J Clin Periodontol 2001; 28: 57–64
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Journal of Clinical Periodontology
ISSN 0303-6979

# The influence of margins of restorations on the periodontal tissues over 26 years

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*Schätzle M, Lang NP, Ånerud Å, Boysen H, Bürgin W, Löe H: The influence of margins of restorations on the periodontal tissues over 26 years. J Clin Periodontol 2000; 27: 57–64.* © Munksgaard, 2001.

***Abstract***
**Aim:** The purpose of this investigation was to examine the long-term relationship between dental restorations and periodontal health.
**Material and Methods:** The data derived from a 26-year longitudinal study of a group of Scandinavian middle-class males characterized by good to moderate oral hygiene and regular dental check-ups. At each of 7 examinations between 1969 and 1995, the mesial and buccal surfaces were scored for dental, restorative and periodontal parameters. The mesial sites of premolars and molars of 160 participants were observed during 26 years (1969–1995). A control group with 615 sound surfaces or filling margins located more than 1 mm from the gingival margin in all 7 surveys was compared with a test cohort with 98 surfaces which were sound or had filling margins located more than 1 mm from the gingival margin at baseline (1969) and had a subgingival filling margin 2 years after (1971).
**Results and conclusions:** The study confirmed the long held concept that restorations placed below the gingival margin are detrimental to gingival and periodontal health. In addition, this study suggests that the increased loss of attachment found in teeth with subgingival restorations started slowly and could be detected clinically 1 to 3 years after the fabrication and placement of the restorations. A subsequent "burn-out" effect was suggested.

Key words: dental restorations; gingival health; periodontal attachment loss; longitudinal study

Accepted for publication 18 February 2000

In daily practice, overhanging margins of dental restorations present a frequently observed problem (Waerhaug 1960, Silness 1964, Björn et al. 1969, 1970, Lange 1981, Lang et al. 1988) which may greatly interfere with the maintenance of gingival and periodontal health (for review see Leon et al. 1977).

It is now generally accepted that overhanging restorations promote gingivitis by promoting the local accumulation of bacterial plaque rather than resulting in mechanical irritation (Waerhaug 1960). Epidemiological (Alexander 1967, 1968, Gilmore & Sheiham 1971, Hammer & Hotz 1979) and clinical experimental studies (Silness et al. 1964, 1970a, 1970b, 1974, Renggli & Regolati 1972, Rodriguez-Ferrer et al. 1980, Than et al. 1982, Lang et al. 1983, 1988) have demonstrated close associations between such iatrogenic factors and the pathogenesis of local periodontal lesions.

Histological studies have shown that every filling margin placed subgingivally represents a plaque retaining factor, even if the marginal adaptation may be clinically acceptable (Waerhaug 1960). Hence, subgingivally placed restoration margins may always be associated with gingivitis. Whether or not and to what extent this gingival lesion will result in loss of connective tissue attachment including bone loss can only be documented in longitudinal studies (Valderhaug & Birkeland 1976).

On the basis of an existing longitudinal data base on the natural history of periodontal disease (Löe et al. 1978a–c), the purpose of this study was to test the hypothesis that subgingival margins of dental restorations are associated with increased plaque accumulation, more severe gingival inflammation and loss of attachment than supragingival filling margins located more than 1 mm from the gingival margin or tooth surfaces that are clinically sound.

## Material and Methods

### Sources of data

The information presented in this paper was obtained through a longitudinal study of the initiation and progression of periodontal disease in man conducted in Norway between 1969 and 1995. The study population has been described earlier (Löe et al. 1978a–c, 1986, Ånerud et al. 1991). The Norwegian group was established in Oslo in

*Table 1a.* Criteria for the calculus index based on the retention index system (Löe 1967)

| |
|---|
| 0=no calculus |
| 1=supragingival calculus |
| 2=subgingival calculus |
| 3=abundance of calculus |

*Table 1b.* Criteria for the gingival caries index based on the retention index system (Löe 1967)

| |
|---|
| 0=no caries |
| 1=supragingival cavitation |
| 2=subgingival cavitation |
| 3=large cavitation |

*Table 1c.* Criteria for the gingival restoration index based on the retention index system (Löe 1967)

| |
|---|
| 0=no dental restoration in the gingival area or no margin of dental restoration closer than 1mm to the gingival margin |
| 1=supragingival margin of dental restoration extending less than 1 mm below the gingival margin |
| 2=subgingival margin of dental restoration extending more than 1 mm below the gingival margin |
| 3=grossly insufficient marginal fit of dental restoration in a supra- and/or subgingival location |

