European Journal of Orthodontics 29 (2007) 157–160
doi:10.1093/ejo/cjm001

The effect of oral health education on dental plaque development and the level of caries-related *Streptococcus mutans* and *Lactobacillus* spp.

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SUMMARY The aim of this study was to determine the influence of oral hygiene instruction (OHI) on oral hygiene status and on the reduction of inducing bacteria (*Streptococcus mutans* and *Lactobacillus* spp.) in 30 subjects (12 males and 18 females) with an age range from 10 to 14 years. The patients were instructed on how to carry out effective oral hygiene close to brackets and ligatures, and in the use of dental floss for cleaning spaces around brackets, between the teeth and under archwires. The plaque index (PI) was used to measure oral hygiene status, and the level of *S. mutans* and *Lactobacillus* spp. was determined using the colour reaction time test before and after 1 month of OHI. Statistical analysis included a Student's *t*-test and chi-square test.

The results showed that OHI significantly improved oral hygiene. The percentage of patients with a PI exceeding 1 decreased from 23.3 to 10 per cent and for those with a PI below 0.1 it increased from 20 to 60 per cent. The level of *S. mutans* and *Lactobacillus* spp. was not reduced. The percentage of subjects with excessive levels of *S. mutans* (above 10^6 bacteria in 1 ml of saliva) decreased after OHI but only from 73.3 to 70 per cent. For *Lactobacillus* spp., a level above 10^5 of bacteria in 1 ml of saliva was found for all subjects at both time points. Patients with fixed appliances, trained in scrupulous tooth cleaning, remain at risk of developing caries and should be carefully monitored.

Introduction

The human oral cavity is a complex ecosystem inhabited by more than 300 bacterial species, mycoplasmas, protozoa, and yeasts (Marcotte and Lavoie, 1998). Any external interference could disturb the delicate balance between components of microflora in this environment. Fixed orthodontic appliances are an example of such interference. Bonding of brackets usually includes acid etching of enamel, which results in changes in the morphology and chemical nature of the oral cavity. It has been found that decalcified enamel constitutes good support for adhesion and proliferation of *Streptococcus mutans*, *Veillonella* spp., and *Actinomyces viscosus* (Boyar *et al.*, 1989). It is also known that living cells easily adhere and colonize polymeric surfaces (Griesser *et al.*, 1993; Röder *et al.*, 1993; Tamada and Ikada, 1993; Zühlke *et al.*, 1993; Langer, 1995; West and Hubbell, 1999). Thus, composite resins containing polymers used for attaching brackets to etched enamel provide surfaces especially prone to adhesion and growth of microorganisms (Weitman and Eames, 1975; Gwinnett and Ceen, 1979; Sukontapatipark *et al.*, 2001). Moreover, the configuration of fixed appliances promotes retention of food and reduces efficiency of self-cleaning by saliva (Balenseifien and Madonia, 1970). In effect, fixed dental appliances induce development and retention of bacterial plaque (Balenseifien and Madonia, 1970; Zachrisson, 1976; Gorelick *et al.*, 1982; O'Reilly and Featherstone, 1987; Ögaard *et al.*, 1988; Mitchell, 1992). Development of dental plaque usually leads to an increased level of caries inducing bacteria in the oral cavity, e.g. *S. mutans* and *Lactobacillus* spp. (Balenseifien and Madonia, 1970, Diamandi-Kiopioti *et al.*, 1987; Boyar *et al.*, 1989). However, according to Bloom and Brown (1964), *Lactobacillus* spp. may not be the primary constituent of dental plaque.

The above observations indicate that fixed orthodontic appliances induce a certain risk for the development of caries. Therefore, orthodontists commonly recommend scrupulous tooth cleaning. This subject has been discussed by many authors (Zachrisson, 1974; Gold, 1975; Schwaninger and Vickiers-Schwaninger, 1979; Trombelli *et al.*, 1995) who, in addition to regular tooth brushing, often suggest measures such as the use of an electric toothbrush (Trombelli *et al.*, 1995) and irrigation (Schwaninger and Vickiers-Schwaninger, 1979). To decrease the bacterial level and plaque, various mouthwashes and varnishes have been used (Harrap and Best, 1984; Addy, 1986; Axelsson and Lindhe, 1987; Schaeken *et al.*, 1989; Sandham *et al.*, 1991; Machuca *et al.*, 1997; Twetman and Petersson, 1997; Van Lunsen *et al.*, 2000).

