of patients with TMD (5, 6, 27, 31). Systematic reviews have also shown that treatment with stabilisation appliances is better than no treatment in the management of TMD (1, 38).

Treatment regimens cannot be effective unless the patient follows the treatment recommendations and maintain the treatment (7, 16). The terms compliance and adherence have often been used interchangeably to describe the patients´ engagement in the treatment procedure. The term compliance connotes a negative patient - provider relationship where the patient follows the care providers "orders" passively. The use of the term compliance has therefore been heavily criticised (19). Adherence is used in this paper because it suggests a positive patient - provider relationship where the patient is active and follows the treatment recommendations due to a mutual agreement with the care provider (37).

The problem of non-adherence is extensive. *Donovan & Blake* (8) have shown that 10 % to 85 % of all patients were non-adherent to treatment recommendations depending on treatment modality and method of measurement. Other studies have reported that 30 % to 70 % of all patients fail to adhere to recommended health instructions (21, 36, 39).

Many different factors have been proposed to influence patient adherence. Side effects of treatment (29, 41), negative attitude towards the given therapy (4, 29), forgetfulness (4, 41), ignorance (42), treatment costs (30, 42) and low confidence in health care (18, 33) are some factors that have been discussed. In general, the patients attitude toward disease/illness and treatment seems to be of great importance to the degree of adherence.

In dentistry the problem of non-adherence is obvious in the treatment of periodontal disease. Inadequate oral hygiene may lead to periodontal treatment failure in the long term, even with professional supportive therapy (34). Consequently, success in periodontal treatment is highly dependent on the patient following treatment recommendations and maintaining good oral hygiene (34). *Strack et al* (40)

reported that half of all patients were less than highly adherent to even simple oral hygiene instructions.

Low patient adherence has also been observed in patients receiving treatment for chronic pain. Among patients who had completed a multidisciplinary pain program, patient adherence was low, averaging around 42 % for individual regimens (24). Only 12.3% of the respondents showed complete adherence to their total combination of prescribed regimens. *Riley et al* (35) showed that patients evaluated at a facial pain clinic, who received treatment recommendations, had a self-reported adherence to recommended treatments that ranged from 50 % to 93 %. Change of medication and interocclusal appliance therapy had the best adherence rates (93 % and 90 %, respectively) while recommended surgery had the lowest adherence rate at follow up (50 %). *Wassel et al* (43) reported in a one year follow-up study that 55 % of the patients had used their interocclusal appliance in the previous six months, but only 31 % had done so daily. In a long term follow-up study it was shown that 27 % of subjects who had received interocclusal appliance treatment 18 to 20 years earlier because of TMD still used their appliances frequently or regularly (2). In a prospective short-term study concerning TMD treatment recommendations, *Wig et al* (44) concluded that adherence varied widely across patients and therapies. In that study, patients with higher initial pain and jaw function limitation levels were more adherent to treatment recommendations than patients with less pain and jaw function limitations.

The aims of the present study were to investigate the level of patient adherence to treatment with hard acrylic interocclusal appliance in general dentistry in Sweden compared to patient adherence of patients treated at a specialist clinic and also to see if some general factors could predict patient adherence or non-adherence.

Material and methods

A postal questionnaire was sent to all adult patients (≥20 years of age) that had received a hard acrylic interocclusal appliance from the public dental health service in the County of Uppsala during 2007 (n=388). The same questionnaire was also sent to all adult patients that had received a hard acrylic interocclusal appliance at the Department of Stomatognathic Physiology, The Institute for Postgraduate Dental Education in Jönköping during the same year (n=69). The questionnaire comprised 9 multiple choice question. In 4 questions, the patients had the possibility to give an open answer. The patients were asked to answer questions in the following categories: what kind of interocclusal appliance have you received (illustrated with pictures of different appliances); what was the indication for the therapy; did the therapy have a positive effect; frequency of usage; reasons for not using the appliance. The questionnaire was sent by post during January to May 2009. The patients who did not respond received a reminder 5 weeks after the initial questionnaire was sent out. At the specialist clinic, the patients case files were scrutinized and the patients answers were correlated to the information in the case files.

The results are presented as frequencies and mean values. For the statistical analyses of differences between variables and groups, Fisher's Exact Test has been used. A p-value < 0.05 has been considered as a statistically significant difference.

Results

Demographics, response rate and type of hard acrylic interocclusal appliance

The response rate in general dental practice was 71 % (n=274). The majority of the patients were women (65 %). The mean age of the patients was 40 years (range: 20-82). There was no statistically significant difference between responders (n=274) and non-responders (n=114) in respect of age and gender. The distribution of the different types of interocclusal appliances made are presented in Table 1.

Table 1. Distribution (%) of different interocclusal appliances made in general dental practice and at a specialist clinic.

Type of appliance	General dental practice n=274	Specialist clinic n=63
Stabilisation appliances	97	37
Shore appliance	1	48
Molar supporting appliance	0	9
Combination of stabilisation appliance and a soft appliance in the opposing jaw	0	3
No answer	2	3

At the specialist clinic the response rate was 91 % (n=63). Seventy-nine per cent of the patients were women and the mean age was 48 years (21-89). A higher frequency of other types of interocclusal appliances was seen in the specialist material compared to general dental practice (Table 1).

Table 2. Indications (%) for treatment with hard acrylic interocclusal appliances in general dental practice and at a specialist clinic. One treatment could have more than one indication.

Indications	General dental practice n= 274	Specialist clinic n=63	p-value
No answer	0	0	n.s.
Tooth wear due to bruxism	86	41	p<0.001
Frequent fractures of teeth and fillings due to bruxism	15	6	n.s.
Sensitive/tender teeth due to bruxism	12	17	n.s.
Pain from the masticatory system	32	78	p<0.001
Restricted mouth opening capacity and difficulties performing jaw movements	9	44	p<0.001
I don´t know why I received a interocclusal appliance	1	2	n.s.
Tension-type headache	39	51	n.s. (p=0.09)
Other indications*	2	6	n.s.

*Tinnitus ; Tongue thrusting ; Ear pain; Mobile teeth as a result of bruxism; Subluxation of the TMJs.

Indications for treatment

The patients' opinions of why they had received the appliance treatments are presented in Table 2. The most common indication for appliance treatment in general dental practice was tooth wear due to bruxism. Eighty-six per cent of the patients (n=236) reported this indication and in 33 % of the cases (n=89), this was the only indication. At the specialist clinic, tooth wear due to bruxism was reported in 41 % of the cases, but in only 2 % of the cases this was the only indication. The most common indication for appliance treatment at the specialist clinic was pain from the masticatory system. The second most common indication was tension-type headache both in general dental practice and at the specialist clinic. In general dental practice more patients, compared to the specialist clinic, reported the indication tooth wear due to bruxism (p<0.001). At the specialist clinic, the indications pain from the masticatory system, and limited jaw-function were more frequent reasons for treatment compared to the general dental practice material (p<0.001). A tendency (p=0.09) that tension-type headache was a more common indication at the specialist clinic was also seen. At the specialist clinic the agreement between the questionnaires and the case files concerning indications for treatment was very good (88%).

Duration of symptoms and patients' opinions concerning treatment effect

A majority of patients both in general dental practice and at the specialist clinic had had their symptoms 1 year or more before receiving the treatment, Table 3.

Table 3. Distribution (%) of duration of symptoms before initiation of treatment in general dental practice and at a specialist clinic.

Duration of symptoms before initiation of treatment	General dental practice n=274	Specialist clinic n=63
1 year or more	74	65
6-12 months	13	14
3-6 months	6	11
1-3 months	4	7
Less than 1 month	1	3
No answer	2	0

Table 4. Distribution (%) of treatment effect of interocclusal appliance therapy in general dental practice and at a specialist clinic.

Treatment effect	General dental practice n=274	Specialist clinic n=63
Good effect	57	48
Some effect	28	36
No effect	7	13
Negative effect	2	2
No symptoms to begin with	3	0
No answer	3	1

Eighty-five per cent (n=234) of the patients in general dental practice reported good or some effect of the treatment, 7 % (n=19) reported no effect, and only 2 % (n=4) had experienced a negative effect of the treatment. Almost the same figures were reported by the patients treated at the specialist clinic (Table 4).

At the specialist clinic, the agreement between the questionnaires and the case files concerning duration of symptoms as well as treatment effect was very good (93% and 75 %, respectively).

Patients' adherence and reasons for not using the interocclusal appliance

In general dental practice, 73 % (n=201) of the patients still used the interocclusal appliance 1½-2 years after they had received them. Ninety-nine per cent (n=199) of these patients used the appliance only at night and 1 % (n=2) used the appliance both during day and night.

Seventy-one per cent of the patients (n=142) used the appliance 5-7 times a week, 21 % (n=42) used the appliance 3-4 times a week, and 8 % (n=17) used the appliance 1-2 times a week.

Ninety per cent of the patients (n=181) stated that the appliance usage was working well or very well and only 10 % (n=20) thought that the appliance usage was working less well.

At the specialist clinic, 54 % (n=34) of the patients used the interocclusal appliance 1½-2 years after they had received the appliance. The difference in patient adherence between the specialist clinic and general dental practice was statistically significant (p<0.001). Ninety-one per cent (n=31) of the patients used the appliance only at night, 3 % (n=1) used it only during the day, and 6 % (n=2) used the appliance both during day and night. Sixty-two per cent of the patients (n=21) used the appliance 5-7 times a week, 15 % (n=5) used the appliance 3-4 times a week, and 23 % (n=8) used the appliance 1-2 times a week.

Ninety-one per cent of the patients (n=31) thought that the appliance usage was working well or very well and only 9 % (n=3) thought that the appliance usage was working less well.

The main reasons for not using the appliances, both in general dental practice and at the specialist clinic, were different comfort aspects. Other factors were that the patients had become symptom free or

Table 5 Distribution (%) of reasons for not using the hard acrylic interocclusal appliance in general dental practice and at a specialist clinic. One treatment could have more than one reason.