*Table 3.* Mean plaque (PlI) and mean gingival index (GI) scores at survey 7

| | Control sites | | Test sites | | *p*-values | |
|---|---|---|---|---|---|---|
| | PII | GI | PII | GI | PII | GI |
| survey 1 | 1.43 | 0.76 | 1.57 | 1.19 | 0.011* | 0.001* |
| survey 2 | 1.57 | 0.58 | 1.77 | 1.07 | 0.001* | 0.001* |
| survey 3 | 1.52 | 0.47 | 1.66 | 1.03 | 0.021* | 0.001* |
| survey 4 | 1.54 | 0.70 | 1.81 | 1.19 | 0.001* | 0.001* |
| survey 5 | 1.64 | 0.88 | 1.88 | 1.38 | 0.004* | 0.001* |
| survey 6 | 1.54 | 0.59 | 1.74 | 1.12 | 0.024* | 0.001* |
| survey 7 | 1.58 | 0.86 | 1.74 | 1.29 | 0.097 | 0.001* |
| | Control sites | | Test sites | | *p*-values | |
| | PlI | GI | PlI | GI | PlI | GI |
| $\Delta$ survey 1, 2 | $0.15^{+}$ | $-0.18^{+}$ | $0.19^{+}$ | $-0.12$ | 0.518 | 0.365 |
| $\Delta$ survey 2, 3 | $-0.05^{+}$ | $-0.12^{+}$ | $-0.10$ | $-0.04$ | 0.462 | 0.267 |
| $\Delta$ survey 3, 4 | 0.00 | $0.24^{+}$ | $0.13^{+}$ | $0.22^{+}$ | 0.105 | 0.758 |
| $\Delta$ survey 4, 5 | $0.08^{+}$ | $0.13^{+}$ | 0.04 | 0.15 | 0.644 | 0.894 |
| $\Delta$ survey 5, 6 | $-0.09^{+}$ | $-0.23^{+}$ | $-0.12$ | $-0.21$ | 0.775 | 0.862 |
| $\Delta$ survey 6, 7 | 0.02 | $0.28^{+}$ | 0.00 | 0.21 | 0.822 | 0.606 |

* Significant differences ($p<0.05$).
$^{+}$ Significant differences between two surveys ($p<0.05$).

1969 and consisted of 565 male gymnasium (high school) and non-dental, non-medical university students and junior faculty between 17 and 30+ years of age. The group was randomly selected by the Norwegian Bureau of Statistics. The participants were all born and raised in the city of Oslo and had received regular systematic dental care since early childhood. In response to questionnaires at the start of the study and at subsequent examinations, all participants reported seeing their dentist on a regular basis, owning a tooth brush, and brushing their teeth at least 1× a day.

#### Clinical parameters

This Norwegian group was examined in 1969, 1971, 1973, 1975, 1981, 1988 and 1995. The examinations were performed in well-equipped clinical facilities at the Dental Faculty, University of Oslo. The clinical examinations included assessment of the periodontal tissues and caries and associated factors (Löe et al. 1978a).

At each examination throughout the investigation, the mesial and buccal surfaces of all teeth (excluding 3rd molars) of every participant were scored by the same examiner using a pointed probe.

From 1981 onwards, the clinical examinations also included the distal and lingual surfaces. The following clinical indices or measurements were used.

- Gingival index (GI) (Löe & Silness 1963)
- Plaque index (PlI) (Silness & Löe 1964)
- Calculus index (CI) (Löe 1967) (Table 1a)

*Table 2.* Survey and number of sites examined at each survey during 26 years

| | No. patients | Patients of the control cohort | Patients of the test cohort | Number of teeth | Total control teeth | | Total test teeth | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | (%) | | (%) |
| survey 1 | 160 | 159 | 69 | 713 | 615 | 86.3 | 98 | 13.7 |
| survey 2 | 160 | 159 | 69 | 713 | 615 | 86.3 | 98 | 13.7 |
| survey 3 | 160 | 159 | 69 | 713 | 615 | 86.3 | 98 | 13.7 |
| survey 4 | 128 | 127 | 57 | 544 | 465 | 85.5 | 79 | 14.5 |
| survey 5 | 84 | 83 | 37 | 361 | 313 | 86.7 | 48 | 13.3 |
| survey 6 | 69 | 68 | 33 | 307 | 264 | 86.0 | 43 | 14.0 |
| survey 7 | 54 | 53 | 28 | 272 | 237 | 87.1 | 35 | 12.9 |

| | Total sites | Total control sites | | Total test sites | | Distribution of the control sites | | | | Distribution of the test sites | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (%) | | (%) | premolars (%) | | molars (%) | | premolars (%) | | molars (%) | |
| survey 1 | 713 | 615 | 86.3 | 98 | 13.7 | 504 | 82.0 | 111 | 18.0 | 50 | 51.0 | 48 | 49.0 |
| survey 2 | 713 | 615 | 86.3 | 98 | 13.7 | 504 | 82.0 | 111 | 18.0 | 50 | 51.0 | 48 | 49.0 |
| survey 3 | 713 | 615 | 86.3 | 98 | 13.7 | 504 | 82.0 | 111 | 18.0 | 50 | 51.0 | 48 | 49.0 |
| survey 4 | 544 | 465 | 85.5 | 79 | 14.5 | 395 | 85.0 | 70 | 15.0 | 42 | 53.2 | 37 | 46.8 |
| survey 5 | 361 | 313 | 86.7 | 48 | 13.3 | 262 | 83.7 | 51 | 16.3 | 23 | 47.9 | 25 | 52.1 |
| survey 6 | 307 | 264 | 86.0 | 43 | 14.0 | 220 | 83.3 | 44 | 16.7 | 22 | 51.2 | 21 | 48.8 |
| survey 7 | 272 | 237 | 87.1 | 35 | 12.9 | 171 | 84.6 | 31 | 15.4 | 16 | 45.7 | 19 | 54.3 |

- Gingival caries index (GCI) (Löe 1967) (Table 1b)
- Gingival restoration index (GRI) (Löe 1967) (Table 1c)
- Loss of attachment (LA) (Glavind & Löe 1967) was assessed to the nearest mm
- Beginning in 1975, gingival recession from the cemento-enamel junction was also recorded.

For the purpose of the present analysis, the criteria for a gingival restoration index (GRI) (Table 1c) and a gingival caries index (GCI) (Table 1b) derived from the previously published retention index system (Löe 1967) were of special interest.

