DOI: 10.1111/j.1365-263X.2007.00865.x

Effect of dietary habits on laser fluorescence values of visually sound occlusal surfaces among Finnish schoolchildren

VUOKKO ANTTONEN[1,2], HANNU HAUSEN[2], LIISA SEPPÄ[2] & AHTI NIINIMAA[2]

[1]Municipal Oral Health Service of Oulu City and [2]Institute of Dentistry, University of Oulu, Oulu, Finland

International Journal of Paediatric Dentistry 2008; 18: 124–130

Aim. This study was designed to ascertain whether schoolchildren with unfavourable dietary habits have higher values for laser fluorescence on clinically sound occlusal tooth surfaces than do those who have favourable dietary habits.

Design. The study was conducted in two phases. In the first phase, 462 children aged 13–14 years answered a questionnaire on dietary habits. The children were ranked according to a total score based on the presumed harmfulness of their dietary habits. One hundred children with the lowest and highest dietary scores were invited to the second phase of the study consisting of a visual examination, laser fluorescence scanning of premolars and molars, and an oral self-care questionnaire.

Results. Seventy-four and 76 children with favourable and unfavourable habits, respectively, were examined. A total of 1221 sound occlusal surfaces were scanned. Children with unfavourable dietary habits had higher median laser fluorescence values than did those with favourable habits ($P < 0.0246$). The effect of dietary habits was strongest in molars.

Conclusion. High laser fluorescence values on several clinically sound occlusal surfaces of a child may indicate unfavourable dietary habits.

Introduction

Dental caries is still a public health concern in Finland. The mean DMFT score among 12-year-old children was 1.2 in 1991 and has remained at that level[1]. During the past 15 years, sales of chocolate and candy have increased markedly[1], while the frequency of toothbrushing and, hence, exposure to fluoridated toothpaste have remained among the lowest in Europe[2,3]. So far, attempts to identify in advance those individuals who are likely to develop dental decay have not been very successful[4]. Therefore, we decided to determine whether laser fluorescence could be used to detect dietary habits that favour the development of enamel demineralization.

A laser fluorescence device DIAGNOdent® (KaVo, Biberbach, Germany) has been developed to detect early demineralization of dental enamel. The device has been found to be promising in detecting and monitoring demineralization of occlusal tooth surfaces *in vitro*[5–7] and *in vivo*[8–13]. It has also been reported by Li *et al.*[14] that mean values for laser fluorescence in the first permanent molars were significantly higher for caries-active than for caries-inactive 6- to 7-year-old children. The DIAGNOdent device has been recommended for use as an adjunct to visual inspection[15].

This study was designed to determine whether schoolchildren with unfavourable dietary habits have higher values for laser fluorescence on clinically sound occlusal surfaces than do those with favourable dietary habits. Toothbrushing can be assumed to be a confounding or modifying factor on the association of laser fluorescence values with dietary habits and was therefore included in the analyses. The hypothesis was that children with favourable dietary habits have lower laser fluorescence values on sound occlusal tooth surfaces than do those with unfavourable habits.

Materials and methods

Phase 1

Children in grade 7 (12–14 years old) at 12 junior high schools in the city of Oulu, Finland, were invited by letter to join the first phase of the study. Of the total number of 1173 children in 7th grade, 462 (263 girls and 199

Correspondence to:
Dr Vuokko Anttonen, PO Box 5182, University of Oulu, Oulu 90014, Finland. Tel.: +358 40 7766328; Fax: +358 8 5375560; E-mail: vuokko.anttonen@oulu.fi

boys) took part in this phase. The mean age of the children was 13.8 years (SD 0.4). At school the children answered a computer-assisted dietary questionnaire under the supervision of a dental hygienist. The instrument had been piloted in the city of Jyväskylä, Finland, in 2004[16]. The questions covered dietary habits during school and leisure time as well as the amount of money spent on snacks and the social context while snacking. The answers were scored between –2 and 2 according to the presumed effect of the habit on caries risk (–2 = harmless; 2 = harmful), and a total score was calculated for each child (Appendix). At the conclusion of the first phase the children were ranked according to this score.

Phase 2

One hundred children with the lowest and highest dietary scores (favourable and unfavourable dietary habits, respectively) were invited to the second phase of the study, which consisted of a clinical dental examination and laser fluorescence scanning of the visually sound occlusal surfaces of premolars and molars and an oral self-care questionnaire. One hundred and fifty children (58 boys and 92 girls) took part in this phase. The mean interval between the dietary questionnaire of Phase 1 and the procedures of Phase 2 was 0.5 years (SD 0.2). From the oral self-care questionnaire, only the information regarding toothbrushing frequency was used in the current study.

