Laser fluorescence (LF) in monitoring influence of targeted tooth brushing on remineralization of initial caries lesions on newly erupted molar teeth – RCT

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Abstract

Purpose Remineralization after regular use of fluoride tooth paste has been detected even in weeks. This study aimed to demonstrate remineralization of initial lesions in newly erupted second molars using laser fluorescence scanning after one month's tooth brushing intervention. **Design** The study group was selected among 124 13-14-year-old school-children, 51 of whom at baseline had at least one initial lesion with LF value >10 in their second molars. Laser fluorescence (LF) values were registered at baseline and after one month's follow-up period. All participants were individually taught targeted tooth brushing of their second molars and randomly provided tooth paste with 0 or 1500ppm fluoride. Brushing frequency was questioned at baseline and after the follow-up. Change in LF values was compared considering content of fluoride in the paste, the tooth and brushing frequency. **Results** Brushing frequency increased slightly during the intervention. In lesions with LF values >30 at starting point, improvement was least detected; whereas in lesions with LF values ≤30 change in LF values demonstrated improvement. Improvement was detected especially in upper molars despite the fluoride content in the paste. **Conclusions** LF is useful in monitoring remineralization of incipient lesions even in weeks. Targeted tooth brushing induces remineralization. LF could be a valuable motivating tool in promoting patients' self-care and controlling caries.

Key words: Tooth brushing, remineralization, Initial caries lesion, Laser fluorescence

Introduction

Fluoride has been used in dental prevention for more than 70 years and is thought to be the main reason for caries decline in the industrialized world, also in Finland since 1970's (Marthaler 2004, Suominen-Taipale et al. 2004). Oral health of children and adolescents improved distinctly until 1990s, but has remained at that level ever since (Marthaler 2004). In Finland, the mean DMFT score at 12 years was 1.2 in 1991 (Nordbad et al. 2004). Caries is still common among the young; in 1991 20 % of the 5-year-old children and 75 % of the 15-year-olds had dental caries (Vehkalahti et al. 1997). In a recent epidemiological study among young males (19.6 years on average) 45% were in need of restorative treatment and one in five had sound teeth without restorations (Tanner et al. 2013).

Factors associated with progression of caries lesions have been reported to be i.e. the amount and quality of oral bacteria (biofilm), composition and amount of saliva, tooth's morphology and insufficient fluoride consumption (Braga et al. 2009; Watt and Rouxel 2012). The occlusal surface of the tooth is most vulnerable to caries lesion progression during eruption until the tooth reaches its counterpart in the opposite jaw in occlusion (Ekstrand et al. 2005; Duturuk et al. 2011). Occlusion disturbs the biofilm mechanically thus hindering its growth. Biofilm may also be efficiently disturbed by brushing. Undisturbed biofilm causes demineralization on the tooth surface causing eventually caries lesions develop. Targeted brushing of erupting teeth has been studied in Nexö, Denmark, since the 1980's and it has shown excellent results. There has been a significant decrease in caries prevalence over decades (Ekstrand et al. 2005).

According to the Finnish Oral Health 2000 -survey among adults, there was an association between tooth brushing frequency and dental cleanness. However, this association was weaker than expected, which indicates the inefficiency of tooth brushing (Suominen-Taipale et al. 2004). A significant

difference has been noticed between brushing frequency among genders; boys neglect tooth brushing more often than girls. According to the WHO school oral health survey (2012), 55% of the 11-year- old Finnish girls brushed their teeth more frequently than once a day when the respective figure for boys was 37%. Brushing frequency increased towards older age groups; yet, the difference between the genders remained. Finnish adolescents are ranked among the least frequent tooth brushers in Europe. (Currie et al. 2014)

The beneficial effects of the use of fluoride on remineralization of teeth have been detected in numerous interventions. In a recent report, Twetman (2009) reported on beneficial effect of daily use of fluoride tooth paste on caries prevention in children compared with placebo. Schirrmeister et al. (2007) reported in their clinical study a significant remineralization of initial lesions using both 1450ppm and 5000ppm fluoride tooth pastes after two weeks' follow-up period. The affect, however was even more distinct by 5000ppm tooth paste. Similar results were reported by ten Cate et al. (2008) who studied clinically the effect of 1450 and 5000ppm fluoride concentrations on re- and demineralization of initial lesions (over 150µm). However, Nordström and Birkhed (2010) reported that 1450ppm and 5000ppm fluoride tooth pastes have similar effect on remineralization of active initial lesions.