#### Sample size

For this analysis, 160 of all 565 individuals who in 1969 were examined in the first survey were selected on the basis of (1) having no fillings, or no filling margins extending closer than 1 mm from the gingival margin on the mesial surfaces of all available premolars and molars, and (2) being present at the examinations in surveys 2 (1971) and 3 (1973).

The test group of 98 sites was established in 1971 and comprised all mesial surfaces, which between surveys 1 and 2 had had fillings placed, and which extended more than 1 mm below the gingival margin. The control group consisted of 615 sites, which at all 7 surveys were sound, or which the filling margins were no closer than 1 mm from the gingival margin.

As in most longitudinal studies of this size and length, a certain number of the sample dropped out and could not be followed up. Others would miss one or more examinations, but showed up at the last survey. Of the 565 persons who started in the main investigation in 1969, 223 showed for the examination 26 years later. Of the 160 persons who participated during the first 4 years, 54 presented at all 7 surveys.

During the first 4 surveys the intervals between surveys were 2 years. While the patient pool remained unchanged for the first 3 examinations, 32 subjects were lost between survey 3 and survey 4. The intervals between surveys 5 and 6 and between surveys 6 and 7 were 6 and 8 years, respectively.

Table 2 lists the number of subjects, teeth and surfaces in the test and control groups at each survey.

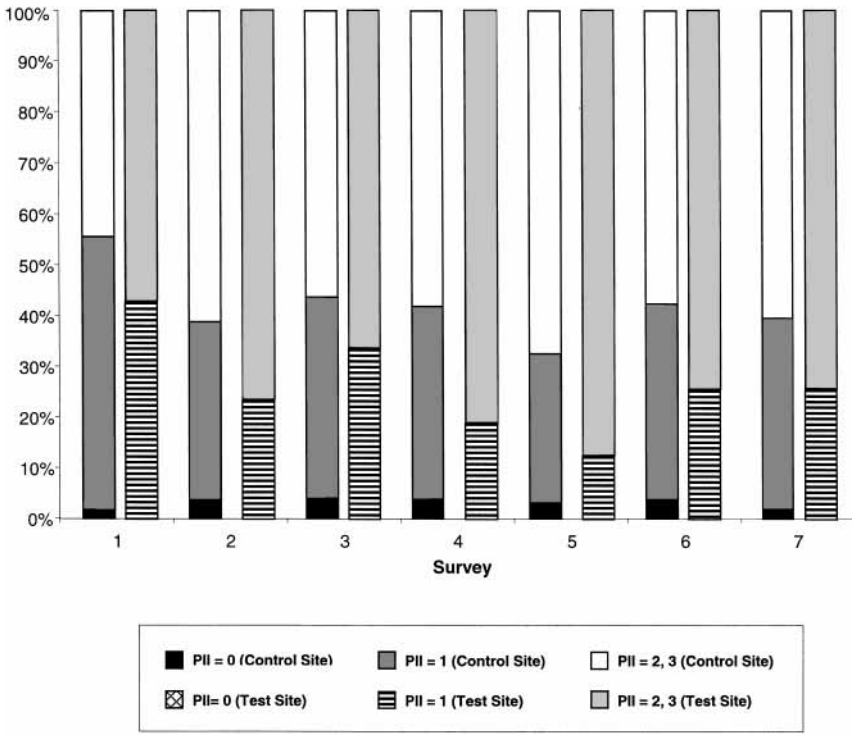


*Fig. 1.* Frequency distribution of plaque index (PlI) scores for the control and test sites at the 7 surveys 1969–1995.

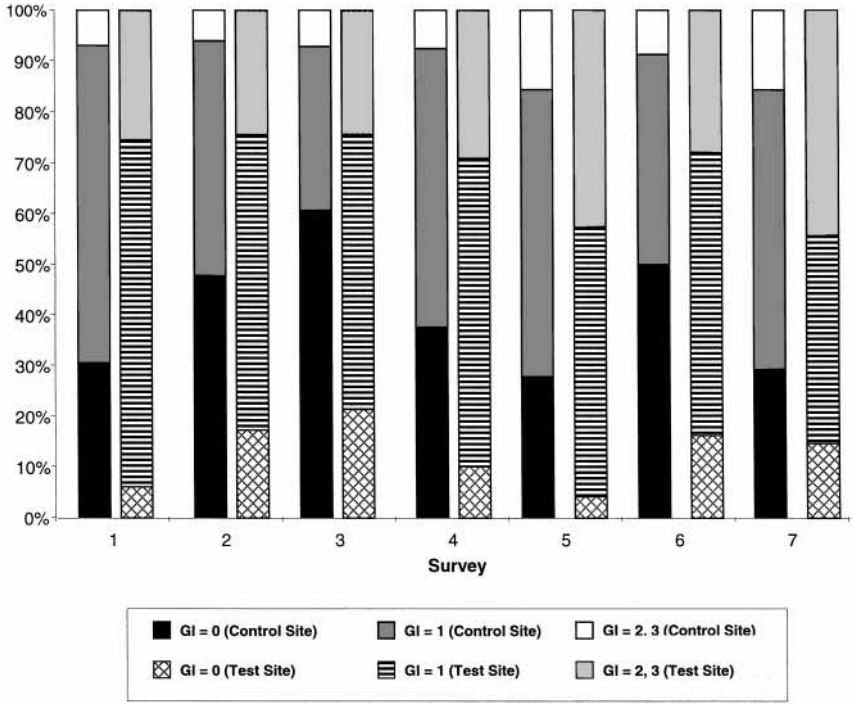


*Fig. 2.* Frequency distribution of gingival index (GI) scores for the control and test sites at the 7 surveys 1969–1995.