Clinical examination

An experienced dentist (V.A.) examined the occlusal surfaces of the molars and premolars using the light of the dental unit, a plane mirror and a probe. The reproducibility of the clinical examination was validated in a previous study, the kappa value (sound vs. D_3MFS) being 0.85 for the visual examination[12]. During the inspection the surfaces were blow-dried using a 3-in-1 syringe. A blunt probe was used to feel gently the texture of the surface without damaging the fissures. Fibre-Optic Transillumination was used as an adjunct to visual examination to confirm suspected decay. Surfaces with inactive or initial active caries, dentinal caries, fillings, and sealants were excluded from the analyses. The surface was considered clinically sound when there were no visual signs of demineralization in the enamel structure after air drying[17]. A dental nurse registered the findings on a laptop computer. During the clinical examination the dentist was unaware of the dietary group of each child.

DIAGNOdent

DIAGNOdent® (Kavo) scanning was done after visual examination of the teeth. The device was calibrated individually for each child according to the manufacturer's instructions. The surfaces were blow-dried, but not cleaned professionally. Occlusal surfaces of visually sound premolars and molars were scanned. Conical tip A was run along the fissure turning and tilting with the aid of the acoustic signal of the device to find the highest value for each surface. The peak value on a scale from 0 to 99 was called out by the dentist and recorded by the dental nurse in the same way as in the clinical examination. In the previous study the dentist's (V.A.) intraclass correlation coefficient (ICC) for the laser fluorescence measurements was 0.78[12].

Statistical analysis

Because of the skewness of the data, median laser fluorescence values were used for comparisons. Values were calculated separately for the upper and lower premolars and molars among the groups of children with favourable and unfavourable dietary habits. Boxplots were used to illustrate the distribution of the group-specific laser fluorescence values. The statistical software package SPSS 14.0.1 was used for the bivariate analyses. The repeated measures analysis of variance (PROC MIXED, SAS Institute Inc., Cary, NC, USA; software release 9.1.3) was used for multivariate modelling to adjust for the dependency of the observations. In the multivariate analysis, a logarithmic transformation was applied to the laser fluorescence values to reduce the skewness of the original data. In addition to dietary and toothbrushing habits, type of tooth (molar/

premolar) and jaw (upper/lower) were used as independent variables. Toothbrushing was excluded from the final model since it did not modify the effect of dietary habits on laser fluorescence values.

Ethical aspects

The Ethics Committee of the Northern Ostrobothnia Hospital District gave their approval for the study. Written consent was obtained from all participants and their parents. The education manager of the city of Oulu granted permission to conduct the computer-assisted dietary questionnaire survey in the junior high schools of the city.

Results

Figure 1 shows the distribution of subjects according to dietary scores at the end of Phase 1 of the study. The mean dietary scores for the two subgroups invited to participate in Phase 2 are also shown ($n = 100$ in both groups). Seventy-four children with favourable and 76 children with unfavourable dietary habits took part in Phase 2. A total of 1221 sound occlusal surfaces were scanned.

Median laser fluorescence values according to children's dietary and toothbrushing habits, type of tooth and the jaw are shown in Table 1. The median laser fluorescence value of children with favourable dietary habits was lower than that of the children with unfavourable habits ($P < 0.0246$). Table 2 shows the results of the repeated measures analysis of variance with the logarithmic laser fluorescence value as the response variable and dietary habits as well as the type of the tooth and the jaw as independent variables. All the

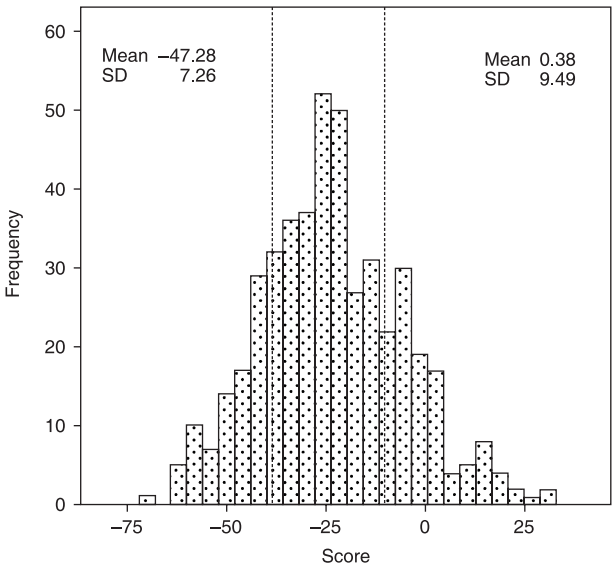

Fig. 1. Distribution of the children in the original study group (Phase 1) according to dietary scores. Means and standard deviations are given for the children who participated in Phase 2 of the study.