Reasons for not using the interocclusal appliance	General dental practice n= 73	Specialist clinic n=29	p-value
I became symptom free	21	28	n.s.
My dentist told me that I didn´t had to use the interocclusal appliance any more	0	3	n.s.
I had difficulties sleeping with the interocclusal appliance	32	31	n.s.
I felt queasy when using the interocclusal appliance	0	17	p<0.001
My mouth became dry when using the interocclusal appliance	11	7	n.s.
The interocclusal appliance tightened the teeth	40	28	n.s.
The interocclusal appliance felt big and uncomfortable	16	21	n.s.
Using the interocclusal appliance gave me general discomfort	29	31	n.s.
After a while I forgot to use the interocclusal appliance	23	7	n.s. (p=0.09)
The interocclusal appliance did not give any treatment effect	14	21	n.s.
The interocclusal appliance worsened my symptoms	4	3	n.s.
The interocclusal appliance broke	4	0	n.s.
I misplaced the interocclusal appliance	1	7	n.s.
Other causes*	7	10	n.s.

* The appliance did not fit after prosthetic rehabilitation or after filling therapy; Stopped using the appliance because of cancer disease; The appliance gave me gingivitis; The appliance chafe my gums; The appliance did not fit any longer.

that the appliance did not have had any treatment effect (Table 5). At the specialist clinic, more patients had stopped using their appliance because they felt queasy when using the appliance compared to the general dental practice material ($p<0.001$). On the other hand, in general dental practice there was a tendency ($p=0.09$) that more patients, compared to the specialist clinic material, had stopped using their appliance because they forgot to use the appliance after a while.

Differences between patients who still used their appliance and those who had stopped

In general dental practice, the indications tooth wear due to bruxism and tension-type headache were more common among the patients who still used their interocclusal appliance compared to those who did not ($p<0.001$). There was also a tendency ($p= 0.07$) that the indication frequent fractures of teeth and fillings due to bruxism was more common among the patients who still used their interocclusal appliance. Those who still used their appliance reported a better treatment effect compared to patients who had stopped using the appliance ($p<0.001$).

At the specialist clinic, the indication tooth wear due to bruxism was more common among the patients who still used their interocclusal appliance compared to those who did not ($p<0.001$). There was also a tendency ($p=0.08$) that patients with tension-type headache showed a better adherence. Also in this group, those who still used their appliance reported a better treatment effect compared to patients who had stopped using the appliance ($p<0.05$).

Discussion

The response rate both in general dental practice and at the specialist clinic (71 % and 91 %, respectively) has to be considered good for a postal questionnaire study.

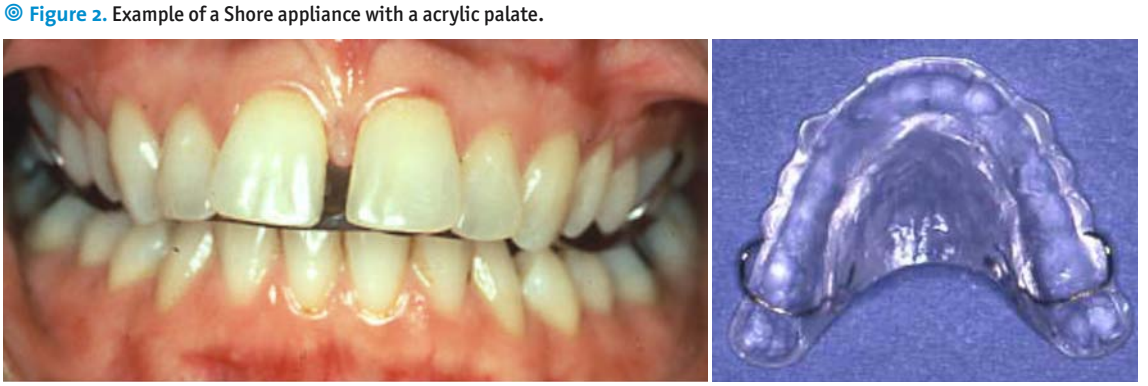
In general dental practice, the by far most frequently used hard acrylic interocclusal appliance was the stabilisation appliance. At the specialist clinic other appliances was used to a much greater extent. One reason for this could be that the patients who had been referred for specialist treatment were more complex cases compared to those treated by the general practitioners, resulting in a greater need for different types of appliances. Another explanation is, of course, that the experienced specialists are more familiar with uncommon types of appliances and their specific indications.

The Shore appliance (Fig. 2) was frequently used at the specialist clinic. This appliance has been recommended as an alternative to the stabilisation appliance in patients who need to wear the appliance in the daytime, patients with a tongue parafunction and in cases with a large overbite or overjet (3).

The most common indication for appliance treatment in general dental practice was tooth wear due to bruxism. At the specialist clinic this indication was much less common. This difference has earlier been shown by *Lindfors et al* (22). The discrepancy found might indicate that patients where the main complaint is tooth wear are successfully managed by general practitioners. Another explanation might be that clinical signs of tooth wear without pain or headache is probably an over treated condition in general dental practice (22).

A tendency was seen that the patients at the specialist clinic had a shorter symptom duration before receiving interocclusal appliance therapy. An explanation for this might be that patients with pain and jaw function limitations are referred to specialist settings immediately when acute symptoms occur. Patients with more dentally related problems might

Figure 2. Example of a Shore appliance with a acrylic palate.



not be considered to have acute problems in comparison to the patients with pain problems.

A majority of patients, both in general dental practice and at the specialist clinic (85 and 84 % respectively), considered the appliance treatment to have had a good or some treatment effect. This result is in line with earlier clinical studies (5, 6, 27, 31). This study clearly shows that the risk of self perceived negative treatment effect when using hard acrylic interocclusal appliances is very small, only 2 %, and can therefore be considered to be negligible.

Significantly more patients from general dental practice still used their appliances after 1½-2 years compared to those treated at the specialist clinic. This can probably be explained by the fact that the treatment indications in general dental practice more often were "life-long" treatment indications such as tooth wear due to bruxism. At the specialist clinic, the indication pain from the masticatory system was much more common compared to the general dental practice. It can be speculated that patients with pain symptoms stop using their appliance when the symptoms fade away. However, the number of patients who reported that they had stopped using their appliance because they were symptom free was not greater at the specialist clinic than in general dental practice.

The main reasons for not using the interocclusal appliance, both in general dental practice and at the specialist clinic, were different comfort aspects (see Table 5). More patients at the specialist clinic felt queasy when using the interocclusal appliance. This might partly be explained by the higher frequency of Shore appliances made at the specialist clinic.

The necessity of subsequent readjustments of interocclusal appliances is stressed in many textbooks (3). Still, *Lindfors et al* (22) have shown that in a majority of cases treated in general dental practice, such readjustments are not made. Since optimisation of retention, fit and occlusal stability are of probable importance both for therapeutic outcome and for comfort reasons, there might be a potential for clinical improvement in this respect. In cases where subsequent readjustment do not improve the oral comfort, an alternative smaller appliance, e.g. the Relax® appliance, might be considered (28).

Both in general dental practice and at the specialist clinic, the indication tooth wear due to bruxism was more common in patients who still used their interocclusal appliances compared to those who did not. In general dental practice the indication tension-type headache was also more common in patients who still used their interocclusal appliances. One explanation for this could be that these indications are long-term conditions, even though the symptoms fluctuate over time, and that the patients therefore are prone to continue the treatment for symptom relief.

A good treatment effect is a factor which seems to motivate the patient to continue the recommended treatment. Thus, a higher patient adherence was seen, both in general dental practice and at the specialist clinic, among patients who experienced a good treatment effect.

At the specialist clinic the agreement between the answers in the questionnaire and the information in the case files was very good. Considering earlier studies concerning indication for treatment with interocclusal appliances (22) and treatment effect of interocclusal appliances (5, 6, 27, 31), one can hypothesize that the agreement most likely is good also in general dental practice material.

Main conclusions:

- Patient adherence to hard acrylic stabilisation appliances made in general dental practice in Sweden is good.
- A vast majority of patients experience that the interocclusal appliance had good or some treatment effect.
- The major reasons for not using the interocclusal appliance were different kinds of comfort problems.
- A perceived good treatment effect, as well as treatment of more long-term conditions, predicted a better patient adherence to hard acrylic stabilisation appliances.

Acknowledgment

We thank the FOU council, Public dental health service, Uppsala, Sweden, for financial support. The help from Mats Nilsson, Jönköping, Sweden, for the statistical analyses is acknowledged.

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SEITO – Stockholm Eastman Index of Treatment Outcome

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Abstract

◎ To obtain high quality in orthodontics; it is important to evaluate the treatment. There are many indices for evaluation of treatment outcome however all of them compare treatment outcome with ideal occlusion. Therefore Stockholm Eastman Index of Treatment Outcome (SEITO) was invented. This index relates the treatment outcome to the treatment goal. SEITO is a morphological index based on criteria from the records including study casts, and/or intra oral photos.

Method: The outcome of treatment is related to the treatment goal as stated in the records. Pre-treatment goals are divided into subgroups; overjet, vertical relation anterior/lateral), anterior cross bite, transverse relations, impacted teeth and space crowding/spacing. Each subgroup is scored; the points are 0, 1, 3 or 5 depending on the severity of the malocclusion. The points for each subgroup are added to give a total sum of treatment goal points. Each post-treatment subgroup above is evaluated. If the treatment goal is fulfilled, the treatment outcome points are equal to the treatment goal points. If not – there is a reduction in the outcome points. Finally the outcome points are expressed as a percentage of the treatment goal points and form a measure of the success of treatment.

Conclusion: SEITO index is a simple and quick way to obtain a picture of the quality of treatment outcome, and the only orthodontic index that relates the treatment outcome to the treatment goal.

Key words

Orthodontics, indexes, quality control

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SEITO – ett index för utvärdering av ortodontisk behandling

KARIN PROM, VIVECA BRATTSTRÖM

Sammanfattning

◎ För att uppnå bra kvalité inom ortodonti är det viktigt att utvärdera behandlingen. Det finns många index för att utvärdera behandlingsresultat men samtliga jämför resultatet med det optimala bettet. Av det skälet skapades Stockholm Eastman Index of Treatment Outcome (SEITO) som relaterar behandlingsresultatet med behandlingsmålet. SEITO är ett morfologiskt index baserat på uppgifter från journalen, inkluderat studiemodeller och/eller intraorala foton.