Laser fluorescence (LF, DIAGNOdent, KaVo, Biberbach, Germany) has been used in dentistry since 1990's. Demineralized tissues induce higher fluorescence values than healthy ones. The signal of fluorescence emission is processed and expressed quantitatively on the display (0-99). The method is sensitive in detecting occlusal caries lesions, especially the initial ones compared with i. e. visual detection. It has been suggested that DIAGNOdent®-device can be used for monitoring progress and arrest of caries lesions as well as for diagnostic help for visual detection of lesions (Schirrmeister et al. 2007; Lussi et al. 2001; Anttonen 2007).

Our aim was to investigate the effect of targeted tooth brushing of newly erupted second molars with initial caries lesions using tooth paste with or without fluoride for one month. We hypothesized that targeted tooth brushing is effective in remineralization of initial caries lesions. Another hypothesis was that fluoride increases the effect of brushing.

Material and methods

Study group

All children in the 7th grade aged 13-14 years in one junior high school in Oulu, Finland (n=124), were given a lesson on tooth brushing by dental hygiene students supervised by their teacher (HH). After the lesson, the occlusal surfaces or fissures of recently erupted second molars of all pupils were screened using LF (TM). If the LF value was >10 (estimated as initial caries lesion) at least in one second molar, the pupil was requested to participate the intervention study. A consent form was given to volunteers to be signed by themselves and their parent/caregivers. Total of 51 children fulfilling the clinical criteria returned the signed form; the total number of their second molars to be screened was 204 (Figure 1)

Intervention and screening

To investigate remineralization indicated by changes in LF values, teeth of the participants were scanned and LF values registered before and after the intervention. The field phase of the study was conducted by a fourth year dental student (TM) supervised during the study by an author familiar with the use of DIAGNOdent device (VA).

At baseline and in the end of the intervention self-reported brushing activity of each child was registered. They were questioned if they brushed their teeth *every day*, and if so, *once a day* (7 times a week) or *twice a day* (14 times /week). They could also choose the options: *5-6 times/week, 3-4 times*

/ week and *less frequently*. They could also estimate how many times a week they brushed.

The participants were given a tooth brush and were taught individually how to brush the occlusal surfaces of second molars emphasizing cleaning those teeth with initial lesions. Brushing instruction was given by an oral hygienist student with the help of a wall and hand mirrors. Each participant was also randomly given a 75ml tooth paste tube containing either 0ppm or 1500ppm fluoride. The children were instructed to use only the given tooth paste every time they brushed teeth. In every tube there was a serial number – the key to the fluoride content. The fluoride concentration remained unknown to the child, the instructors and the researchers until the data were analyzed.

During the instruction session the second molar teeth to be scanned were brushed thoroughly without paste. After the teaching session TM scanned the occlusal surfaces using DIAGNOdent®-device. The pupils and the examiner were seated on a normal chair and the examiner wore a forehead light. Before scanning, each surface was blow-dried using compressed air for five seconds. DIAGNOdent®-device was calibrated according to the manufacturer´s instruction and individually against each child´s clean upper incisor´s buccal surface. The occlusal tip of the device which extended to the fissures was the same for each child and was disinfected between the scannings. The biggest LF value in every scanned molar was registered by the oral hygienist student on a computer program designed for this study. LF-scanning was repeated in the same manner after one month follow-up period. Each visit lasted approximately 15 minutes and was conducted at the school location.