Table 1. Laser fluorescence values of teeth according to the type of the tooth, dietary habits and toothbrushing frequency.

	n	Mean of logarithmic laser fluorescence value	Median of laser fluorescence value	Interquartile range of laser fluorescence value	
				25%	75%
Dietary habit					
Favourable	685	1.69	4	2	8
Unfavourable	536	1.86	5	2	12
Toothbrushing*					
Two times a day	857	1.75	4	2	10
Once a day	267	1.71	4	2	10
Less than once a day	91	2.07	6	3	14
Type of tooth					
Premolar	910	1.46	3	2	6
Molar	311	2.66	14	5	31
Jaw					
Upper	588	1.67	4	2	8
Lower	633	1.86	4	2	12

*Toothbrushing data were missing for one person.

Table 2. Summary of the results of the repeated measures analysis of variance with logarithmic laser fluorescence values as the response variable.

	Estimate	SE	Significance
Intercept	1.34	0.062	$P < 0.0001$
Type of tooth			
Molar = 1, Premolar = 0	1.34	0.034	$P < 0.0001$
Jaw			
Lower = 1, Upper = 0	0.14	0.034	$P < 0.0001$
Dietary habits			
Unfavourable = 1, Favourable = 0	0.23	0.084	$P = 0.0246$

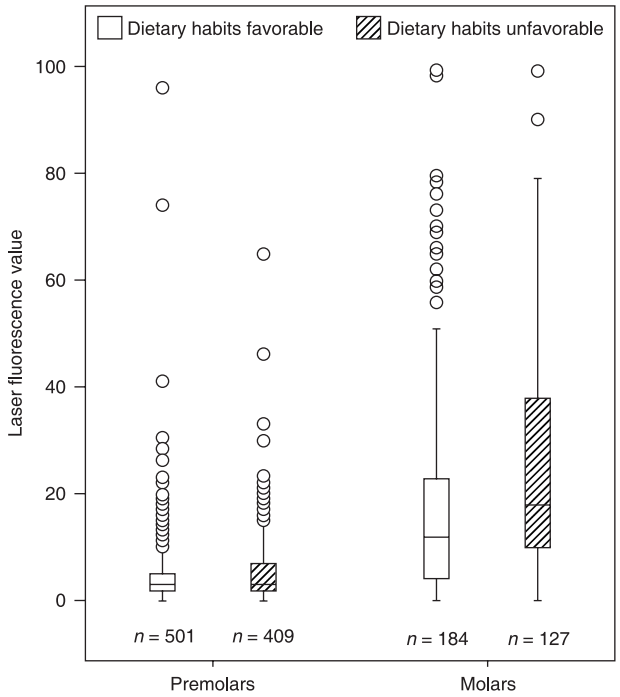

Fig. 2. Box plots describing the distribution of laser fluorescence values of the occlusal surfaces of sound premolars and molars among children with different dietary habits. Interpretation of the box plot: – = median; the box extends from the lower to the upper quartile (IQR). Values more than 1.5 IQR's from the end of the box are labelled as outliers (○).

effects were statistically significant at least at $P < 0.05$ level.

Figure 2 shows laser fluorescence values according to the type of tooth and dietary habits. Children with favourable dietary habits had the smallest median laser fluorescence values. The effect of dietary habits was stronger in molars than in premolars.

Discussion

In this study children with favourable dietary habits had, on average, lower values for laser fluorescence than did those with unfavourable habits. This is in line with our study hypothesis and with the results of Li *et al.*[14] concerning caries active and inactive children.

The effect of jaw on laser fluorescence values was observed in the multivariate analysis only. Its size and direction agrees with that reported by Li *et al.*[14]. The reason for the tendency of higher laser fluorescence values in the lower jaw can only be speculated. Possible explanations might be the earlier eruption of lower teeth and more difficult cleaning and self-cleaning of occlusal surfaces in mandibular molars especially while erupting. The differences in the anatomy of the occlusal fissures between lower and upper teeth may encourage more retention of plaque in lower molars causing demineralization.

In the present study, where we investigated the applicability of laser fluorescence to screening of large numbers of children, occlusal surfaces were blow-dried but not cleaned professionally. In a previous study[18] we found no significant differences in the laser fluorescence values of sound premolars or molars before and after professional cleaning. Based on those results, we suggested that cleaning is necessary only when operative intervention is considered. In a recent study where laser fluorescence was used for epidemiological purposes, Aleksejuniene *et al.* also found that the presence of plaque did not affect the results of laser fluorescence values to any substantial level[19].