Metod: Behandlingsresultatet är relaterat till behandlingsmålen som finns i journalen. Behandlingsmålen som ställs upp före behandlingsstart delas upp i undergrupper; horisontell överbitning, vertikal överbitning (anteriort/lateralt), frontal invertering, transversella relationer, retinerade tänder samt trångställning/glesställning. Varje undergrupp får en poäng, poängen 0, 1, 3 eller 5 beroende på svårighetsgraden av malocklusionen. Poängen för grupperna summeras och ger den sammanlagda behandlingsmålspoängen. Efter behandlingen utvärderas undergrupperna igen med avseende på resultatet. Om behandlingsmålet är fullständigt uppnått blir det fullpoäng, om inte reduceras resultatpoängen i motsvarande omfattning som resultatet inte är uppnått. Slutligen beräknas behandlingsresultatet i procent av behandlingsmålet och uttrycker därmed lyckandefrekvensen av behandlingen.

Konklusion: SEITO-indexet är ett snabbt och enkelt sätt att få en bild av kvalitén på behandlingen, det enda ortodontiska index som relaterar behandlingsresultatet med behandlingsmålet.

Introduction

The evaluation of treatment is important in order to achieve high quality and good treatment results in orthodontics (12). It is therefore essential to evaluate the treatment outcome. The awareness of quality has increased since the 1990's when Euro-Qual (13) was established, and other indices for evaluating treatment results were developed, e.g. PAR (Peer Assessment Rating) (19) and ICON (Index of Complexity, Outcome and Need) (8). The PAR index divides the occlusion into eleven morphological components; each component of malocclusion is scored. The greater the deviation from optimal alignment and occlusion, the higher is the score. The points of the eleven components are added and the pre-treatment sum compared with the post-treatment sum. The difference reflects the degree of improvement following treatment. ICON has two parts, one for grading treatment need and one for evaluating treatment outcome. Treatment results are similar to PAR using pre- and post-treatment scores; the greater the malocclusion the higher the score. These are dived into six categories, five morphological and one aesthetic.

Another well known index, mostly used in the US is the OGS (Objective Grading System) (6) developed by the American Board of Orthodontics, this is a very detailed index. Every millimetre and degree deviating from ideal occlusion get reduction in the score.

There are also other indices for treatment outcome; as *Gottlieb´s index* (12) which also correlate the post-treatment results in relation to the occlusion pre-treatment. This index has ten components; three of them include the sagittal relation. The categories that need correction pre-treatment get five points (zero to the others). If the malocclusion is corrected, the category gets five points. If not, the score is less than five and could be minus one point if the status is worsened during treatment. *Eismann´s* (10) method for evaluation of orthodontic treatment shows in detail the discrepancy from ideal occlusion, grading the discrepancy in millimetre and degrees. Fifteen variables are measured according to defined rules for scoring, pre- and post-treatment. The amount of reduction in points indicates the degree of success of treatment. OMFI (Occlusal Morphology and Function Index) (20,21) is another index which differs from the rest because the occlusal function is evaluated. This index is divided into six morphological and four functional components. These ten components are graded as acceptable or non-acceptable.

Indexes for treatment outcome compare the treatment results with optimal occlusion. Studies by *Kattner & Scheider* (15) and *Ahlgren* (2) show that only a minority of orthodontic treatments obtain optimal occlusion as described in *Andrews* "six keys" (3). Optimal occlusion however is not always the goal of treatment and ideal occlusion is not always possible to obtain.

The aim of SEITO was to develop a simple, quick and accurate way to objectively grade the outcome of orthodontic treatment, related to the goal of treatment.

Method

SEITO comprises six categories: overjet, vertical relation (anterior/lateral), anterior crossbite, transverse relation, impacted teeth, crowding/spacing. These six categories are evaluated before and after treatment; pre treatment goals and treatment results.

Scoring

Commence with the treatment goals stated in the records and study casts/photos. Score the pre-treatment goals for the six categories in the left column of the SEITO form (Appendix A). The definitions of the scores are presented in Table 1. If the malocclusion before treatment is severe, the goal is scored as 5. If the malocclusion is less severe the goal is scored as 3 (Table 1). If there is no malocclusion or if that specific malocclusion is not to be corrected, the goal is scored as 0.

The results, according to the final casts/photos or directly at the patient, are then scored in each of the six categories to the standards in Table I. The attained goal points (the outcome of treatment) are recorded in the right column of the SEITO form.

When the treatment goal is scored as 5, the attained goal can be 5 or less (Table I). When the treatment goal is scored as 3, the attained must be 3 or less. The attained goal score can never be higher than the initial treatment goal score. If some of the variables get worse during treatment, this is recorded as minus points, whether the goal is scored as 0 or more.

If, for example, a posterior crossbite should be kept, the scored goal point is 0. If the posterior crossbite remains after treatment the attained goal is scored as 0. If the crossbite has been corrected even though it was not a goal stated in the record, the goal point is 0. On the other hand if the crossbite is to be corrected (goal score 3 or 5) and this is not fulfilled, the attained goal score becomes worse than the treatment goal score (Table I).

Table 1. Scores pre- and post treatment

PRE TREATMENT (treatment goal)				
Points	Overjet	Vertical relation Overbite (anterior/lateral)	Vertical relation Open bite (anterior/lateral)	Anterior Crossbite
5	> 9 mm, ≤ -1 mm	≥ 4/4 coverage of lower incisor	> 1 mm discrepancy ≥ 4 teeth >1 unit edge to edge bite	≥ 1 unit crossbite or
3	6-9 mm, < 0 up to -1 mm	¾- 4/4	> 1 mm discrepancy 1-4 teeth	1 unit edge to edge
0	0-6 mm	< 3/4	< 1mm discrepancy	No unit cross- or edge to edge bite
Points	Transverse relation	Impacted Teeth	Crowding/Spacing (upper/lower)	
5	>2 units cross- or edge to edge bite, ≥ 1 scissors bite	≥ 1 tooth impacted	> 4 mm crowding/spacing, spacing distal of canines not counted	
3	1-2 units cross- or edge to edge bite	---	2-4 mm crowding/spacing, spacing distal of canines not counted	
0	No unit cross- or edge to edge bite	No impacted tooth	< 2 mm crowding/spacing, spacing distal of canines not counted	

POST TREATMENT (treatment outcome)				
Points	Overjet	Vertical relation Overbite (anterior/lateral)	Vertical relation Open bite (anterior/lateral)	Anterior Crossbite
5/5 3/3	Overjet = 0-4 mm	Overbite = 0 - < ¾ coverage of lower incisor	Overbite = 0-3/4, ≤ 1 mm opened	All units in good occlusion
3/5	Overjet = 4-6 mm	Overbite > ¾ no gingival contact	Open bite > 1 mm, 1-3 teeth or 4 anterior teeth	1 tooth edge to edge (worse before), all other in good occlusion
1	Some improvement	Some improvement	Some improvement	Some improvement
0	Unchanged	Unchanged	Unchanged	Unchanged
-1	≤ 2 mm worsened	Some worsened	1 unit worsened; open > 1 mm	1 tooth worsened to max edge to edge
-3	2-3 worsened	Overbite > ¾ no gingival contact (better before)	2-3 units or 4 anterior worsened; open > 1 mm	2 teeth worsened to max edge to edge
-5	> 3 mm worsened	Overbite > 4/4 (better before)	>3 units or >4 anterior worsened; open > 1 mm	≥ 1 worsened to cross bite
Points	Transverse relation	Impacted Teeth	Crowding/Spacing(upper/lower)	
5/5 3/3	All units in good occlusion	All teeth erupted	< 2 mm crowding/spacing, spacing distal of canines not counted	
3/5	≤ 2 units cross- or edge to edge bite posterior (no scissors bite)	All teeth erupted but not in position	2-4 mm crowding/spacing, spacing distal of canines not counted	
1	Some improvement	Some improvement	Some improvement	
0	Unchanged	Unchanged	Unchanged or changes < 1 mm	
-1	1 unit more cross- or edge to edge bite	---	1-2 mm worsened, spacing distal of canines not counted	
-3	2-3 units more cross- or edge to edge bite or 1 more scissors bite	---	2-4 mm worsened, spacing distal of canines not counted	
-5	> 3 units more cross- or edge to edge bite or >1 scissors bite	---	> 4 mm worsened, spacing distal of canines not counted	

At the end of the SEITO form the result is presented; the sum of the treatment goal score (before treatment) and the attained goal score (post treatment). The attained scores are divided by the treatment goal scores and multiplied by 100; the success of the treatment is shown in per cent. SEITO user's guide (Appendix B) provides a quick way to get to know the index.

Definitions

Apart from recording crowding/spacing all recording is done with the dental casts in occlusion.

1. Overjet: The recording zone is from canine to canine and the maximum overjet is recorded. A negative overjet is recorded if both central incisors either a canine-to-canine relationship is involved (otherwise anterior crossbite). The overjet is recorded in millimetre with the ruler held parallel to the occlusal plane (Figure 1).

2. Vertical relation (anterior/lateral): The overbite is recorded according to how many quarters of the upper incisors that are covered by the lower incisors, measured at the deepest part. Note that an important aspect is if there is gingival contact or not. An open bite is recorded in millimetres and the numbers of teeth involved, only gaps over 1mm are registered. The vertical relation is evaluated at 90 degrees to the longitudinal axis of the tooth crown (Figure I). If the anterior and posterior segments differ, they are registered separately. For example, anterior deep bite along with lateral open bite.