#### Data analysis

Test sites with subgingivally located filling margins placed between surveys 1 and 2 were compared with control sites by using the Students *t*-test for independent samples.

For the comparison of significant

*Table 4.* Distribution of maximum calculus index (CI) scores

| | Control sites | | | | Test sites | | | |
|---|---|---|---|---|---|---|---|---|
| | CI=0 (%) | CI=1 (%) | CI=2 (%) | mean CI | CI=0 (%) | CI=1 (%) | CI=2 (%) | mean CI |
| survey 1 | 87.32 | 7.97 | 4.72 | 0.17 | 90.82 | 5.10 | 4.08 | 0.13 |
| survey 2 | 92.85 | 4.88 | 2.28 | 0.09 | 96.94 | 0.00 | 3.06 | 0.06 |
| survey 3 | 86.18 | 9.59 | 4.23 | 0.18 | 95.92 | 0.00 | 4.08 | 0.08 |
| survey 4 | 88.39 | 7.53 | 4.09 | 0.16 | 96.20 | 0.00 | 3.80 | 0.08 |
| survey 5 | 73.16 | 12.78 | 14.06 | 0.41 | 75.00 | 2.08 | 22.92 | 0.48 |
| survey 6 | 72.35 | 19.32 | 8.33 | 0.36 | 86.05 | 2.33 | 11.63 | 0.26 |
| survey 7 | 83.17 | 10.40 | 6.44 | 0.23 | 94.29 | 0.00 | 5.71 | 0.11 |

| | Control sites (CI) | Test sites (CI) | *p*-values |
|---|---|---|---|
| $\Delta$ survey 1, 2 | $-0.08^{+}$ | $-0.07$ | 0.869 |
| $\Delta$ survey 2, 3 | $0.09^{+}$ | 0.02 | 0.100 |
| $\Delta$ survey 3, 4 | $-0.02$ | 0.00 | 0.228 |
| $\Delta$ survey 4, 5 | $0.26^{+}$ | $0.40^{+}$ | 0.249 |
| $\Delta$ survey 5, 6 | 0.01 | $-0.19$ | 0.187 |
| $\Delta$ survey 6, 7 | $-0.17^{+}$ | $-0.17$ | 0.977 |

* Significant differences ($p<0.05$).
$^{+}$ Significant differences between two surveys ($p<0.05$).

changes in the variables between 2 surveys longitudinally, the Wilcoxon Rank test was used. The level of significance was set at $\alpha=0.05$.

## Results

### Clinical parameters

*Plaque index (PlI)*

The mean Plaque Indices for both test and control groups are illustrated in Table 3 and Fig. 1. The PlI increased significantly for the test sites between surveys 1 and 2 and reached averages of PlI=1.57−1.77. The mean PlI of the control sites remained fairly constant, and yielded averages between PlI=1.43 and 1.64. The level of oral hygiene over the entire 26 years period represented a moderate to good standard, where some plaque (PlI≥1) was present at all sites in the test group. PlI=0 was observed only in a small proportion (≤4%) of the control sites (Fig. 1).

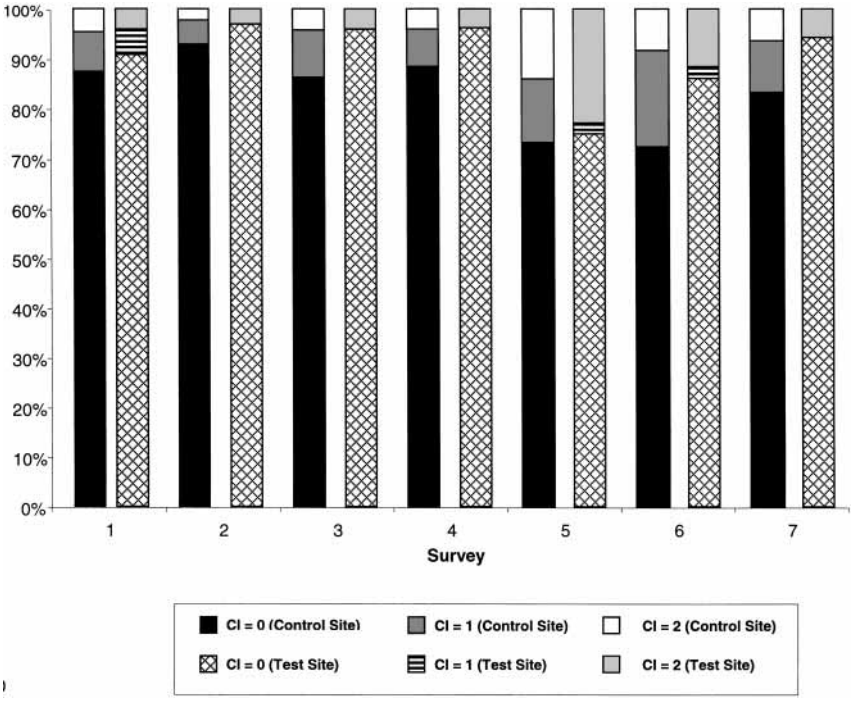


*Fig. 3.* Frequency distribution of calculus index (CI) scores for the control and test sites at the 7 surveys 1969–1995.