TM was trained on the use of the device on extracted teeth as well as in the clinical setting by VA. The oral hygienist students were given instructions how to train participants to targeted tooth brushing and how to record findings. VA visited the examination site twice to ensure the protocol. A computer program was used for this purpose.

Statistical analysis

The mean brushing frequencies were calculated according to gender and the test group (SD) at baseline and after the intervention and the change in it accordingly. The power calculation was accomplished to investigate the sufficient size of the study group using the paired sample *t test* comparing the figures presented by Schirrmeister et al. (2007) in their article.

For the analyzes, the LF values were categorized indicating different stages of caries lesions according to the manufacturer: 0-10, 11-20, 21-30, >30. Sound teeth (<10) as well as those with fillings were excluded from the analyses. Correlation between the change in LF values and brushing frequency was investigated using correlation coefficient (r). The significance of the differences between the groups was evaluated using chi-square test. Difference in LF values between the groups was analyzed using t-test. The difference between LF values at different scanning occasions was analyzed by paired-samples t-test. The differences between the groups were considered statistically significant at p values <0.05. SPSS for Windows version 18.0 (SPSS, Inc., Chicago, IL, USA) was used for the analyses and G*Power version 3.1.9.2 was used for power calculation.

Ethical aspects

The children with their own and their parents' written consent, participated the study. For the study, a positive statement was given by the ethical commission of the Northern Ostrobothnia health care district (73/2006 section 164). The researchers and the examinees were blinded concerning the fluoride content of the tooth paste given to the examinees for the intervention. Identification of the participants was excluded from the data before analyses. The key to the fluoride group was opened by the statistician for the analyses.

Results

The study group comprised 51 (out of 124 7th graders) children distributed in fluoride (n=26) and non-fluoride (n=25) groups (Table1). The process is illustrated in a flow chart (Figure 1). The size of the study group was proven sufficient by power calculation.

At baseline and in the end of the follow-up period there was no statistically significant difference in brushing frequencies between fluoride and non-fluoride groups, nor between the genders. On average children brushed their teeth 11-12 times /week at baseline and about 12 times /week after the intervention (Table1). Improvement of brushing frequency was similar in fluoride and non-fluoride groups. Brushing frequency of boys improved more than that of the girls during the intervention, but the difference between the genders was not statistically significant ($p=0.077$) (Table1).

LF values decreased distinctly in upper teeth despite the group indicating remineralization ($p\leq0.001$). Decrease was most distinct in right molars in the non-fluoride group ($p<0.05$). In lower molars there was no significant change observed (Table 2).

Majority of LF values of lesions with values 11-20 at starting point, remained unchanged. During the intervention the condition improved for every third upper molar and every fifth lower molar (LF 0-10; regarded as sound according to the manufacturer). Also disimprovement was detected, but none of those lesions had values >30 in the end. Considering LF values 21-30 at starting point, about 40% of the lesions remained unchanged. In this category, improvement was detected in about half of the upper lesions and one third of lower ones including those regarded as sound after intervention. Disimprovement was more present in lower teeth than upper ones. Even for lesions with LF>30 at baseline, improvement was detected, but it was not as evident as in other two categories (Figure 2).

Discussion

Laser fluorescence scanning can be useful in demonstrating influence of targeted tooth brushing of occlusal initial lesions of second molars after an intervention lasting only for one month. The condition of the lesion at baseline seems affect remineralization potential – remineralization of initial lesions with LF values <20 is most promising. Surprisingly, this is true regardless fluoride content in the tooth paste. Because remineralization was observed after targeted tooth brushing taught individually, remineralization may be more due to quality than frequency of brushing.

It can be speculated if the outcome of the intervention would be better if the inclusion criteria of lesions had been more precise (10 to 30 or even 10 to 20). Additionally it can be speculated that lesions with high LF values don't have the potential to remineralize as a response to targeted brushing and fluoride. In earlier works LF value 30 has been suggested as a cutoff point for estimating need of invasive treatment (Anttonen et al. 2003) or may be a sealing This study supports this assumption – initial lesions with low LF values are more likely to remineralize compared to the ones with high values. This is also supported by Schirrmeister et al. (2007) who showed that initial caries lesions lower LF values (<20) can be remineralized with brushing and using fluoride. Other non-invasive methods e.g. fissure sealants could be used for more progressed lesions (Kantowitx et al. 2013). At baseline the LF values were also higher in the fluoride group compared to the non-fluoride group, except in upper left molars which could have caused some bias.