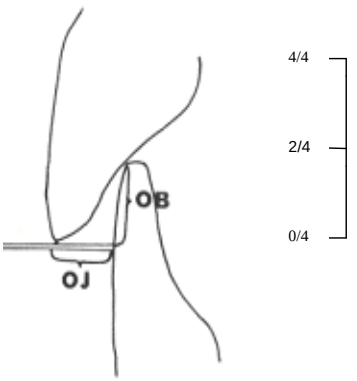
3. Anterior crossbite: The recording zone is from canine to canine. Anterior crossbite records when single tooth is involved (if both the central incisors either a canine-to-canine relationship is involved – record it as overjet, see 1.). Anterior crossbite is recorded as present or not.

4. Transverse relation: Left and right sides are recorded separately and registered as an average. The recording zone is from the first premolar to the last erupted molar.

5. Impacted teeth: The treatment goals state whether there are any impacted teeth and if they should be treated. A tooth is impacted when the eruption time is significantly delayed and there are no clinical/or radiographic signs of eruption.

6. Crowding / Spacing: The recording is done for each jaw separately, all teeth are included. The sum of the mesio-distal crown width is compared with the available arch circumference and any discrepancy is recorded in millimetres. No estimations are attempted with regard to the curve of Spee or the degree of incisors inclination. An impacted tooth is estimated using the mesio-distal width of the contra lateral or an average width. If a retained primary tooth has a permanent successor the permanent tooth width is used. If a permanent tooth is missing, the width of the primary tooth is used in case it is to be kept; otherwise the width of the replacement tooth is used. If the dentition is primary or mixed dentition, the visible permanent teeth are scored. Minor gaps distal to canines are not recorded, due to expected spontaneous closure. Larger gaps distal to the canines, which are planned for closure, are recorded.

Figure 1. OJ = Overjet; OB= Overbite (vertical relation)



Discussion

The evaluation of treatment has been an important part of orthodontics for many years and several indices for evaluating treatment outcome have been developed (8, 10, 12, 19). Contemporary treatment outcome indices, however, relate the result to ideal occlusion. The exception is an early study by *Bergström & Halling* (5) where they used a method to relate the actual treatment result to the desired treatment result.

Orthodontic treatment cannot always reach an ideal occlusion (2, 15) and therefore the treatment goal should be individualized. However, the agreed individualized goal must be clearly stated in the record. Additionally some patient's are not willing or able to undergo a long lasting and complicated treatment and therefore a compromised solution is chosen. Consequently the result of the treatment could be successful without optimal occlusion. *Ackerman et al.*(1) discuss 2006 if the America Board of Orthodontics index, OGS, should take in consideration that the ideal occlusion is not always achievable and stable. Furthermore, there is no evidence-based research that shows that ideal occlusion is the best

(1). *Mohlin and Kurol* (17) wrote in a review 2003 that the treatment should be based on an individual analysis of the consequences of the malocclusion. According to available studies it is only a few malocclusions that is important to correct preventable (ectopic eruption and large overjet), the rest is often for psychosocial or aesthetics reasons. Since SEITO relates the treatment goal and not ideal occlusion, treatment outcome could be 100 per cent even if, for example, a crossbite is kept – provided that this is the goal. If the crossbite is corrected anyway, there will not be minus points in the crossbite column. But if the correction causes an open bite there will be minus points in the vertical relation column.

The index of *Gottlieb* (12) has ten components, three of them relate to the sagittal relation. *Angle* (4) based ideal occlusion on the relationship of the first molars. More recently ideal occlusion has been correlated to upper incisors position (16) and the frontal segments is more important than the sagittal relation. SEITO does not evaluate the intercuspidation of the first molars as it seldom is regarded as a treatment goal. *Ferguson* (11) concludes in a study that correct sagittal intercuspidation was only achieved for a minority of the patients and didn't seem to be related to post-treatment stability. The side effects of an incorrect sagittal occlusion however – i.e. large overjet or anterior crossbite - are included in the SEITO index.

The most deviant tooth in an overjet is recorded because it is exposed to the highest trauma risk. *Järvinen* (14) has shown that an overjet > 6 mm causes the greatest trauma risk with the severest injuries. An important part in the overjet discussion is the effect on lip closure. Incompetent lip closure causes an increased risk for dental trauma (14), and it is often found in combination with an overjet > 6 mm. Even thou SEITO does not evaluate lip closure – reduction to less than 6 mm gives the highest goal points.

The anterior vertical relationship is recorded in relation to upper central incisors coverage of the lower incisors, as in PAR (19) and ICON (8). Contact between the lower incisors and the palatal mucosa is an important criteria, because it may cause gingival retraction of the palatal attachment leading to periodontal breakdown (18). The lateral vertical relation is recorded as contact or not (open bite more than one millimetre).

Impacted teeth are recorded as erupted or not in the SEITO definitions because there is nothing in between, you cannot grade it.

Minor gaps distal to the canines are not recorded because they do not cause a problem with aesthetics and often close spontaneously following mesial drifting of the teeth. If there are wider gaps distal to the canines and the goal is to close them they should be recorded.

Most orthodontic indices are morphological like SEITO, performed on dental casts, omits an evaluation of function. It is unclear today if functional interferences give rise to TMD or muscular problems (7, 22). Since SEITO is made from dental casts it neither states where the middle of the central incisors is according to the middle of the face. SEITO is not suitable for minor malocclusions like small diastema, single rotations or minor spacing/crowding.

If there are missing teeth then the pre-prosthetic orthodontics could not be evaluated until the prosthetics is finished. The post-treatment scoring should be done with prosthetics in place.

SEITO is based on treatment results compared to the goals and gives one measure of the level of quality at the clinic. Thus, there might be a risk that an unethical orthodontist sets too low goals in order to overachieve. That eliminates the possibility to enhance the quality of treatment outcome.

If the treatment result will be evaluated on photos only, overbite and overjet have to be noted in the record.

Richmonds et al. (19) claim that PAR takes about six minutes to record, SEITO is quicker and could even be performed by trained orthodontic assistances. Draker (9) wrote that an ideal index should be quick, simple, accurate and reliable – which SEITO index is aiming at.

Conclusion

SEITO index (Stockholm Eastman Index of Treatment Outcome) is a simple and quick way to get a picture of the quality of treatment outcome. Moreover SEITO is the only contemporary orthodontic index that relates the treatment outcome to the treatment goal.

Appendix A

SEITO-Form

PAT ID:	SCORES PRE-TREATMENT (TREATMENT GOAL)	SCORES POST-TREATMENT (TREATMENT OUTCOME)
OVER JET		
VERTICAL RELATION (ANTERIOR/LATERAL)		
ANTERIOR CROSS BITE		
TRANSVERSE RELATION		
IMPACTED TEETH		
CROWDING/ SPACING UPPER		
LOWER		
SUM		

RESULT: ADDED TREATMENT OUTCOME: ..... (outcome sum) /.....(goal sum) x 100= .....%

Appendix B

SEITO – User´s guide

The index is based on traits from the record, the patient, dental casts and/or intra oral photos. This index intends to visualize the relationship between the goal of the treatment and the treatment outcome.

• *1) Scoring of the treatment goals*
The treatment goals are stated in the record. They are scored in the left column of the SEITO form. If the malocclusion is severe the score is 5. If the malocclusion is less severe the score is 3 (Table I). If there is no defect or if the specific trait is not to be corrected, the score becomes 0.

-If, for example, a posterior cross bite should be left untreated the score is 0. If the posterior cross bite remains after treatment the outcome is scored as 0. But if the cross bite is to be corrected (scored goal 3 or 5) and this not is achieved, the outcome score becomes worse than the scored goal (Table I).

- Anterior cross bite applies to single teeth in cross bite; negative overjet is when if either both central incisors or canine-to-canine are involved
- Overjet, the greatest deviating tooth is recorded
- The vertical relations is evaluated 90 degrees to the longitudinal axis of the tooth crown

• *2) Scoring the treatment outcome*
Study the final casts, photos and/or working casts for retention. Compare the results in the six categories to the standards in Table I. Score the outcome in the right column in the SEITO form. When the goal is 5, the outcome can be 5 or less (Table I). When the goal is 3, the outcome can be 3 (best result, 5/5, 3/3) or less. The second line in Table I outcome (3/5) can only occur when the goal is 5. If some of the variables get worse during treatment this is depicted by a corresponding minus point regardless of, whether the goal is 0 or more. The outcome can never reach a higher score than the goal score.

• *3) Add up the results*
Count the sum of the goal and the outcome scores. Divide the outcome total with the goal total x 100, to get the outcome in per cent.

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Esthetic views on facial and dental appearance in young adults with treated bilateral cleft lip and palate (BCLP). A comparison between professional and non-professional evaluators

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Abstract

◎ The aim of the present study was to make a comparison between the professional and non-professional evaluations concerning the esthetic outcome after the completion of patients who have been treated for bilateral cleft lip and palate. A web-based questionnaire, with 12 photo sets, was answered by 25 orthodontists and 20 young adults who had been treated with orthodontic fixed appliances. They ranked the three first features they noticed when looking at each photo set, and then rated specific variables as being bad, fairly good, good, or excellent. At the end of each set, they had an opportunity to add any additional comments. The three features first noticed by the orthodontists were 'the upper lip', 'the nose' and 'the scar'. The young adults reported first 'the teeth', 'the upper lip' and 'occlusion/alignment of the teeth'. The specific variables similarly rated by orthodontists and young adults were 'the profile of the face', 'the form of the upper lip' and 'the entire facial appearance'. The orthodontists were less critical than the young adults concerning 'the upper teeth alignment', 'the lower teeth alignment', 'shape of the upper teeth', and 'color of the upper teeth'. The individual opinion on each separate set of photos was additionally important in explaining the rating, regardless the category of being either orthodontists or young adults.

Key words

Cleft lip and palate, esthetic assessments, treatment outcome, questionnaire

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Estetiska synpunkter på utseende och bettförhållanden hos unga vuxna som behandlats för dubbelsidig läpp-käk-gomdefekt

En jämförande studie mellan professionella och icke-professionella bedömare

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Sammanfattning

◎ Avsikten med studien var att jämföra bedömningar av det estetiska resultatet, efter avslutad behandling av dubbelsidiga läpp-käk- och gomspalter (LKG), mellan en grupp ortodontister och en grupp unga vuxna. Ortodontisterna (N=25) var alla verksamma inom Västra Götaland-regionen i Sverige. De unga vuxna (N=20) var under behandling med fast apparatur eller hade nyligen avslutats. Deras medelålder var 19 år.