The aims of this investigation were to study the effect of oral hygiene instruction (OHI), the use of floss, and a manual tooth brush designed specifically for orthodontic patients, and to determine plaque and *S. mutans* and *Lactobacillus* spp. levels.

Subjects and methods

Thirty patients (12 males, 18 females) with an age range of 10 to 14 years, treated with fixed appliances at the Department of Orthodontics, Medical University of Lodz, Poland, were included in the study. The levels of *S. mutans* and *Lactobacillus* spp. were assessed using the colour reaction time test (Vivadent, Schaan Liechtenstein). The kit contains agar plates for cultivation of *S. mutans* and *Lactobacillus* spp. The plates were inoculated with saliva obtained from the patients and incubated at 37°C for 48 hours. Bacteria levels were then evaluated to compare the density of colonies of *S. mutans* and/or *Lactobacillus* spp. with the chart provided by the supplier. In addition, each patient's plaque index (PI) according to Silness and Löe (1964) was determined. Briefly, determination of PI was performed as follows: visualization of dental plaque was achieved using plaque colourant disclosing tablets (RedCote, J.O. Butler Co., Chicago, Illinois, USA). A score of 0 to 3 was assigned for the four sides of each tooth; score 0 when there was no plaque on the tooth wall, 1 when plaque was invisible to the naked eye but could be collected using a probe, 2 when plaque was visible at the gingival margin, and 3 when plaque not only was visible at the gingival margin but also covered a significant part of the tooth wall. The average score for an individual tooth was equal to the sum of the scores for all sides divided by four, and the PI for each patient was equal to the sum of the average scores for all teeth divided by the number of teeth.

According to Bratthall (1980) and Loesche (1986), levels of *S. mutans* exceeding 10^6 and/or *Lactobacillus* spp. exceeding 10^5 of bacteria per 1 ml of saliva indicate a high caries risk. On the basis of the above criteria, the patients were assigned to a group with either acceptable or excessive levels of *S. mutans* and *Lactobacillus* spp.

PI was determined for the incisors and first molars in the upper and lower arch. The average value of these 12 teeth was used to register oral hygiene: 'very good' corresponded to $\mathrm{PI} < 0.1$, 'good' to $0.1 \leq \mathrm{PI} < 1$, 'poor' to $1 \leq \mathrm{PI} < 2$, and 'very poor' to $2 \leq \mathrm{PI} \leq 3$.

After determination of the average PI and *S. mutans* and *Lactobacillus* spp. levels, the subjects were provided with manual toothbrushes specifically designed for orthodontic patients (Ortho P35, Oral-B Laboratories, Kronberg im Taunus, Germany) and were instructed on how to efficiently clean their teeth. The heads of these toothbrushes are shaped in such a way that they fit the brackets. The manufacturers suggest an additional period of intensive brushing in the horizontal direction with brackets and ligatures fitting rifts on the brush and scrupulous cleaning of the spaces around brackets, under the arch and between teeth with dental floss. One month after OHI, oral hygiene and *S. mutans* and *Lactobacillus* spp. levels were again determined.

Statistical analysis

The hypothesis that the average PI values and the difference in average values before and after OHI (ΔPI) differ significantly was verified, assuming that the analysed variables had a normal distribution. The hypothesis that the distribution of patients into groups with different hygiene status does not depend on OHI was verified using the chi-square goodness-of-fit test for contingency tables. The calculations were made according to Green and Margerison (1978).

Results

The average PI values [$\overline{\mathrm{PI}} = \sum_i \mathrm{PI}_i/N$ where PI_i denotes the PI for patient 'i' and N is the total number of patients] before and after OHI for females, males, and the genders combined are shown in Table 1 together with the difference in average PI values. The data indicate that the $\overline{\mathrm{PI}}$ for males was higher than for females. However, at the confidence level of $\alpha = 0.05$, this difference was not significant.