LF- values decreased more distinctly in upper right molars. It has been studied that lower molars are more likely to develop caries lesions sooner than upper molars maybe due to their location and deep fissures complicating cleaning (Larmas et al. 1995). It may have been easier for our participants to clean their upper than lower teeth. In our study, there was even slightly disimprovement in lower molars in the non-fluoride group. Other confounding factors possibly affecting the results were not analyzed here; such as sugar consumption or secretion rate of saliva or general health of the

children. However, because the groups (fluoride and non-fluoride) were randomly comprised there is no reason to believe that these factors would be different in these groups.

Here, the effect of targeted brushing i. e. disturbing the biofilm on erupting tooth surface mechanically seems to be significant; even no distinct difference was detected between the fluoride and non-fluoride groups. Somewhat contradictory results were reported by Schirrmeister et al. (2007) and ten Cate et al. (2008) who found fluoride concentration in the tooth paste meaningful for remineralization. They did not consider the effect of brushing itself in their study. In the study by Schirrmeister et al. (2007), all lesions had LF values below 20 at baseline; whereas in our study the mean LF value was 39.4 and some lesions had even values beyond 40. It seems that true initial lesions (LF values 11-20) have the best response to targeted brushing whereas targeted brushing with or without fluoride does not improve lesions with LF values >30. Feng et al. (2007) had a non-fluoride placebo group in their study together with the sodium fluoride (NaF 1450 ppm F) and sodium monofluorophosphate (MFP; 1450 ppm F) groups. In all three groups remineralization occurred, but more rapidly in the fluoride groups than in the placebo group (Feng et al. 2007). It has been shown, that in addition to fluoride, calcium and phosphate ions can increase remineralization and decrease demineralization (Amaechi et al. 2013).

Brushing harasses mechanically the biofilm. It is well known that caries does not develop on a clean tooth surface. Our findings on the remineralizing impact of targeted tooth brushing after one month on initial caries lesions are in accord of those in the study by Schirrmeister et al. (2007), where remineralization was seen already after two weeks. In both studies LF method was used for monitoring change in mineralization. Our results are also in accord with those from Nexö where the follow-up period lasted for decades. In 1999 the mean DMF-S among 18-years in that community was the lowest in whole Denmark and the proportion of those with completely healthy teeth

was the highest in the whole nation (Ekstrand et al. 2005). Although the short intervention time may be considered a limitation of this study, the results of this targeted tooth brushing intervention are encouraging.

Brushing habits in the present study group were below the national average at baseline: in the School Health Survey 48% reported brushing their teeth twice a day or more often when in our study only 35.3% of the children brushed their teeth twice a day in the beginning and 45.1% in the end. According to the WHO's School Oral Health Survey boys are also lazier tooth brushers than girls are (National Institute of Health and Welfare. School Health Promotion Study 2010/2011). Here gender was not statistically significantly associated with brushing frequency either at baseline or in the end of the intervention. Almost every tenth (9.8%) of the children improved their brushing habits during this study to meet the recommended level. If the change of brushing frequency had improved more, the decrease in LF values could have been more significant. It can be discussed if brushing was inadequate due to for instance low motivation among some, in this specific age group. Anyway, no change in demineralization is better than its increase and can be considered as positive effect.

This study was not carried out in a dental office to maximize the number of participants. Despite this, the study group was limited; only 51 participated for the whole period. It can also be speculated if the results by LF scanning are reliable. To improve the results the tooth surfaces were cleaned by supervised brushing prior scanning, because plaque can affect the LF values (Anttonen et al. 2005). For practical reasons, no repeated measurements of lesions were performed. TM was only instructed on the use of the device and supervised prior and during the field phase of the by VA. This, however is a short-coming in this study. Even if this study supports the protocol of an earlier study by Tetuan et al. (2005), in which school nurses used LF scanning at school location for screening for restorative treatment need. LF scanning

method can also be useful for children's motivation and oral health promotion.