*Gingival index (GI)*

The mean GI was significantly greater in the test sites at all observation periods, and reached values between GI=1.03−1.38, whereas, the mean of the control sites varied between GI=0.47−0.88 during the same observation periods. In the control sites, a slight, but significant decrease of the mean GI was observed from survey 1 to 2, from survey 2 to 3 and from survey 3 to 4. In the test sites, however, the increase in the mean GI between survey 3 and 4 was also statistically significant (Table 3). The frequency distribution of various gingival index scores are depicted in Fig. 2 and showed a significant increase of GI=0 scores between surveys 1 and 2, and between surveys 2 and 3 in both test and control sites, respectively. There were fewer GI=2 or 3 scores in the control sites (≤16%), as compared with the test sites, in which between 24% and 45% bled on probing (GI≥2) at the different observation periods.

*Calculus index (CI)*

Table 4 shows the frequency distribution of the different gingival calculus index (CI) scores of both test and control sites. Generally, more than 85% of all the surfaces were calculus free during the first 6 years of observation (survey 1–4) in both test and control sites (Fig. 3), and no statistically significant differences between mean CI or frequencies of CI scores were noticed be-

*Table 5.* Distribution of maximum gingival caries index (GCI) scores

| | Control sites | | | | Test sites | | | |
|---|---|---|---|---|---|---|---|---|
| | GCI=0 (%) | GCI=1 (%) | GCI=2 (%) | mean GCI | GCI=0 (%) | GCI=1 (%) | GCI=2 (%) | mean GCI |
| survey 1 | 98.7 | 1.30 | 0.00 | 0.01* | 77.55 | 16.33 | 6.12 | 0.29* |
| survey 2 | 99.51 | 0.33 | 0.16 | 0.01 | 100.00 | 0.00 | 0.00 | 0.00 |
| survey 3 | 99.19 | 0.65 | 0.16 | 0.01 | 98.98 | 1.02 | 0.00 | 0.01 |
| survey 4 | 99.78 | 0.22 | 0.14 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| survey 5 | 100.00 | 0.00 | 0.00 | 0.00* | 97.92 | 2.08 | 0.00 | 0.02* |
| survey 6 | 100.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| survey 7 | 100.00 | 0.00 | 0.00 | 0.00* | 97.14 | 2.86 | 0.00 | 0.03* |

| | Control sites (GCI) | Test sites (GCI) | *p*-values |
|---|---|---|---|
| $\Delta$ survey 1, 2 | −0.01 | −0.29$^{+}$ | 0.001* |
| $\Delta$ survey 2, 3 | 0.00 | 0.01 | 0.544 |
| $\Delta$ survey 3, 4 | 0.00 | −0.01 | 0.334 |
| $\Delta$ survey 4, 5 | 0.00 | 0.02 | 0.322 |
| $\Delta$ survey 5, 6 | 0.00 | −0.02 | 0.323 |
| $\Delta$ survey 6, 7 | 0.00 | 0.03 | 0.324 |

* Significant differences ($p<0.05$).
$^{+}$ Significant differences between two surveys ($p<0.05$).

*Table 6.* Distribution of maximum gingival restoration index (GRI) scores

| | Control sites | | | | Test sites | | | |
|---|---|---|---|---|---|---|---|---|
| | GRI=0 (%) | GRI=1 (%) | GRI=2 (%) | mean GRI | GRI=0 (%) | GRI=1 (%) | GRI=2 (%) | mean GRI |
| survey 1 | 100.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| survey 2 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 2.00 |
| survey 3 | 100.00 | 0.00 | 0.00 | 0.00* | 6.12 | 9.18 | 84.69 | 1.79* |
| survey 4 | 100.00 | 0.00 | 0.00 | 0.00* | 5.06 | 13.92 | 81.01 | 1.76* |
| survey 5 | 100.00 | 0.00 | 0.00 | 0.00* | 2.08 | 8.33 | 89.58 | 1.88* |
| survey 6 | 100.00 | 0.00 | 0.00 | 0.00* | 4.65 | 20.93 | 74.42 | 1.70* |
| survey 7 | 100.00 | 0.00 | 0.00 | 0.00* | 2.86 | 28.57 | 68.57 | 1.66* |

* Significant differences ($p<0.05$).

tween test and control groups. Only at survey 5, were there significantly more sites with subgingival calculus (CI=2 ) in the control sites (14.1%) than in test sites (22.9%).

*Gingival caries index (GCI)*
Table 5 presents the data for the mean and proportional distribution of the gingival caries index scores (GCI). At the test sites only 77.6% scored GCI=0 at the baseline examination compared to 98.7% with GCI=0 at the control sites. Between surveys 1 and 2 most carious lesions were filled resulting in 100% of the surfaces scoring GCI=0 in survey 2. While almost 100 % of the control sites scored GCI=0 at surveys 5, 6 and 7, the test sites demonstrated significantly higher GCI-scores at surveys 1, 5 and 7.

