Chemical plaque control and prevention of extrinsic tooth discoloration in vivo

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Extrinsic discoloration of teeth has frequently been observed in connection with the use of chemical plaque-preventive agents. Preliminary investigations have indicated that oxidizing peroxymonosulfate may effectively reduce this discoloration without interfering with the plaque-preventive capacity of chlorhexidine. In the present experiment a 0.2% chlorhexidine and a 1% peroxymonosulfate solution were used for oral rinsing in a group of 50 military recruits. A double-blind experimental design was followed. The plaque-preventive capacity of chlorhexidine was maintained, and a marked reduction in extrinsic tooth discoloration could be observed. □ *Chlorhexidine; human teeth; plaque prevention*

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Extrinsic discoloration of teeth is an unwanted side effect in connection with the use of chemical plaque-preventive agents such as chlorhexidine (for survey, see Ref. 4). Individual differences in discoloration tendency have, however, been observed. In a previous study, three typical 'stainers' and three 'non-stainers' were selected from a group of dental students (16). Various rinsing regimes were tested in vivo to study the nature and possible ways of preventing such discolorations. The most promising results were obtained with an oxidizing agent based on the use of peroxymonosulfate as a second mouth rise in addition to a 0.2% chlorhexidine solution. These agents have also been tested in various in vitro discoloration studies (10, 11) and in rabbits (2). The results from these experiments support the results from the preliminary in vivo investigation (16).

To test the validity of this concept for prevention of extrinsic chlorhexidine-induced discolorations under less selective conditions, military recruits were chosen as test subjects.

Materials and methods

Fifty military recruits volunteered to participate and signed a written consent giving information about the investigation. The experiment was planned as a double-blind, cross-over design (Fig. 1).

Before start of the experiment the plaque and discoloration situation was recorded and a clinical color picture of their teeth taken in frontal view with ×2/3 before a thorough, professional tooth cleaning was performed. The participants were then arbitrarily allocated to one of two groups of 25 participants each. Two coded bottles of rinsing solutions were distributed to each participant. One contained a 0.2% chlorhexidine acetate solution (CH) (Hibitane®, ICI, Macclesfield, England), and the other contained either 1% peroxymonosulfate (PMS) (Caroat®, Degussa, Frankfurt, FRG) stabilized in a succinic acid–sodium hydroxide buffer adjusted to pH 5.0, or distilled water (Aq. dest.). Group one started with the CH–PMS rinsing procedure and group two with CH–Aq.dest., both used for 1 min consecutively. This rinsing was performed twice daily as their only oral hygiene measure.

After 14 days the plaque and discoloration situation was recorded and a ×2/3 clinical photo taken. Thorough professional oral hygiene was then performed and a 1-week rest period allowed to prevent any carry-over effect.

Tooth cleaning was then performed before

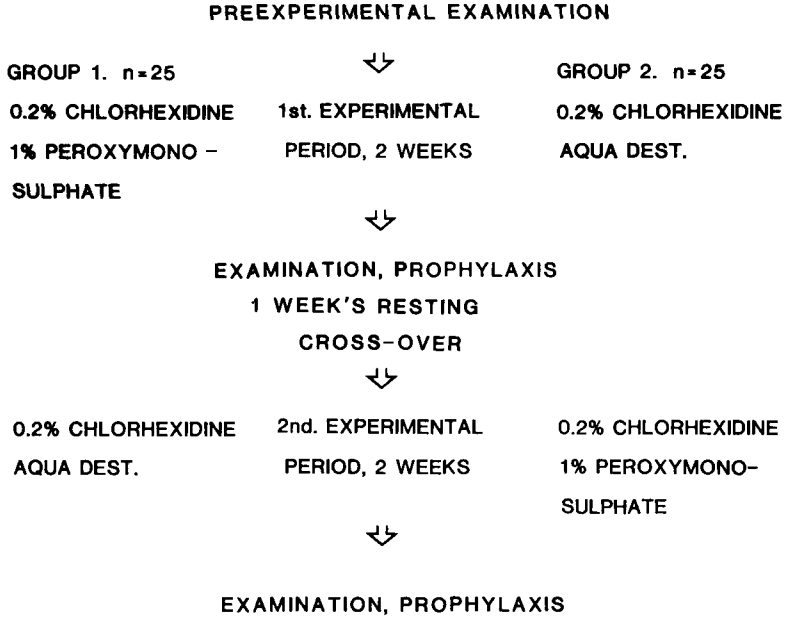

Fig. 1. The design of the study. Fifty military recruits, 19–24 years old, were arbitrarily allocated to one of two experimental groups of 25 persons each. A double-blind cross-over design was followed. 0.2% chlorhexidine and 1% peroxymonosulfate (oxidizing agent) were used as test solutions and 0.2% chlorhexidine and distilled water as control.