To conclude, targeted tooth brushing seems to be effective in remineralization of initial lesions of newly erupted second molars demonstrated by decrease in LF values. The remineralizing effect of targeted tooth brushing seems to be most effective for lesions with LF values not exceeding 30. In future it would be beneficial to study more the effects of targeted tooth brushing limiting the cases to those with LF values <30.

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Authors contribution

The study was conceived and designed by H. Hausen, H.V, H. Heikka and V.A. The field study was performed by T.M and V.A. The data were analysed by H.V. The paper was written by E.J, H.V and V.A.

The authors declare having no conflicts of interest.

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Legends of the figures

Figure 1. A flow chart describing the process in the intervention.

Figure 2. Change in the laser fluorescence values according to the LF categories at baseline (11-20, 21-30, and >30) in upper and lower teeth.

Table 1. Change in brushing frequency compared to the situation at baseline in the fluoride (F) and non-fluoride (non F) groups and among the males and females.

A. **Variable**	**Group** **n (%); n (SD)**		**p**
	F paste n=26	non-F paste n=25	
Gender			
Male	10 (38.5)	10 (40.0)	
Female	16 (61.5)	15 (60.0)	
Tooth brushing frequency (times/week)			
After intervention	12.4 (2.1)	12.2 (2.5)	0.856
Change	0.5 (2.3)	0.8 (3.3)	0.897
B. **Variable**	**Female**	**Male**	**p**
Tooth brushing frequency (times/week)			
After intervention	12.2 (2.4)	12.6 (2.1)	0.658
Change	0.3 (2.9)	1.2 (2.6)	0.077

Table 2. LF values at baseline and after the intervention in upper and lower second molars on both sides in the fluoride and non-fluoride groups.

Second molar at baseline and after intervention	Mean LF value (SD), n		
	F	non- F	Total
Upper			
Baseline	40.1 (21.3)	36.3 (28.0)	38.4 (24.5)
After intervention	36.5 (24.5)	26.0* (20.6)	31.7** (23.3)
Lower			
Baseline	43.5 (25.4)	37.2 (24.9)	40.4 (25.2)
After intervention	41.1 (26.2)	37.9 (27.8)	39.5 (26.9)
Upper			
Left baseline	37.1 (18.0) n=24	38.9 (31.0) n=20	37.9 (24.5) n=44
Left after intervention	37.0 (24.5) n=24	28.4 (23.9) n=20	33.1 (24.3) n=44
Right baseline	43.4 (24.4) n=22	33.3 (24.8) n=18	38.9 (24.8) n=40
Right after intervention	36.0 (25.1) n=22	23.2* (16.6) n=18	30.3**(22.4) n=40
Lower			
Left baseline	40.0 (21.5) n=24	38.1 (24.7) n=24	39.1 (22.9) n=48
Left after intervention	35.4 (19.9) n=24	39.1 (28.8) n=24	37.3 (24.6) n=48
Right baseline	47.0 (29.0) n=23	36.2 (25.7) n=20	42.0 (27.7) n=43
Right after intervention	47.0 (30.8) n=23	36.4 (27.3) n=20	42.1 (29.4) n=43

*$p<0.05$; **$p\leq0.001$

Figure 1.