Ett web-baserat frågeformulär användes. Det innehöll extra- och intra orala foton av 12 patienter med dubbelsidig total LKG-spalt. För varje patientfall fick deltagarna först ange tre saker som man lade märke till i personens utseende (fråga 1). Därefter bedömdes olika variabler; ansiktsprofilen, överläppens form, utjämningen av tandbågarna, tändernas färg och form samt helhetsintrycket av ansiktet (fråga 2). Deltagaren kunde slutligen skriva in egna kommentarer.

Det fanns en skillnad mellan ortodontister och unga vuxna avseende det man först lade märke till. Ortodontisterna angav först överläppen därefter näsan och sedan det kirurgiska ärret. Motsvarande ordningsföljd för de unga vuxna var tänderna, överläppen och utjämningen av tandbågarna (fråga 1). Likartade skattningar enligt de olika bedömningsalternativen (dåligt, ganska bra, bra och utmärkt) gjordes för ansiktsprofilen, överläppens form och helhetsintrycket av ansiktet. Ortodontisterna var mindre kritiska än de unga vuxna avseende utjämningen av överkäkens tänder, utjämningen av underkäkens tänder, tändernas form i överkäken och tändernas färg i överkäken (fråga 2). Dessutom visade studien att den enskilda individens åsikt, oavsett grupptillhörighet, var den variabel som i den logistiska regressionsanalysen enskilt gav den bästa förklaringsgraden.

Introduction

The orofacial cleft is a common craniofacial anomaly. Ethnic and geographic variation affect the incidence values (9). In Sweden, a study carried out in Stockholm showed a value of 2.0/1000 livebirths. The rarest type was a complete bilateral cleft lip and palate (BCLP) with a reported incidence value of 0.3/1000 live births (5). Among different types of cleft, BCLP affects the external appearance of a newborn the most. The defect involves the nose, upper lip on both sides, and alveolar process throughout the hard and soft palate. After treatment is completed, some scars, a deformed nose and a short columella may be more or less noticeable. However, it was found that 'symmetry', 'averageness' and 'a full lip' are important features of an ideal face (1,6). The matter of a good esthetic result after treatment of a BCLP is of utmost importance since external appearance is essential in developing a person's personality and level of self-confidence.

The anterior maxillary dental appearance is also affected by the cleft lesion (3,11). In the judgment of the esthetic outcome in a person treated for a BCLP, the appearance of the frontal dentition is a key indicator. A recently published descriptive study on dental appearance with focus on the anterior maxillary dentition found, in a group of 35 young adults with BCLP, that unilateral or bilateral missing laterals were common (40%) as well as peg-shaped lateral incisors (40%). A good symmetry and a straight midline between jaws after completed treatment were registered for 60% (3). The results in the referred study indicate that a goal of having evenly aligned teeth in a normal occlusion without midline deviations and discrepancies in tooth size was not always achieved after orthodontic treatment. When a good result is achieved, it is believed to help in harmonizing the face.

Concerning the quality of life aspects, although children and adults with cleft do not experience severe psychological problems, some specific problems were reported, e.g. bullying, low satisfaction with facial appearance (7). A qualitative study based on 'Grounded theory' revealed a core category "Hoping to be like others". Persons who suffered from either a BCLP or an isolated cleft palate expressed their desire to appear as normal as other people (2). Many studies have analyzed the satisfaction of the treatment outcome by patients themselves compared to experts. Most results showed that the patients were significantly less satisfied concerning their facial appearance of nose, upper lip and facial symmetry (8,10,12). To our knowledge, there is no study focusing on a comparison between evaluations by professional and non-professionals of the treatment outcome in BCLP patients.

The aim of the present study, therefore, was to compare opinions of professional orthodontists with those of non-professional young adults on the treatment outcome. What features do they focus on when they assess the final results from their esthetical point of view?

Material and methods

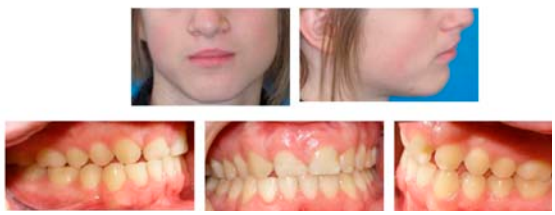
Sets of photographs

There were 24 persons with a BCLP who fulfilled the inclusion criteria for the study, and had a complete set of photos from the beginning of treatment until their last registration at either 16 or 19 years of age. The treatment follows the standard routines of the CLP Team at the Sahlgrenska University Hospital, Gothenburg, Sweden. All of them had been treated between the years 1974-1991. The inclusion criterion was being a Caucasian born with a complete BCLP and had finished active orthodontic treatment. Exclusion criteria were mental disorders and other craniofacial defects except for the cleft. From 24 sets of photographs, one person with a very good treatment result and one with a poor result were chosen according to the authors' opinion to create diversity in the group. Then, ten persons were chosen randomly out of the available 22 cases. There were a total of 12 cases.

The web-based questionnaire was created to include 12 sets of color photographs. In each set, there were two extraoral photos side by side (front, profile) cut off beneath the eyes in order to make the participants anonymous. The intraoral photos (front, right and left side) were presented directly beneath the others (Fig.1). Before the participants answered the questions, they read the questionnaire instructions and a sample question with the photos of a person with a BCLP.

The first question concerned a ranking of the first three things that the evaluators noticed when looking at all the photos. They could answer freely. The second question consisted of four written alternatives (bad, fairly good, good and excellent). One alternative was to be marked for seven different topics. The topics were 1) the profile of the face, 2) the form of the upper lip, 3) the regularity of the upper teeth, 4) the regularity of the lower teeth, 5) the form of the upper teeth, 6) the color of the upper teeth, and 7) the overall impression. Finally, in the third

◎ **Figure 1.** An example of web-based questionnaire in English (Original in Swedish).



1. What are the three features you notice about this person's appearance? Write in order.
1) _____
2) _____
3) _____

2. How will you assess the following items, please mark in a circle.

	bad	fairly good	good	excellent
1) facial profile	0	0	0	0
2) shape of the upper lip	0	0	0	0
3) upper teeth alignment	0	0	0	0
4) lower teeth alignment	0	0	0	0
5) shape of the upper teeth	0	0	0	0
6) color of the upper teeth	0	0	0	0
7) overall appearance (entire face)	0	0	0	0

3. If you have any additional comments, please write in the box below;

question, the evaluator could write down his/her own comments. The evaluators were informed at the beginning that it was not possible to return to a previous web page to change the answers. However, after every second case a pause could be taken.

Evaluators

Two different groups of evaluators were arranged. One was a group of 25 randomly chosen specialists in orthodontics working in the Västra Götaland region of Sweden. The other group consisted of 20 young adults, older than 18 years of age. They did not have any type of cleft, and were either under treatment with fixed appliances or came for their first control after finishing their treatment at the orthodontic clinic, Institute of Odontology, Gothenburg. The orthodontists received a letter including an individual link to the web questionnaire. All orthodontists answered except for six persons who were no longer working in the region. They were replaced with new randomly chosen orthodontists. Young adults were randomly asked when they came for their orthodontic visit at the clinic. Only a few of them did not have time to answer the questionnaire.

The study was approved by the Ethical Committee, Medical Section, The University of Gothenburg. The young adults also signed an informed consent before they participated in the study.

Statistical Analysis

The categories of question two were dichotomized into binary values. The categories 'bad' and 'fairly good' were transformed into 0; and the 'good' and 'excellent' into 1. Each topic was separately analyzed using logistic regression analysis. This analysis was used to test 7 models with individual variable or combinations of the three variables; photo set, individual evaluators and evaluator category. The AIC (Akaike Information Criterion) values were calculated to determine the best model, that is, the model with the lowest AIC. The lowest number showed that the least amount of variance had been left unexplained in the chosen model balancing with a minimum number of the explanatory variables. Furthermore, the Pearson's chi square was used to test if there was any significant differences of either positive or negative associations between the two groups. The p-values< 0.05 were regarded as statistically significant. Frequencies were calculated as a percentage.

Results

The median age of the young adult group was 18 years (range 18-23 years). Among the orthodontists, the age varied from young, recent graduates up to orthodontists close to retirement. In both groups, the gender distribution was similar. Generally, the evaluators spent 30-40 minutes to complete the questionnaire.

For the first question, the feature that the evaluators first noticed varied between orthodontists and young adults. The most common features noticed by the orthodontists were "the upper lip", "the nose" and "the scar". The young adults first noticed "the teeth", "the upper lip" followed by "occlusion/alignment of the teeth" (Fig.2).

For the second question, the logistic regression analyses showed that the best model for demonstrating the least amount of unexplained variance was the combination of each set of photos (N=12) and the

individual opinion from each evaluator (N=45), regardless the category of orthodontist or young adult. From the analysis, the results revealed the same pattern for all seven topics in question two (Table 1).
Concerning the alignment of upper teeth (topic 3), the alignment of lower teeth (topic 4), the shape/form of the upper teeth (topic 5), and the color of the upper teeth (topic 6), the orthodontist group assessed the results more positively than the young adult group (Table 2). For the profile of the face (topic 1), the form of the upper lip (topic 2) and the entire appearance of the face (topic 7), both orthodontists and young adults answered in a similar way giving a non-significant Chi-square value. The results presented above are based on comparisons between the two groups. The answers included the assessments on all 12 photo sets from each evaluator. Within the groups the positive and negative opinions varied among the participants. Alignment of the lower teeth (topic 4) was the variable that varied the most in terms of different opinions among the orthodontists, and the color of upper teeth was that among the young adults (Table 2).

The third question about additional comments showed many different opinions both positive and negative. Many comments concerned lack of oral hygiene for many different sets of photos. A malformed upper lip was often commented on as well as the discolored or wrongly positioned teeth. Most comments concerned the teeth while the total facial appearance was not commented on as often. Many evaluators were positive particularly in their opinions on the total outcome.