The time interval between the questionnaire and examination of the teeth was 0.5 years (SD 0.2). Consequently, for some subjects the dietary habits at the time of the examination might not have been the same as those recorded in the baseline questionnaire. For those subjects, even the laser fluorescence of

occlusal tooth surfaces might have been affected.

The ethics board required that we obtain written consent both from the parents of the children and from the children themselves. Consequently, less than half of those who were invited to the first phase of the study participated in it. It is very likely that the participants had more favourable habits than did those who refused to participate.

Oral health habits are known to be associated with the onset of caries lesions even though their caries predictive power is modest[4]. Since differences in dietary habits were reflected in laser fluorescence values, laser fluorescence scanning can possibly be used for identifying individuals whose dietary habits favour demineralization. Longitudinal studies are required to confirm the caries predictive power of laser fluorescence measurements.

What this paper adds

- The results of this clinical study suggest that there is a way to detect harmful dietary habits before they cause visually detectable demineralization of teeth.

Why this paper is important to paediatric dentists

- This clinical study introduces a method, which may help in early intervention of caries: educating and motivating children for oral self care and applying necessary noninvasive procedures.
- Detecting early demineralization and knowing unfavourable dietary habits of a child make it easier to plan the recall-interval.

Acknowledgements

The Finnish Dental Society Apollonia and the Municipal Oral Health Services of the city of Oulu granted funding to Vuokko Anttonen for this study.

The Municipal Oral Health Services of the city of Oulu granted funding to the oral hygienist Erja Lahtinen for the field-work of the study at schools and during the clinical examination.

The companies Leaf and Fennobon gave Xylitol products to be distributed as lottery prices among the participants of the study.

References

1 Nordblad A, Suominen-Taipale L, Rasilainen J, Karhunen T. *Suun terveydenhuoltoa terveyskeskuksissa 1970-luvulta vuoteen 2000. Stakes Report*. Helsinki, Finland: National Research and Development Centre for Welfare and Health, 2004.

2 Kuusela S, Honkala E, Kannas L, Tynjälä J, Wold B. Oral hygiene habits of 11-year-old school-children in 22 European countries and Canada in 1993/1994. *J Dent Res* 1997; **76**: 1602–1609.

3 Poutanen R, Lahti S, Hausen H. Oral health-related knowledge, attitudes, and beliefs among 11–12-year-old Finnish school-children with different oral health behaviors. *Acta Odontol Scand* 2005; **63**: 10–16.

4 Hausen H. Caries prediction. In: Fejerskov O, Kidd, E (eds). *Dental Caries: The Disease and Its Clinical Management*. Oxford: Blackwell Munksgaard, 2003: 327–341.

5 Lussi A, Imwinkelried S, Pitts N, Longbottom C, Reich E. Performance and reproducibility of a laser fluorescence system for detection of occlusal caries in vitro. *Caries Res* 1999; **33**: 261–266.

6 Alwas-Danowska H, Plasschaert A, Suliborski S, Verdonschot E. Reliability and validity issues of laser fluorescence measurements in occlusal caries diagnosis. *J Dent* 2002; **30**: 129–134.

7 Shi X, Welander U, Angmar-Månsson B. Occlusal caries detection with KaVo DIAGNOdent and radiography: an in vitro comparison. *Caries Res* 2000; **34**: 151–158.

8 Lussi A, Megert B, Longbottom C, Reich E, Francescut P. Clinical performance of a laser fluorescence device for detection of occlusal caries lesions. *Eur J Oral Sci* 2001; **109**: 14–19.

9 Attrill D, Ashley P. Occlusal caries detection in primary teeth: a comparison of DIAGNOdent with conventional methods. *Br Dent J* 2001; **190**: 440–443.

10 Sheehy E, Brailsford S, Kidd E, Beighton D, Zoitopoulos L. Comparison between visual examination and a laser fluorescence system for in vivo diagnosis of occlusal caries. *Caries Res* 2001; **35**: 421–426.

11 Heinrich-Weltzien R, Weerhjeim K, Kühnisch J, Oehme T, Strösser L. Clinical evaluation of visual, radiographic, and laser fluorescence methods for detection of occlusal caries. *J Dent Child* 2002; **69**: 127–132.

12 Anttonen V, Seppä L, Hausen H. Clinical study of the use of laser fluorescence device DIAGNOdent for detection of occlusal caries in children. *Caries Res* 2003; **30**: 129–134.

13 Anttonen V, Seppä L, Hausen H. A follow-up study of the use DIAGNOdent for monitoring fissure caries in children. *Community Dent Oral Epidemiol* 2004; **32**: 312–318.