new coded bottles were distributed, changing the groups in accordance with the cross-over design. After another 2 weeks a final plaque and discoloration recording was performed, photos taken, and the teeth given a final prophylaxis (Fig. 1).

Plaque was scored by the same investigator (HME) all through the investigation in accordance with the Pl.I. defined by Silness & Løe (15). The discoloration situation was registered according to a staining index ranking the visual impression of stain from 0–3 for increasing severity and was also determined from coded color photos of the participants (3). The Wilcoxon signed ranks test for matched pairs (14) has been applied for statistical testing of the discoloration scores.

Results

The pre-experimental recording of plaque and extrinsic discoloration revealed that the mean values of the plaque index scores were 1.3 and 1.4, respectively. No extrinsic tooth discoloration was registered among any of the participants (Fig. 2, Table 1).

After the first rinsing series, only 6 participants from group 1 (CH–PMS) showed any discoloration at all (Table 1), whereas in group 2 (CH–Aq.dest.) 12 participants developed cosmetically disturbing discolorations on their teeth (scores 2 or 3) (Table 1). Their mean plaque index values were almost identical, 0.4 versus 0.5. One participant withdrew from group 2 during this rinsing period owing to mononucleosis.

After a rest period of 1 week and a cross-over change of the rinsing regimes the following results were obtained.

In group 1, now rinsing with CH–Aq. dest., nine persons presented staining index score 2 or 3, and only seven were totally free from extrinsic tooth discolorations. In group 2, rinsing with CH–PMS, only one subject developed an esthetically disturbing discoloration (score 2). The accumulation of plaque was again almost identical, indicated by mean plaque index values of 0.5 for both groups. Fig. 2 gives an overall impression of the consistently low plaque index values in both groups, varying between 0.4 and 0.5, and the effectiveness of PMS in reducing staining. The information given in Fig. 2 is based on mean index values. Statistical test-

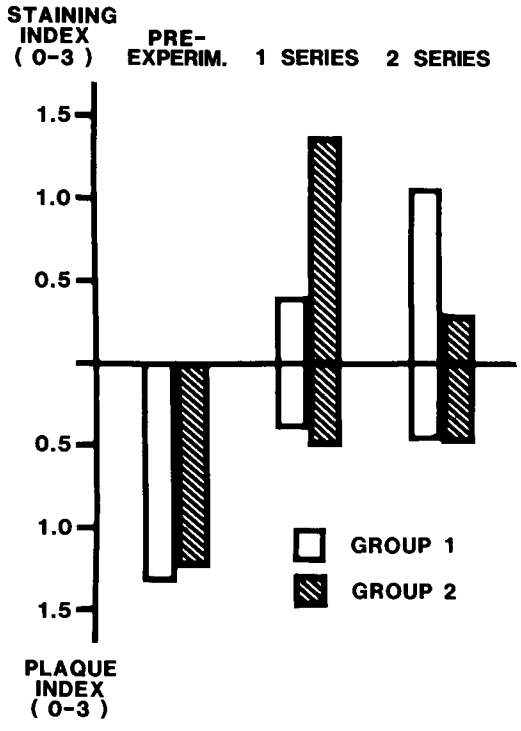

Fig. 2. Staining and plaque index values for the experimental groups. Mean staining index values are given above and plaque index values below the x-axis. The pre-experimental situation is indicated to the left. In the first series group 1 used 0.2% chlorhexidine and 1% peroxymonosulfate, and group 2 used 0.2% chlorhexidine and distilled water rinsing twice daily for 14 days. In the second series the procedures were interchanged between the two groups.

ing of the results revealed a significant difference in extrinsic discoloration induced by the two rinsing procedures ($p < 0.01$).