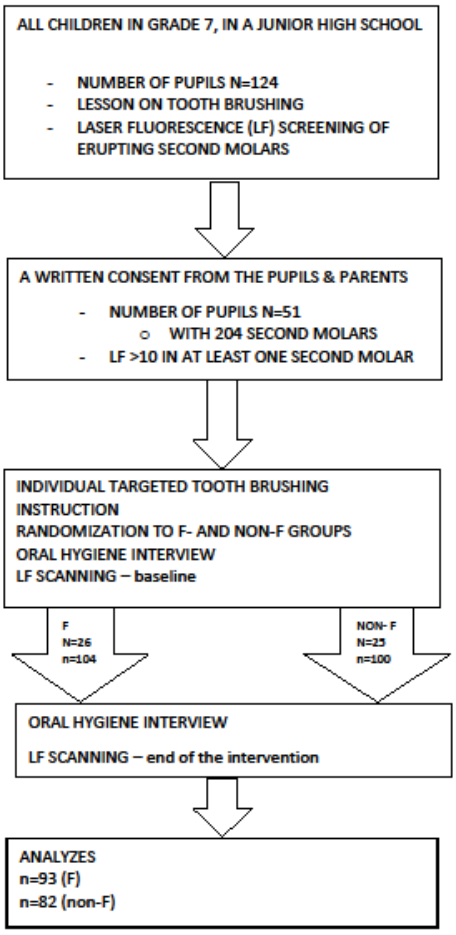
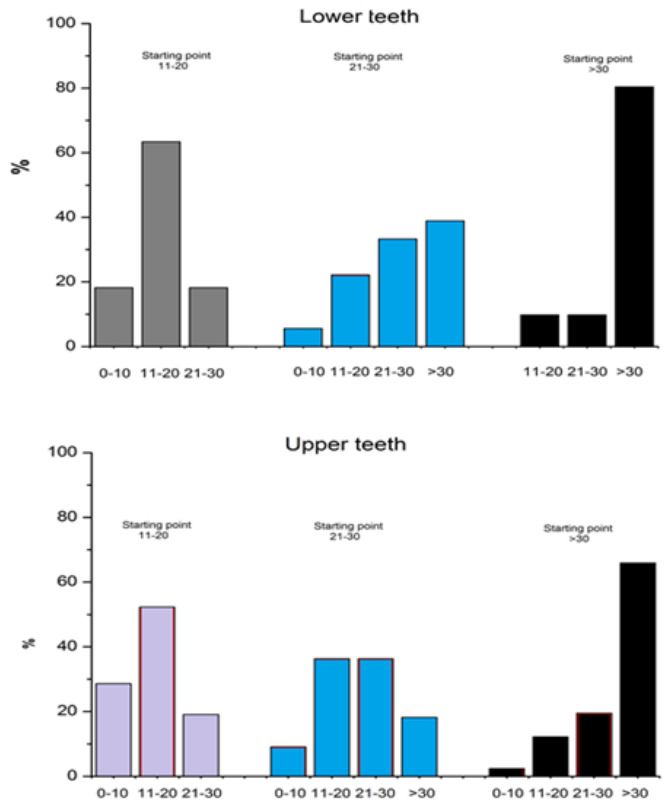

ALL CHILDREN IN GRADE 7, IN A JUNIOR HIGH SCHOOL
- NUMBER OF PUPILS N=124
- LESSON ON TOOTH BRUSHING
- LASER FLUORESCENCE (LF) SCREENING OF ERUPTING SECOND MOLARS
A WRITTEN CONSENT FROM THE PUPILS & PARENTS
- NUMBER OF PUPILS N=51
o WITH 204 SECOND MOLARS
- LF >10 IN AT LEAST ONE SECOND MOLAR
INDIVIDUAL TARGETED TOOTH BRUSHING INSTRUCTION
RANDOMIZATION TO F- AND NON-F GROUPS
ORAL HYGIENE INTERVIEW
LF SCANNING – baseline
F
N=26
n=104
NON- F
N=25
n=100
ORAL HYGIENE INTERVIEW
LF SCANNING – end of the intervention
ANALYZES
n=93 (F)
n=82 (non-F)

Figure 2.


Lower teeth
Starting point 11-20
Starting point 21-30
Starting point >30
%
100
80
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0-10 11-20 21-30 >30
11-20 21-30 >30
Upper teeth
Starting point 11-20
Starting point 21-30
Starting point >30
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100
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