$\overline{\mathrm{PI}}$ values were always lower following OHI (Table 1). To determine the statistical importance of this observation, the hypothesis that $\overline{\Delta\mathrm{PI}} = 0$ (i.e. that there is no difference in PI for patients before and after OHI) was tested. Confirmation of the hypothesis was undertaken using the Student's t-test, where $t = (\overline{\Delta\mathrm{PI}}/s)\sqrt{N-1}$ in which s denotes the standard deviation and n the number of patients. The t values for females, males, and both genders combined were 3.94, 3.82, and 4.87, respectively, and were larger than the critical values of t at the confidence level $\alpha = 0.05$. Thus, the hypothesis that $\overline{\Delta\mathrm{PI}} = 0$ was rejected and an alternative hypothesis that OHI led to a significant reduction in the PI was accepted.

However, OHI did not significantly affect the number of patients with acceptable levels of *S. mutans* and *Lactobacillus* spp. (below 10^6 and 10^5 of bacteria in 1 ml of saliva for *S. mutans* and *Lactobacillus* spp., respectively). The number of female patients with an acceptable level of *S. mutans* increased after OHI from 6 to 7. For male patients no change was observed.

The level of *Lactobacillus* spp. exceeded the acceptable level (10^5 in 1 ml of saliva) in all examined patients and did not depend on OHI.

Table 1 Average plaque indices ($\overline{\mathrm{PI}}$) before and 1 month after oral hygiene instruction (OHI) and the average changes in plaque indices ($\overline{\Delta\mathrm{PI}}$).

	$\overline{\mathrm{PI}}$ before OHI (standard deviation)	$\overline{\mathrm{PI}}$ after OHI (standard deviation)	$\overline{\Delta\mathrm{PI}}$ (standard deviation)
Females	0.414 (0.315)	0.192 (0.265)	0.223 (0.233)
Males	1.099 (0.957)	0.496 (0.670)	0.603 (0.523)
Combined	0.688 (0.722)	0.313 (0.484)	0.375 (0.414)

Discussion

The results of the study were compared with the findings of Borutta *et al.* (2002). However, in their research plaque accumulation was scored on a scale from 0 to 5 using the Quigley-Hein Index (QHI), whereas in the present investigation it was scored on a scale from 0 to 3. Thus, for comparison of the average $\overline{QHI}$ and $\overline{PI}$, the latter should be multiplied by 5/3. Borutta *et al.* (2002) found that for patients using the same type of toothbrush, $\overline{QHI}$ was from 1.32 to 1.71 (1.33 at the initial check-up), whereas for those using powered toothbrushes it ranged from 0.42 to 0.51. In the present investigation before OHI, $\overline{PI}$ = 0.688, which corresponded to a it of 1.15. Thus, at the beginning of both studies the degree of plaque formation was similar. However, 1 month after OHI, there was a decrease in $\overline{PI}$ to 0.375 in the present study, i.e. to a value corresponding to a $\overline{QHI}$ of 0.52 which is close to that found by Borutta *et al.* (2002) for patients using powered brushes ($\overline{QHI}$ = 0.42). The above finding indicates that correctly performed manual oral hygiene and cleaning with dental floss give similar results to those obtained with a powered toothbrush.

The beneficial result of correct manual tooth cleaning was also supported by analysis of the distribution of the patients into groups with various hygiene status determined before and after OHI. The distribution of patients into groups with very good, good, poor, and very poor oral hygiene, performed on the basis of their individual PI, is shown in Figure 1. It is worth noting that the percentage of female patients with very good oral hygiene increased from 16.7 to 66.7 per cent. For males, the corresponding figures were 25 to 50 per cent, respectively.

The hypothesis that the distribution of patients into various hygiene status groups does not depend on OHI was verified. Since the calculated value of χ^2 = 10.961 was higher than $\chi^2_{a=0.05}$ = 7.815, the hypothesis formulated above had to be rejected, and the converse that the observed improvement in the oral hygiene status following OHI was accepted.