*Gingival restoration index (GRI)*
By definition, 100% of the surfaces of the control group scored GRI=0 at all surveys. Also, by definition, in the test

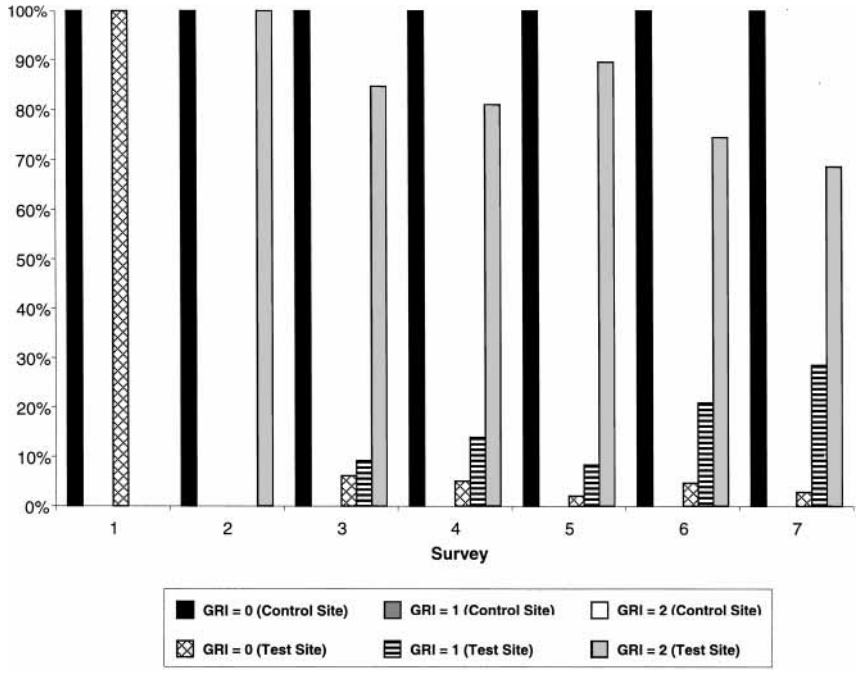


*Fig. 4.* Frequency distribution of the scores for gingival restoration index (GRI) for the control and test sites at the 7 surveys 1969–1995.

*Table 7.* Mean loss of attachment over 26 years

| | Control sites (mm) | Test sites (mm) | *p*-values |
|---|---|---|---|
| survey 1 | 0.24 | 0.27 | 0.666 |
| survey 2 | 0.21 | 0.25 | 0.507 |
| survey 3 | 0.57 | 0.78 | 0.002* |
| survey 4 | 0.65 | 0.82 | 0.039* |
| survey 5 | 0.89 | 1.11 | 0.059 |
| survey 6 | 1.12 | 1.58 | 0.004* |
| survey 7 | 2.22 | 2.48 | 0.200 |

* Significant differences ($p<0.05$).

*Table 8.* Change in mean annual rate of loss of attachment over 26 years

| | Control sites (mm) | Test sites (mm) | *p*-values |
|---|---|---|---|
| $\Delta$ survey 1, 2 | −0.01 | −0.01 | 0.933 |
| $\Delta$ survey 2, 3 | $0.18^{+}$ | $0.27^{+}$ | 0.005* |
| $\Delta$ survey 3, 4 | $0.04^{+}$ | 0.03 | 0.759 |
| $\Delta$ survey 4, 5 | $0.04^{+}$ | $0.06^{+}$ | 0.292 |
| $\Delta$ survey 5, 6 | $0.04^{+}$ | $0.06^{+}$ | 0.264 |
| $\Delta$ survey 6, 7 | $0.16^{+}$ | $0.11^{+}$ | 0.179 |

* Significant differences ($p<0.05$).
$^{+}$ Significant differences between two surveys ($p<0.05$).

group 100% of the sites scored GRI=0 at baseline, and 100% scored GRI=2 at survey 2. In subsequent surveys, a high proportion (~80 %) of all surfaces in the test group scored GRI=2, but an increasing proportion scored GRI=1. A small proportion (≤5%) scored GRI=0 at surveys 3 through 7 (Fig. 4, Table 6).

*Loss of attachment*

The cumulative loss of attachment during the entire study period is shown in Table 7. At baseline, the mean loss of attachment of the tests and controls varied between 0.24 and 0.27 mm. At survey 3, i.e., 4 years after baseline, a significant difference between the mean loss of attachment was seen between test and control sites, with test sites reaching mean values of 0.78 mm and control sites 0.57 mm, respectively. After 19 years, the cumulative mean loss of attachment was 1.58 mm for the test group versus 1.12 mm for the control group. At survey 7, however, the difference between test and control sites was no longer statistically significant.

Table 8 demonstrates the mean annual loss of attachment for the entire duration of the study for both test and control sites. The greatest increase in mean annual loss of attachment was seen between surveys 2 and 3, i.e. between 2 and 4 years of observations after baseline and between 19 and 26 years after baseline (Fig. 5).

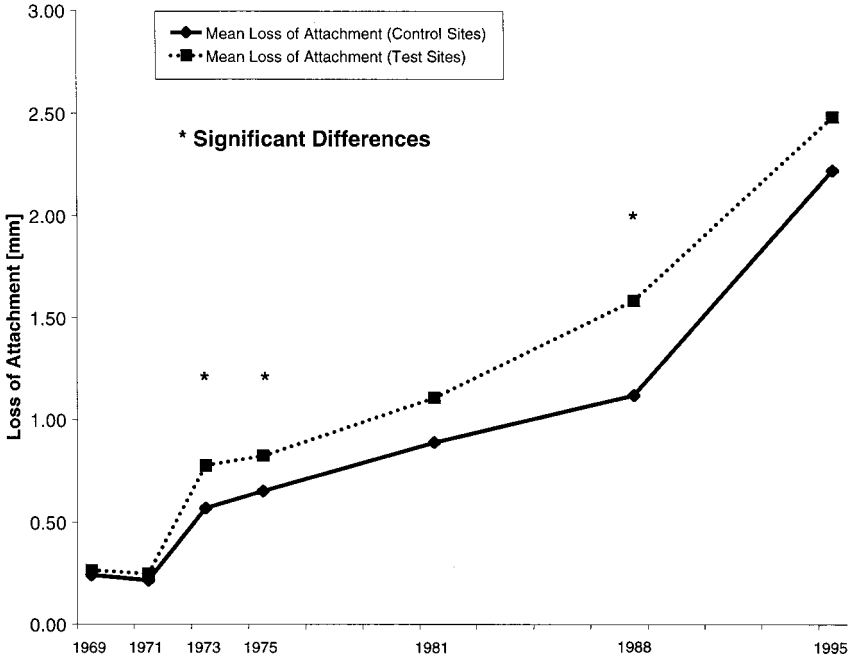


*Fig. 5.* Mean loss of attachment (mm) for the control and test sites for 26 years.