On the basis of the discoloration situation after rinsing with CH–Aq.dest., 'stainers' and 'non-stainers' were grouped for comparison of plaque accumulation. Mean plaque index values were lower among 'stainers' than 'non-stainers' after both rinsing series.

A questionnaire revealed that smoking and tea-drinking were more frequent among 'stainers' than 'non-stainers'. No differences could be found with regard to food habits or the consumption of coffee or red wine (Table 2).

Discussion

In a previous preliminary study of selected dental students, an oxidizing peroxymonosulfate compound was the most promising agent tested for prevention of extrinsic tooth discoloration (16). This ability to reduce the discoloration tendency with maintenance of the plaque-preventive effect of chlorhexidine has been confirmed in the present more extensive field study.

The results show a statistically significant difference in discoloration scores when comparing the results for chlorhexidine with or without an additional peroxymonosulfate rinse. Peroxymonosulfate does not seem to

Table 1. Staining and plaque index values

	Mean Pl.I. values				Staining (St.I. 0–3) scores							
	Group 1		Group 2		Group 1				Group 2			
	Mean	SD	Mean	SD	0	1	2	3	0	1	2	3
Pre-experimental	1.4	0.4	1.3	0.6	25	0	0	0	25	0	0	0
1st series	0.4	0.2	0.5	0.3	19	3	3	0	6	6	9	3
2nd series	0.5	0.3	0.5	0.3	7	9	7	2	17	6	1	0

Mean plaque index values with standard deviation (SD) and the distribution of staining index scores are given for both groups. In the first series group 1 rinsed with 0.2% chlorhexidine and 1% peroxymonosulfate while group 2 acted as control (0.2% chlorhexidine and distilled water). In the second series the rinsing regimes were interchanged between the two groups. The difference in discoloration tendency is statistically significant ($p < 0.01$, Wilcoxon signed rank test for matched pairs).

Table 2. Discoloration and oral intake of various substances

	Staining index 2–3, no. = 21	Staining index 0–1, no. = 26
Smokers	9	3
Tea drinkers	10	3
Coffee drinkers	8	7
Red-wine drinkers	0	0

Drinking and smoking habits are correlated with the discoloration status. Persons with staining index values 2 and 3 (no. = 21) and 0 and 1 (no. = 26) were grouped together. Two participants did not answer the questionnaire.

influence the plaque-preventive capacity of chlorhexidine.

The scores presented here (Table 1, Fig. 2) are based on the clinical examination. The discoloration was also evaluated on the basis of coded color photographs. A comparison of the results revealed only minor differences (3).

The investigation shows that only five persons developed severe staining (score 3), whereas about half of the participants demonstrated cosmetically disturbing discolorations during the investigation. This supports the results of previous chlorhexidine investigations. Only one participant developed more discoloration in connection with the use of peroxymonosulfate (score 1 to 2), whereas this oxidizing compound reduced the discoloration tendency in 29 participants. No difference was registered among the remaining 19.

The mean plaque scores for the two groups were almost identical after completion of the two different rinsing regimes, varying between 0.4 and 0.5. The level of plaque prevention is in accordance with results from other chlorhexidine rinsing experiments (4). The lower plaque index values detected among 'stainers' indicate that staining may be associated with the plaque-preventive effect of chlorhexidine.

The etiology of these extrinsic tooth discolorations are not fully understood, but several theories have been suggested. It has been shown that chlorhexidine may retain organic dyes (7) and react with various organic substances, forming strongly colored products (9). Chlorhexidine may also catalyze organic browning reactions, which are likely to occur in the oral cavity (10). Although chlorhexidine retention may take place directly to hydroxyapatite (7), investigations have indicated that pretreatment with saliva enhances the accumulation of extrinsic discolorations (12). Clinically, these discolorations are located along the gingival margins, in interproximal regions, and lingually on the mandibular incisors—protected areas where organic integuments tend to accumulate undisturbed. It is further observed that these discolorations tend to develop in connection with various chemical agents preventing plaque formation and that they disappear by introducing agents reducing their plaque-preventive capacity (16). These observations point to the acquired pellicle as a major site for extrinsic tooth discolorations.