Discussion

The study indicated that, regarding the facial appearance (question one), both orthodontists and young adults identified "the teeth" as one of the first things they noticed. This emphasizes the importance of dental corrections. In a previous study on young adults with BCLP, an asymmetrical anterior maxillary dentition due to missing and/or peg-shaped lateral incisors, was a common finding (3). Treatment effort is thus needed to solve this esthetic problem since irregular upper front teeth may affect the harmony of the face. However, the orthodontists were

Figure 2. Percentage of the first noticed item when professional (N=25) and non-professional (N=20) evaluators assessed the sets of photos.

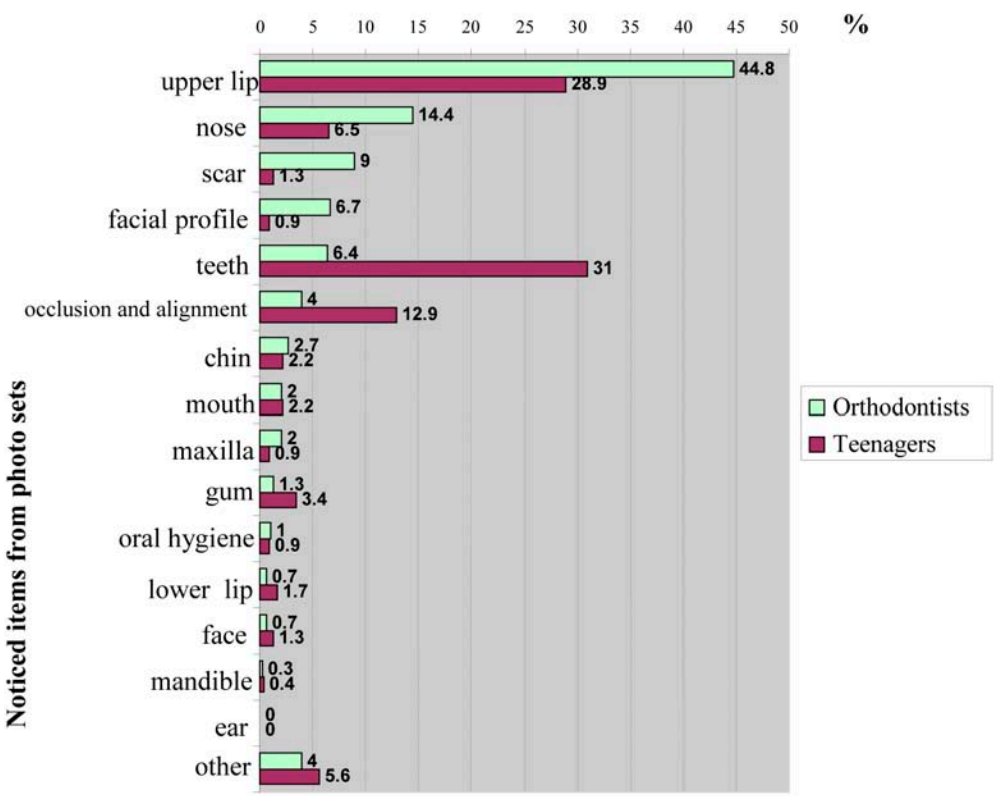


Table 1. The comparison of AIC values (Akaike Information Criterion) from the logistic regression analysis between seven models of seven topics in the question two.

Topic	Model						
	I (A)	II (B)	III (C)	IV (A+C)	V (B+C)	VI (A+B)	VII (A+B+C*)
1	599.21	724.62	746.77	601.2	724.62	528.89	528.89
2	539.82	720.96	752.12	541.81	720.96	412.61	412.61
3	513.68	735.44	737.5	489.01	735.44	404.78	404.78
4	509.89	718.33	727.45	489.77	718.33	391.81	391.81
5	599.40	702.45	740.31	584.59	702.45	479.73	479.73
6	671.46	632.25	715.33	641.33	632.25	513.34	513.34
7	516.85	699.45	740.55	518.59	699.45	368.32	368.32

* A,B and C are the variables tested in each model. A=photo sets (N=12), B=individual evaluator (N=45) and C=categories of evaluator (N=2).

Table 2. The percentage between two binary answers (0,1) from two groups of evaluators; orthodontists and young adults, and the results of difference between two groups.

Part II questions	Orthodontist (%)		Teenager (%)		p-values
	0*	1**	0*	1**	
Face profile	45	55	45	55	0.99
Upper lip form	52	48	51	49	0.99
Upper teeth alignment	42	58	59	41	0.001¤
Lower teeth alignment	36	64	51	49	0.002¤
Shape/Form of upper teeth	45	55	60	40	0.003¤
Color of upper teeth	47	53	69	31	0.004¤
Overall appearance of face	57	43	58	42	0.76

*0= bad or fairly good opinion
**1= good or excellent opinion
¤ p-values (< 0.05) showed the significant difference between professional and non-professional evaluators.
1 = 0.0002, 2 = 0.0004, 3 = 0.0008, 4 = 3.76e-07

found to be less critical about the treatment result concerning the teeth according to question number two. The orthodontist's professional skill may have added to this opinion in that their own experiences and knowledge regarding orthodontic treatment could lead to less expectations of an ideal outcome. It is interesting that young adults in the present study seemed to focus on this matter. All the young adults had their own experience of orthodontic treatment with fixed appliances. They were selected for the study since they were expected to have more knowledge about teeth, occlusion and orthodontic treatment than other persons of the same age group.

For question 2, the judgement on the treatment outcome concerning the general appearance did not differ between the orthodontists and the young adults. They had similar opinions, both positive and negative, including details such as the form of the upper lip and the facial profile. This is in line with the analysis that each person's individual opinion on each specific examination case with photos was the most important factor in the logistic regression, independent of the category of the evaluators (orthodontist or young adult).

The main results were based on Pearson's chi-square tests of frequencies. The results from the logistic regression analyses were complicated to interpret because the variance, left unexplained in the model, could be related to confounders. Confounders, for example, could be gender, variation in age and experiences among the orthodontists, and different basic conditions to understand the questions among the young adults. Since a BCLP is so rare, hardly any of the young adults and not even many of the orthodontists have seen this type of cleft in reality. The objective of the study was to make a comparison between two very different groups in order to see whether there were differences between professional and non-professional assessments.

The number of participants was not large enough for comparisons of opinions between genders. It would have been especially interesting to study young women who are suggested to be strongly influenced by media regarding the importance of good looks. It is interesting that some evaluators commented on poor oral hygiene such as plaque and calculus which was one concern from both orthodontists and young adults. Special oral hygiene programs for this group of patients should be implemented to improve the final outcome. Offerings of an oral hygiene support from other health care professionals could be helpful and probably create a desire for oral health improvement.

Out of clinical experience, many young adults

with CLP develop varying degrees of aversions and tiredness related to their teeth and facial appearance. In a qualitative study, the persons felt less interested in continuing treatment as grown-ups than their doctors who suggested more treatment with the aim to improve both facial and dental appearances (8). In a large study on patients with severe disfigurements, either congenital or acquired, it was concluded that the satisfaction with their facial appearance would seldom reach the level of satisfaction experienced by non-disfigured persons (13).

When considering the type of survey in the present study, the web-based questionnaire was selected instead of the conventional mode of regular mail. It is found that the major advantages of this method were savings of time and costs. In a review study, Fricker and Schonlau (2002) described other advantages together with its limitations. The internet-based survey is more effective and cost-efficient, but still doubtful with its response rate and response accuracy. They also expect an increasing growth of world-wide-web surveys in research (4). Additionally, only twelve sets of photographs were selected in order to generate a questionnaire that was not too time-consuming and tiring to answer. However, the content of the questionnaire could be developed to focus more on specific details in the treatment outcome.

Conclusion

The orthodontists focused primarily on the upper lip followed by the nose and the scar. The corresponding order for the young adults was the teeth, the upper lip, and the occlusion and alignment of teeth. According to the ratings of the topic 'upper and lower teeth alignment', 'the shape/form of the upper teeth' and 'color of the upper teeth', the orthodontist group was less critical than the young adults. Concerning the profile of the face, the form of the upper lip and the entire appearance of the face, orthodontists and young adults did not differ in their ratings. The important finding was that the individual's opinion varied from specific examination, from case to case, despite being an orthodontist or a young adult. This was also reflected in a large variation of personal comments for each separate photo set.

Acknowledgements

This study was supported by the Royal Society of Arts and Sciences in Gothenburg, the Women Dentists Club, Sweden, and the Göteborg Dental Society. Thanks to Gun Lyckner for her help on all administrative work, Per-Olof Blomstrand for his help on the construction of the web-based questionnaire, and Anna Genell for her help on statistical consultation.

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Characteristics of patients referred for Cone Beam Computed Tomography (CBCT) of ectopically erupting maxillary canines

VIANNE KOYE, HANS-GÖRAN GRÖNDAHL

Abstract

◉ The aim was to study the characteristics of patients referred for tomographic examinations of maxillary canines suspected of ectopic eruption and evaluate whether the criteria used for referring the patients could be considered appropriate.

During a 1-year-period all patients (n=63) referred for tomographic examinations of ectopically erupting maxillary canines, when intra-oral x-ray examinations were insufficient to describe the position of the canine and the conditions at adjacent teeth, were examined by means of Cone Beam Computed Tomography (CBCT).

There was a statistically significant overrepresentation of girls (63.5%) among the referred patients. The mean age for the girls was 146.0 ± 22.2 months and for the boys 151.8 ± 17.8 months, a statistically non-significant difference. In total, 91 maxillary canine sites were examined and in 33 of the examined sites (36%) a resorption was found in the root surface of an adjacent tooth, in the vast majority the lateral incisor. Since more than one tooth was occasionally affected the total number of resorptions was 38 of which 14 had reached the pulp (37%).

Considering the frequency of teeth, adjacent to ectopically erupting maxillary canines, that were affected by resorptions it can be concluded that the referral criteria used were appropriate. Given the young age of the patients it can be recommended that tomography should be performed with CBCT techniques that permit the examination of small volumes and result in high quality images.