## Discussion

The present report is part of longitudinal study on the natural history of periodontal disease in a randomly selected population of middle and upper middle class background (with at least 13 years of education). This population had a relatively high standard of oral hygiene and frequency of dental visits. This, in turn, suggests that carious lesions were treated without much delay. The collective restoration index reflected a relatively high standard of restorative dentistry.

The present study has confirmed extended the long held concept that restorations placed below the gingival margin are detrimental to gingival health. At all points of examination during the 26-year period, the degree of inflammation in the gingiva adjacent to subgingival restorations conspicuously exceeded that of gingiva bordering on tooth surfaces without restorations or with filling margins no closer than 1 mm of the gingival margin. It is true that at the baseline, the test sites already displayed a higher GI than the control sites, despite the fact that these sites had not yet received a dental restoration. However, this elevated mean GI scores may be explained by the elevated mean and proportions of gingival caries index scores, indicating the necessity for the placement of a filling. As seen in Table 3, the carious lesions present at baseline and located in the gingival margin area may also have resulted in slightly elevated plaque scores. This fact, that open carious lesions lead to increased plaque retention and gingival inflammation has not been fully appreciated before.

Following the placement of a dental restoration in the test group an increase of loss of attachment was noticed. Subsequently, the level of attachment remained stable over the next 8 years. Then, an other significant increase in loss of attachment occurred at the test sites which can be linked to the increase in gingival caries index scores. It is quite conceivable that the latter necessitated the replacement of some fillings at sites where secondary caries had occurred.

It appears from the present study that subgingival marginal placement of dental restorations results in a significant loss of attachment which may be detected 1–3 years after the restorative procedures. The fact that the gingival restoration index scores improved concomitantly, suggests that a proportion of the subgingivally placed restoration margins now had become located at gingival margin or supragingivally due to recession of the marginal gingiva.

The association between the development of gingival inflammation, recession, increased probing depth and loss of attachment has also been documented in longitudinal studies by Valderhaug & Birkeland (1976), Valderhaug (1980) and Valderhaug et al. (1993). Also clinical experimental studies (Renggli & Regolati, 1972) have demonstrated the development of gingival inflammation by the mere presence of well adapted restorations in the subgingival area. Furthermore, the placement of slightly overhanging filling margins was shown to result in a change of the subgingival microbiota adjacent to the subgingival restoration, favoring the colonization of gram-negative, strictly anaerobic rods (Lang et al. 1983). It is suggested that the shift of the composition of the subgingival mircobiota towards an increased proportion of periodontopathic microorganisms will eventually lead to loss of periodontal support. However, the present study has indicated that this pathogenic process may develop slowly and that 1 to 3 years are needed in order to be detected clinically. Reported studies denying the association between restoration margins and the periodontal conditions (Than et al. 1982, Fisher et al. 1984, Markitziu et al. 1987) must be interpreted with care. Normally, the material analyzed constituted of extracted teeth or some of the variables had not been controlled. While most of the studies published presented only associations between overhanging dental restorations and periodontal conditions (Gilmore & Sheiham 1971, Rodriguez-Ferrer et al. 1980, Lang et al. 1988) or the development of secondary caries (Hammer & Hotz 1979), the present study has documented a time sequence between the placement of the subgingival restoration and the diagnosed loss of periodontal support. It is suggested that following the placement of a subgingival restoration, a period of exacerbation of the gingival lesion and loss of attachment 1 and 3 years ensues and a subsequent "burn-out" effect was suggested. This concept is in agreement with the notion that, irrespective of the triggering mechanism, periodontitis may not progress at the same rate throughout life.

## Acknowledgement

This study has been supported by the Clinical Research Foundation (CRF) for the Promotion of Oral Health, University of Berne, Switzerland.

## Zusammenfassung

*Der Einfluß von Restaurationsrändern auf die parodontalen Gewebe über 26 Jahre*

**Zielsetzung:** Das Ziel dieser Analyse war es, den langfristigen Einfluß von Restaurationsrändern auf die parodontale Gesundheit zu untersuchen.

**Material und Methoden:** Die Daten, die dieser Analyse zugrunde liegen, stammen aus einer über 26 Jahre dauernden longitudinalen Untersuchung einer Gruppe von männlichen der Mittelschicht entstammenden Norwegern mit mäßiger bis guter individueller Mundhygiene und regelmäßigen zahnärztlichen Kontrolluntersuchungen. Zu jedem von 7 Untersuchungszeitpunkten zwischen 1969 und 1995 wurden an den mesialen und bukkalen Flächen aller Zähne kariologische, restaurative und parodontologische Parameter erhoben. Die mesialen Flächan der Prämolaren und Molaren von 160 Studienteilnehmern wurden über 26 Jahre verfolgt (1969–1995). Eine Kontrollgruppe von 615 gesunden Flächen bzw. von Flächen, bei denen der Restaurationsrand bei allen 7 Untersuchungen mehr als 1 mm koronal des Gingivarandes lag, wurde mit einer Testkohorte von 98 Flächen verglichen, die zu Beginn der Untersuchung (1969) gesund waren bzw. Restaurationsränder aufwiesen, die mehr als 1 mm koronal des Gingivarandes lagen, aber 2 Jahre später (1971) subgingivale Restaurationsränder aufwiesen.