Denaturation of a protein will increase its stainability (6). Both chlorhexidine and other chemical plaque-preventive agents are strong denaturants. Beverages such as tea and red wine, frequently associated with tooth discoloration (1), contain substantial amounts of tannins, which also are protein denaturants. Denaturation causes disorganization of a protein by splitting up S-H groups. This makes sulfate available as a reactant. Heyden (5) suggested a close correlation between the discoloration tendency and the presence of sulfate groups.

It has further been shown that discolored pellicle contains high amounts of iron (11), and this is also detected from brownish-black integuments naturally occurring in the dentition (13).

Many iron salts are heavily colored, but both ferric sulfate and ferric phosphate

(phosphate ions are readily available on the tooth surfaces) are white or grayish-white (8). This may explain why an oxidizing agent such as peroxymonosulfate acts as a bleaching agent: both ferric sulfate and ferric phosphate represent oxidized states of these elements. The general bleaching capacity of oxidizing substances is also well known.

The peroxymonosulfate used is a potent oxidizing compound used for various bleaching purposes. The toxicity of the compound is stated as low, but at present the biological testing is not extensive enough to obtain general acceptance for it as a therapeutic agent for oral use.

On the basis of the questionnaire, smoking and tea consumption seem to be more frequent among subjects developing extrinsic tooth discolorations. However, many developed these discolorations without smoking or drinking tea, and, on the other hand, some participants with these habits did not present with discolorations. It is therefore concluded that smoking and tea consumption are predisposing factors but that no absolute relationship exists between these habits and extrinsic discoloration of teeth.

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References

1. Addy, M., Prayitno, S., Taylor, L. & Cadogan, S. An in vitro study of the role of dietary factors in the aetiology of tooth staining associated with the use of chlorhexidine. J. Peridontol. Res. 1979, 14, 403–410
2. Ellingsen, J. E., Rölla, G. & Eriksen, H. M. Extrinsic dental stain caused by chlorhexidine and other denaturating agents. J. Clin. Periodontol. 1982, 9, 317–322
3. Eriksen, H M., Jemtland, B., Finckenhagen, H. J. & Gjermo, P. Evaluation of extrinsic tooth discoloration. Acta Odontol. Scand. 1979, 37, 371–375
4. Eriksen, H. M. & Nordbø, H. Extrinsic discoloration of teeth. J. Clin. Periodontol. 1978, 5, 229–236
5. Heyden, G. Relation between locally high concentration of chlorhexidine and staining as seen in the clinic. J. Periodontol. Res. 1973, 8, Suppl. 12, 76–80
6. Hjeljord, L. G., Sønju, T. & Rølla, G. Chlorhexidine-protein interactions. Scand. J. Dent. Res. 1973, 8, Suppl. 12, 11–16
7. Jensen, J. E. Binding of dyes to chlorhexidine-treated hydroxyapatite. Scand. J. Dent. Res. 1977, 85, 334–340
8. Merck Index. 8th. ed. Merck & Co., Rahway, N.J., 1968
9. Nordbø, H. Discoloration of human teeth by a combination of chlorhexidine and aldehydes or ketones in vitro. Scand. J. Dent. Res. 1971, 79, 356–361
10. Nordbø, H. Ability of chlorhexidine and benzalconium chloride to catalyze browning reactions in vitro. J. Dent. Res. 1979, 58, 1429
11. Nordbø, H., Eriksen, H. M., Rölla, G., Attramadal, A. & Solheim, H. Iron staining of the acquired enamel pellicle after exposure to tannic acid or chlorhexidine. A preliminary report. Scand. J. Dent. Res. 1982, 90, 117–123
12. Prayitno, S. & Addy, M. An in vitro study of factors affecting the development of staining associated with the use of chlorhexidine. J. Periodontol. Res. 1979, 14, 397–402
13. Reid, J. S., Beeley, J. A. & MacDonald, D. G. Investigation into black extrinsic tooth stain. J. Dent. Res. 1977, 56, 895–899
14. Siegel, S. Nonparametric statistics for the behavioral sciences. McGraw-Hill, 1956, pp. 75–83
15. Silness, J. & Løe, H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. Acta. Odontol. Scand. 1964, 22, 121–135
16. Solheim, H., Eriksen, H. M. & Nordbø, H. Chemical plaque control and extrinsic discoloration of teeth. Acta Odontol. Scand. 1980, 38, 303–309

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