Key words

Cone Beam Computed Tomography, maxillary cuspids, ectopic eruption

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Digital volymtomografi (CBCT) av patienter med ektopiskt erumperande överkäkskuspider

VIANNE KOYE, HANS-GÖRAN GRÖNDAHL

Sammanfattning

◎ Mellan 1-3% av alla överkäkskuspider har rapporterats inte bryta fram på normal plats i normal tid. Detta gör överkäkskuspiden till den tand, efter den tredje molaren, som oftast drabbas av ektopisk eruption. Uppgifter i litteraturen gör gällande att det förekommer resorption på angränsande incisiver i 12-49% vid fall av ektopisk eruption av överkäkskuspiden. Därför är det, bl.a. ur ortodontisk synvinkel, viktigt med noggrann röntgendiagnostik då man kliniskt kan misstänka eruptionsavvikelser. Intraoral röntgenundersökning är förstahandsalternativet, men då rotytorna på angränsande tänder inte kan avbildas, bör någon form av tomografisk avbildning övervägas. Det har visats att man med datortomografi (CT) upptäcker ett mycket större antal tänder med resorption än vad man gör med intraorala röntgenundersökningar. CT har dock nackdelen att ge relativt höga stråldoser och att vara kostsam. Avsikten med föreliggande undersökning var, att med den teknik som kallas Cone Beam Computed Tomography (CBCT) eller digital volymtomografi och som är en mindre doskrävande teknik, undersöka vad som karaktäriserar de patienter som remitteras för kompletterande tomografisk undersökning av ektopiskt erumperande överkäkskuspider. En övergripande avsikt var att bedöma om de kriterier som använts för att remittera patienterna kunde anses ändamålsenliga.

Patienterna som inkluderades i studien var alla de som under en 12-månadersperiod remitterades för tomografisk utredning av överkäkskuspiderna sedan en intraoral undersökning inte hade kunnat fastställa närliggande tänders status. De totalt 63 patienterna undersöktes med CBCT-utrustningen Accu-I-Tomo F80 FPD. Flickor var statistiskt överrepresenterade (63,5%) och i genomsnitt ca 6 månader yngre än de undersökta pojkarna.

Sammanlagt undersöktes 91 hörntandsområden och i 36% av fallen upptäcktes resorption på någon granntand, vanligen den laterala incisiven. Så mycket som 37% av alla resorptioner hade nått pulpan. Mot bakgrund av dessa värden bedömer vi att kriterierna för att remittera patienter för tomografisk utredning av ektopiskt erumperande överkäkskuspider har fungerat väl. Vi rekommenderar att sådan utredning ska göras med CBCT och inte med CT med tanke på skillnaden i framförallt stråldoser och kostnader.

Introduction:
From about 1% to 3% of all maxillary canines have been reported not to erupt normally making it the second most frequent tooth with eruption disturbances after the third molar 6,7,10. Eruption disturbances of the maxillary canine may cause adverse effects on neighbouring teeth, notably root resorptions, most often seen in the adjacent lateral incisor 10. In e.g. the orthodontic decision making process knowledge of the location of an un-erupted maxillary canine is essential. So is information about the presence and, not least, the extent of root resorption in an adjacent tooth. Even though root resorptions have been reported to occur also when the maxillary canine erupts normally, it is much more common when it does not. In the latter cases a frequency of root resorptions in adjacent permanent incisors have been reported to vary between 12-49 % 2, 8, 9 and it has been noted to occur up to 4 times more often in girls than in boys 10.

Guidelines have been developed for when to perform radiography of maxillary canines that, from a clinical point of view, do not appear to erupt normally. This means a failure of a tooth to erupt at its normal position in the dental arch within a normal time interval 6,8,10. At the age of 10 the maxillary canine should be palpable on the buccal aspect of the dental arch. If it is, the risk of adverse effects on adjacent teeth is considered small compared with when it cannot be palpated in this location. Among the most important referral criteria for a radiological examination are, therefore:

1. Asymmetry on palpation or a pronounced difference in eruption of the maxillary canine between the left and right side.
2. Non-palpable canine in case of normal occlusal development.
3. Late eruption of a lateral incisor or a pronounced displacement of it.

The radiological examination can be comprised of a number of intra-oral radiographs by which the position of the canine relative to adjacent teeth can be ascertained. When there is no overlapping between the canine and neighbouring teeth and both the mesial and distal aspects of the latter appear undamaged, the risk for resorptions in these teeth can be considered small. Then, no further radiographic examination needs to be made. Obviously, this is also the case should resorptions be detected in the intraoral radiographs. In other circumstances one should consider performing a tomographic examination.

When the above criteria were applied to 3000 10-15-year-old children in Sweden8 and intra-oral radiographs were taken, it was found that 7% needed complementary radiographic examinations to determine the position of the maxillary canine. When selecting 84 children in whom 125 maxillary canines were considered to erupt ectopically it was found that in 29% of the latter the canine and lateral incisor overlapped to an extent making it impossible to determine whether the incisor was undamaged or not. With the use of polytomography it was found that 12.5% of the ectopic canines caused root resorption, a frequency twice as high as that found when only intraoral radiography was performed.

In a later study, in which *Ericson and Kurol10* compared intraoral radiography with computed tomography (CT), even higher frequencies of root resorption were noted. The authors remarked that the sensitivity of intraoral radiography in respect to the diagnosis of root resorption in teeth adjacent to ectopically erupting maxillary canines in most cases is too low for treatment planning.
Bjerklin & Ericson2 studied 80 children with ectopically positioned maxillary canines where the diagnosis and treatment plan was originally based on conventional radiography. A year later a CT examination was performed on all the children resulting in modified treatment plans for 44% of the children.
In a questionnaire study by *Bjerklin & Bondemark1* Swedish orthodontists were asked whether access to CT data influenced their decision-making regarding the extraction of lateral incisors with root resorptions in cases of ectopically erupting maxillary canines. They found only small discrepancies between orthodontists with and without access to CT data. In patients with space deficiencies 55% of the orthodontists considered extraction of an affected lateral incisor only when the root resorption had reached the pulp. Another 37% of the orthodontists would extract a lateral incisor with a root resorption reaching halfway to the pulp. In cases without space deficiencies 82% of the orthodontists did not recommend extraction of an affected lateral incisor until the root resorption had reached the pulp.

Orthodontists with and without access to CT images used the same criteria as to when a lateral incisor showing root resorption should be extracted. Therefore, in light of the differences found when computed tomography is used than when it is not, it seems likely that orthodontists without access to CT will perform extractions at later stages of root resorptions than orthodontists with access to CT.

This may also explain why guidelines for when to refer a patient for a CT examination have remained unchanged over the years.

Considering that CT yields relatively high radiation doses and that the patients, in whom impacted maxillary canines are examined, are young teenagers and children it would be an advantage if a technique yielding lower radiation doses could be used. In the end of the 1990:s a new method for acquiring tomographic information of the teeth, jaws and facial skeleton was introduced, namely Cone Beam Computed Tomography (CBCT). Since its introduction many manufacturers have started to produce CBCT machines. Large variations are found between different machines in terms of e.g. the size of the volume that is exposed and the radiation dose being delivered.

The aim of the present study was to evaluate the characteristics of patients referred for CBCT examinations of ectopically erupting maxillary canine in respect to gender, age, location of the impacted canine, and location and extent of root resorptions in adjacent teeth. We also wanted to evaluate whether the referral criteria for CBCT examinations could be considered appropriate.

Patients and methods

Patients and criteria for CBCT examinations

The patients of this study consisted of all patients (n=63)who, during a 12-month period between June 2008 – May 2009, were referred to the Department of Oral and Maxillofacial Radiology, Institute for Postgraduate Dental Education, Jönköping, Sweden, for a tomographic examination of ectopically erupting maxillary canines. Previously taken intraoral radiographs, according to the indications mentioned in the introduction and described by *Ericsson & Kurol,6* had been considered insufficient for determining whether resorptions in neighbouring teeth were present or not by the referring dentist. Hence, the perceived need for tomographic examination. After scrutinizing the intraoral radiographs and taking new ones if poor quality of previous ones could be the reason for the inability to diagnose the presence or absence of resorptions, cone beam CT examinations were made. Thus, the same criteria used by *Ericson &Kurol 6* for performing CT examinations of ectopically erupting maxillary canines were applied.

Cone beam CT examination

All radiographic examinations were made with an Accu-I-Tomo F80 FPD CBCT unit (J. Morita Mfg Corp, Kyoto, Japan) with which 3 fields of view can be examined (4x4, 6x6 and 8x8 cm). The smallest volume was used in practically all cases. In patients who were to be examined bilaterally a radiologist made the decision whether or not this volume would be sufficient. If not, two volumes of 4x4 cm were used due to the lower radiation dose that would be delivered than when using the 6x6 cm volume.15 Typical exposure parameters were 75 kV, 6-7 mA, 17.5s rotation time (360° rotation). Primary data reconstruction was made by the acquisition software (i-Dixel-3DX, 3D, Version 1.8, J. Morita Mfg Corp, Kyoto, Japan) providing axial, frontal, and sagittal views. Secondary reconstructions were made with the same software to obtain 0.5 mm thick, contiguous slices. The axial slices were sent to PACS using DICOM export for later reformatting at a workstation with AGFA IMPAX 6 Multi Planar Reconstruction. The workstation comprised a HP computer (Z400 W3520) with a graphic card (Barco MXRT5200) and 21-inch flat panel mono-chromatic monitors (Barco MDCC-2121, 2 MP resolution). One observer made all diagnoses in a room with dimmed light. Reconstructions were made so that slices could be made perpendicular to the long axis of the canine and their neighbouring teeth, respectively. This provided visualization of the teeth in axial, coronal and sagittal planes.