14 Li S, Zou J, Wang Z, Wright J, Zhang Y. Quantitative assessment of enamel hypomineralization by KaVo DIAGNOdent at different sites on first permanent molars of children in China. *Pediatr Dent* 2003; **25**: 485–490.

15 Bader J, Shugars D. A systematic review of the performance of a laser fluorescence device for detecting caries. *J Am Dent Assoc* 2004; **135**: 1413–1426.

16 Kasila K, Hausen H, Anttonen V. A report on a survey of dietary habits of school children. *Suom Hammaslaakarilehti* 2005; **12**: 700–705.

17 Ekstrand K, Ricketts D, Kidd E. Reproducibility and accuracy of three methods for assessment of demineralisation depth on the occlusal surface: an in vitro examination. *Caries Res* 1997; **32**: 247–254.
18 Anttonen V, Seppä L, Hausen H. Clinical study on the effect of professional cleaning of occlusal tooth surfaces on laser fluorescence measurements. *Caries Res* 2005; **39**: 280–283.
19 Aleksejuniene J, Tranæus S, Skudyte-Rysstad R. DIAGNOdent – an adjunctive diagnostic method for caries diagnosis for epidemiology. *Community Dent Health* 2006; **23**: 217–221.

Appendix

A questionnaire on dietary and comfort-eating habits of schoolchildren

1. How often do you eat the following meals sitting down at a table?

If you do, do you eat			
	Every day or almost every day	Occasionally during the week	Never or hardly ever
Breakfast	–2	–1	+2
Meal at school	–2	–1	+2
Dinner	–2	–1	+2
Supper	–1	0	+1

2. How often do you eat the following parts of the meal at school?

If you do, do you eat			
	Every day or almost every day	Occasionally during the week	Never or hardly ever
Warm course	–2	–1	+2
Salad/vegetables	–2	–1	+2
Bread	–2	–1	+2

3. How often do you eat the following snacks?

If you do, do you eat			
	Every day or almost every day	Occasionally during the week	Never or hardly ever
Candy/sweets	+2	+1	–2
Potato chips	+2	+1	–2
Soft drinks	+2	+1	–2
Concentrated juice	+2	+1	–2
Biscuits	+2	+1	–2
Sweet rolls/cakes	+2	+1	–2
Chocolate	+2	+1	–2
Raisins	+2	+1	–2
Xylitol-lozenges	–1	0	+1

4. Do they sell soft drinks, candy, or other snacks at your school?

Yes	0
No	0

5. How often do you drink soft drinks or eat candy or other snacks while doing the following things?

If you do, do you drink/eat them			
	Every day or almost every day	Occasionally during the week	Never or hardly ever
On the way to school	+2	+1	–2
At school	+2	+1	–2
On the way home from school	+2	+1	–2
Upon coming home	+2	+1	–2
Doing homework	+2	+1	–2
Playing with a computer or a PlayStation.	+2	+1	–2
Watching TV or videos	+2	+1	–2
Spending time with your friends	+2	+1	–2
Playing sports	+2	+1	–2
Doing other activities	+2	+1	–2

6. Compared to you, do other kids of your age drink soft drinks, eat candy/sweets and other snacks

Less than you	+2
As much as you	0
More than you	–2

7. How often do you buy the following snacks for yourself?

If you buy, do you buy			
	Every day or almost every day	Occasionally during the week	Never or hardly ever
Candy/sweets	+2	+1	–2
Potato chips	+2	+1	–2
Soft drinks	+2	+1	–2

8. How many euros a week do you spend on soft drinks, candy/sweets and other snacks?

€

9. What is your most common drink at meals (only one choice in each column)

	At school	At home
Milk	–2	–2
Juice	+2	+2
Concentrated juice	+2	+2
Tap water	–2	–2
Soft drinks	+2	+2
Diet soft drinks	+1	+1
Bottled water	–2	–2
Something else		

10. What is your most common drink for thirst (only one choice in each column)

	At school	At home
Milk	–2	–2
Juice	+2	+2
Concentrated juice	+2	+2
Tap water	–2	–2
Soft drinks	+2	+2
Diet soft drinks	+1	+1
Bottled water	–2	–2
Something else		

11. How often do you use chewing gum?

If you do, do you chew			
	Every day or almost every day	Occasionally during the week	Never or hardly ever
Xylitol chewing gum	–2	–1	+2
Other chewing gum	+2	+1	–2

12. When you use chewing gum, how many pieces during the day?

13. For statistics we would like to know your age and whether you are a girl or a boy
My age is

Years

I am

a girl	
a boy	

Thanks!