Corbett *et al.* (1981) reported that patients with banded orthodontic appliances had significantly higher levels of *S. mutans* than subjects wearing unbanded appliances. One could expect that OHI should lead to an improvement in oral hygiene and eventually to an increase in the number of patients with acceptable levels of *S. mutans* and *Lactobacillus* spp. However, according to the present findings OHI did not have any beneficial influence on bacterial level, regardless of patient gender or type of bacteria, and the number of patients with an acceptable bacteria level was quite low.

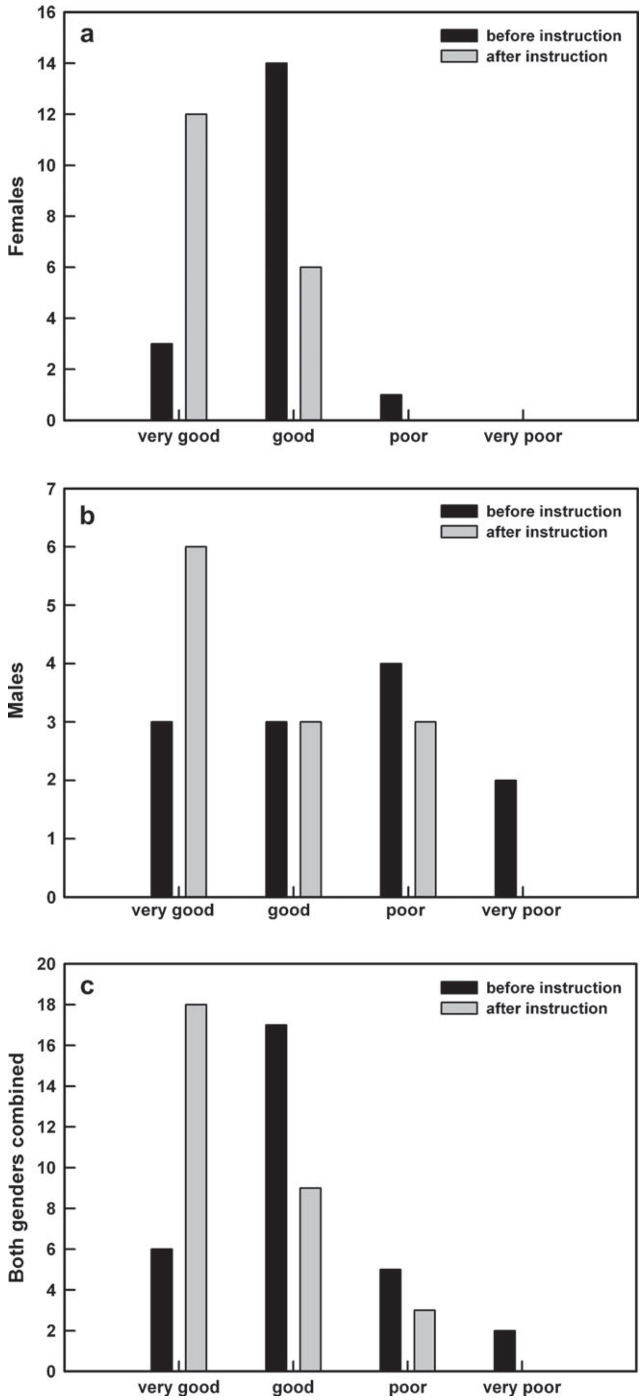

Figure 1 Distribution of the number of females (a), males (b), and both genders combined (c) with very good, good, poor, and very poor hygiene before and after oral hygiene instruction.

Conclusions

The findings of this study indicate that in patients with fixed orthodontic appliances, intensive brushing and careful cleaning with dental floss of the spaces around brackets, under archwires and between the teeth, leads to a significant increase in the level of oral hygiene characterized by the PI. However, these measures were insufficient to decrease *S. mutans* and *Lactobacillus* spp., levels. Thus, patients with fixed appliances have a higher caries risk.

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