The following variables were analyzed:

- Location of the cusp of the canine in the alveolar process (buccal, central or palatal)
- Resorption of the neighbouring tooth/teeth (yes/no, tooth number)
- Location of the resorption (cervical, central, apical or a combination thereof).
- Extent of the resorption (mild = less than 1/3 into the dentine, moderate = more than 1/3 into the dentine but not reaching the pulp, deep = involving the pulp)

Statistics

Data were analysed with the PASW Statistics 18.0.1 program providing descriptive statistics, t-test for independent samples with p-value set at <0.05, chi-square test with Fisher´s exact test with p-value set at <0.05.

Results

Of the 63 patients 23 were boys (36.5%) and 40 were girls (63.5%), a statistically significant difference

in gender frequency amongst the referred patients ($p<0.05$). The ages ranged from 9 to 17 years with a mean age of 146.0 ± 22.2 months for the girls and 151.8 ± 17.8 months for the boys. There was no statistically significant difference between the ages for boys and girls ($p>0.05$).

In 35 of the patients the clinical problem was found on one side only and in 28 it was found bilaterally. Bilaterality was more common in girls in whom it was found in 50% (20/40) of the cases as opposed to 35% (8/23) among boys. This difference was not statistically significant ($p>0.05$).

Totally 35x1 + 28x2 = 91 maxillary canine sites were radiographically examined. In most cases (62%) the cusp of the maxillary canine was found in a buccal position, in 30 % in a palatal and in 8% in a central position. In more than 1/3 of the examined sites (33/91 = 36%) a resorption was found in the root surface of an adjacent tooth (Table 1). Root resorptions were more often found in teeth belonging to girls (24/61 = 39%) than in those belonging to boys (9/30 = 30%), a difference that did not reach a statistically significant level ($p>0.05$).

Table 1. No. of resorbed and nonresorbed teeth adjacent to unerupted maxillary canines related to the position of the cusp of the unerupted maxillary canine in the alveolar process (buccal, central, palatal).

Cusp position	Resorption		Total
	Yes	No	
Bucc	18	38	56
Centr	2	6	8
Pal	13	14	27
Total	33	58	91

The lateral incisor was, by far, the most commonly affected tooth. Resorptions were also found in a few premolars but in none of the medial incisors.
The numbers of teeth with and without resorption depending upon the position of the cusp of the maxillary canine are presented in Table 1. No statistically significant difference was found in the frequency of resorbed teeth as a function of the position of the cusp of the maxillary canine. Nor was any statistically significant relation found between the position of the cusp and the depth of the resorptions (Table 2). Patients in whom root resorptions were found were, on the average, around 10 months older (12 years and 10 months) than patients in whom no resorptions were detected (12 years and 0 months), a statistically significant difference ($p<0.05$).

Table 3 shows the site of the resorptions (cervical, middle, apical, combination of sites). The table demonstrates that 14 out of a total of 38 resorptions (37%) had reached the pulp, that is, had an extent that might influence the orthodontic decision-making. The majority of the deep resorptions were placed apically or embraced both the apical and the middle part of the root. The relation between the position of the resorption and its depth is statistically significant ($p<0.05$).

Table 2. Depth of the resorptions (1: Mild = less than 1/3 into the dentine, 2: Moderate = more than 1/3 into the dentine but not reaching the pulp, 3: Deep = involving the pulp) relative to the position of the cusp of the unerupted maxillary canine in the alveolar process (buccal, central, palatal).

Position of the canine cusp	Depth of resorptions			Total
	1	2	3	
Bucc	9	2	9	20
Cent	5	1	0	6
Pal	5	2	5	12
Total	19	5	14	38

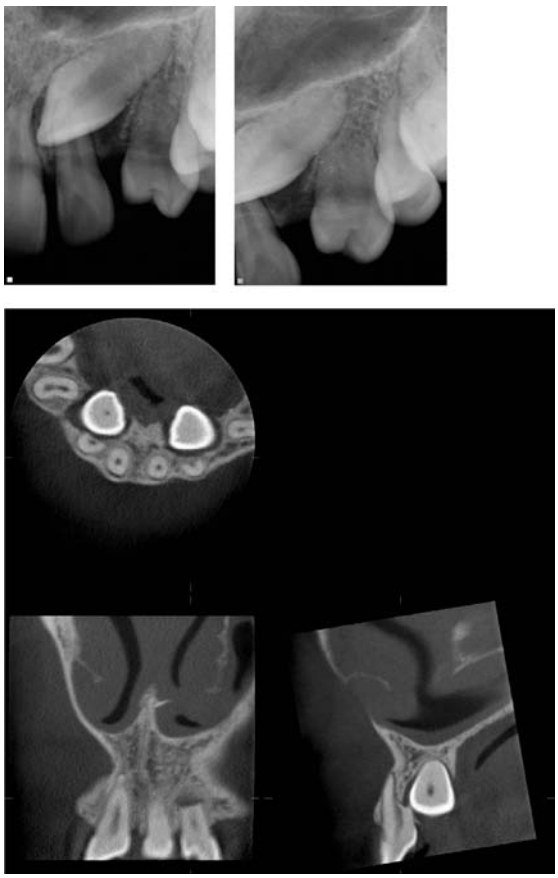
Table 3. The depth of the resorptions (1: Mild = less than 1/3 into the dentine, 2: Moderate = more than 1/3 into the dentine but not reaching the pulp, 3: Deep = involving the pulp) relative to their site (cervical, middle part of root, apical, combination of sites).

Site of Res.	Depth of resorption			Total
	1	2	3	
Cerv	8	0	1	9
Middle	9	3	2	14
Apical	1	2	5	8
Comb.	1	0	6	7
Total	19	5	14	38

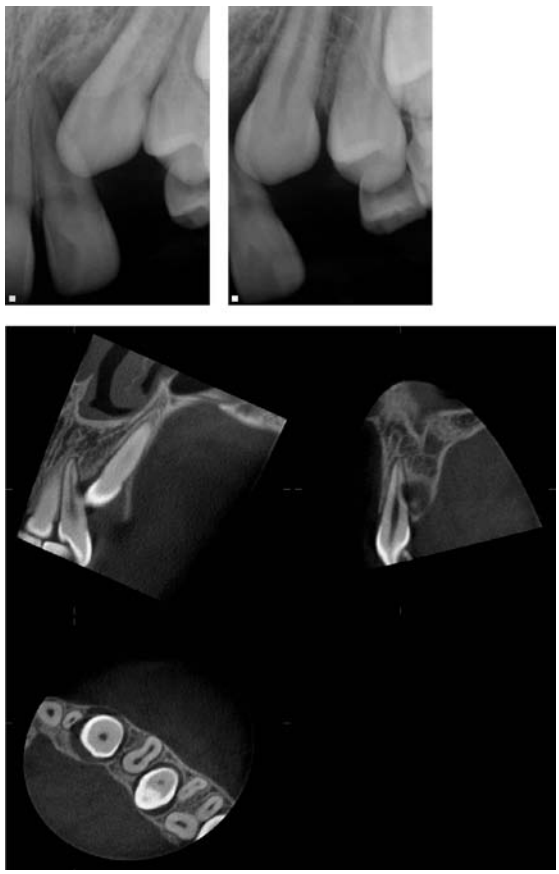
Discussion:

Tomography has previously been found superior to conventional x-ray methods for the assessment of root resorptions associated with unerupted maxillary canines.10 In particular, this is the case when the teeth adjacent to the canine cannot be imaged free from being superimposed onto the image of the canine and when resorptions are situated on the buccal or palatal root surfaces of neighbouring teeth (Figs 1, 2). In the present study patients were referred for Cone Beam CT for evaluation of unerupted maxillary canines when conventional x-ray examinations failed to provide the necessary information in patients in whom radiography was indicated according to previously established guidelines 6. Root

◎ Figure 1.



◎ Figure 2.



resorption in teeth adjacent to the impacted canine was present in 36 % of the examined sites which is similar to the frequency of 38% found by *Ericson & Kurol10* in the same county of Sweden. This indicates that the guidelines developed for when to perform radiography of maxillary canines are justified and still applicable. Needless to say, a tomographic examination of ectopically erupting maxillary cuspids provides more information, essential to the orthodontic decision-making, than that about resorptions in adjacent teeth. The position of the tooth and its anatomy also play important roles in this process.

Ericson & Kurol5 showed that higher frequencies of root resorptions were found with CT than with motion tomography. This is no doubt due to the better image quality in CT images than in images obtained with motion tomography. During the latest decades Cone Beam CT has evolved as a strong alternative to CT in cases where hard tissue changes need to be evaluated within limited regions. With CBCT the examined volume can be made much smaller than in CT. For this and other reasons the radiation dose to the patient will be considerably lower from CBCT than from CT. This is of particular importance when patients belong to young age groups in which the risks associated with ionizing radiation are higher than in others. 3 *Ludlow et al* have reported doses from large volume CBCT scanners of between 50 microSv and 1024 microSv. The large spread in reported doses is mainly caused by differences in scanner models, imaging protocols and dose calculation techniques. In 2009 *Roberts et al.17* compared the effective dose from cone beam CT (i-CAT, Imaging Sciences International, Hatfield, PA, USA) for a variety of dental examinations. They registered effective doses of approximately 93

microSv for a 6 cm high-resolution examination in the maxilla. This is significantly lower than doses from conventional CT which have been reported to be around 2000 microSv for routine head examinations. Some CBCT machines permit small cylindrical volumes, such as 4x4 cm and 6x6 cm, to be examined. Together with exposure factors (tube voltage and current) that are considerably lower than in CT examinations, this provides possibilities of obtaining the required information at significantly lower doses than with CT.12

The spatial resolution associated with CBCT varies with the type of machine used but is, for most CBCT units, higher than in CT. Regarding visualisation of trabecular bone, periodontal ligament space and lamina dura, CBCT has been ranked superior to multislice CT. 14 Considering also that the cost of a CBCT examination is lower than that of a CT examination there is little doubt that CBCT scanners can and will play an important role in the diagnosis of hard tissue structures of the dento-maxillofacial region, such as resorptions caused by impacted teeth.

When tomography of ectopically erupting maxillary canines is clinically indicated it should be made with CBCT equipment permitting examinations of small volumes and yielding high quality images13.

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