**Ergebnisse:** Ab der 3. Untersuchung ließ sich ein statistisch signifikanter Unterschied hinsichtlich des kumulativen Attachmentverlustes zwischen Test- und Kontrollgruppe feststellen: Kontrolle: 0.57 mm; Test 0.78 mm ($p=0.002$). Nach 26 Jahren war der kumulative Attachmentverlust in der Test immer noch größer als in der Kontrollgruppe, allerdings konnte zu diesem Zeitpunkt kein statistisch signifikanter Unterschied mehr beobachtet werden: Kontrolle: 2.22 mm; Test: 2.48 mm ($p=0.2$).

**Schlußfolgerungen:** Die Analyse bestätigte das seit langem bestehende Konzept, daß subgingival lokalisierte Restaurationsränder sich schädlich auf die gingivale und parodontale Gesundheit auswirken. Die Ergebnisse dieser Studie legen den Schluß nahe, daß der verstärkte Attachmentverlust an Zähnen mit subgingivalen Kronenrändern langsam beginnt und erst 1–3 Jahre nach Herstellung und Inkorporation der Restaurationen klinisch festgestellt werden kann. Ein sukzessiver "Burn-out"-Effekt wird vermutet.

## Résumé

*Influence des bords de restaurations sur les tissue parodontaux durant 26 ans*

Le but de cette étude a été d'examiner la relation à long terme entre les obturations dentaires et la santé parodontale. Les données proviennent d'une étude longitudinale de 26 années sur un groupe d'hommes scandinaves de classe moyenne caractérisé par une hygiène buccale bonne à modérée avec des visites dentaires régulières. A chacune des 7 visites passées entre 1969 et 1995 les surfaces mésiales et vestibulaires ont été analysées pour les paramètres dentaires d'obturation et parodontaux. Les sites mésiaux des prémolaires et molaires des 160 participants ont été observés durant 26 années (1969 à 1995). Un groupe contrôle de 615 surfaces seines ou de bords d'obturation situés à $>1$ mm de la gencive marginale se retrouvant dans chacun des 7 visites a été comparé à un test de 98 surfaces saines ou ayant des bords d'obturations localisés à $>1$ mm de la gencive marginale lors de l'examen initial (1969) ainsi qu'une terminaison d'obturation sous-gingivale 2 années après (1971). Cette étude confirme le vieux concept que veut que les obturations placées sous la gencive marginale soient nuisibles à la santé parodontale. De plus, cette étude suggère que l'augmentation de la perte d'attache trouvée au niveau des dents à restaurations sous-gingivales débutait lentement et ne pouvait être détectée cliniquement qu'une à 3 années après la fabrication et le placement de ces restaurations. Un effet en éclair subséquent a été suggéré.

## References

Ånerud, Å., Löe, H. & Boysen, H. (1991) The natural history and clinical course of calculus formation in man. *Journal of Clinical Periodontology* **18**, 160–170.

Alexander, A. G. (1967) Periodontal aspects of conservative dentistry. *British Dental Journal* **123**, 542–543.

Alexander, A. G. (1968) Periodontal aspects

of conservative dentistry. *British Dental Journal* **125**, 111–114.

Björn, A. L., Björn, H. & Grkovic, B. (1969) Marginal fit of restorations and its relation to periodontal bone level. Part I: Metal fillings. *Odontologisk Revy* **20**, 311–322.

Björn, A. L., Björn, H. & Grkovic, B. (1970) Marginal fit of restorations and its relation to periodontal bone level. Part II: Crowns. *Odontologisk Revy* **21**, 337–346.

Fisher, D., Markitziu, A., Fishel, D. & Brayer, L. (1984) A 4-year follow-up study of alveolar bone height influenced by two dissimilar Class II amalgam restorations. *Journal of Oral Rehabilitation* **11**, 399–405.

Gilmore, N. & Sheiham, A. (1971) Overhanging dental restorations and periodontal disease. *Journal of Periodontology* **42**, 8–12.

Glavind, L. & Löe, H. (1967) Errors in the clinical assessment of periodontal destruction. *Journal of Periodontal Research* **2**, 180–184.

Hammer, B. & Hotz, P. (1979) Nachkontrolle von 1- bis 5jährigen Amalgam-, Komposit- und Goldgussfüllungen. *Schweizerische Monatsschrift für Zahnheilkunde* **89**, 301–314.

Lang, N. P., Kiel, R. A. & Anderhalden, K. (1983) Clinical and microbiological effects of subgingival restorations with overhanging or clinically perfect margins. *Journal of Clinical Periodontology* **10**, 563–578.

Lang, N. P., Kaarup-Hansen, D., Joss, A., Siegrist, B., Weber, H. P., Gerber, C., Saxer, U. P. & Curilovic, Z. (1988) The significance of overhanging filling margins for the health status of interdental periodontal tissues of young adults. *Schweizer Monatsschrift für Zahnmedizin* **98**, 725–730.

Lange, D. E. & Schwöppe, G. (1981) Epidemiologische Untersuchungen an Rekruten der Bundeswehr (Mund- und Gebissbefunde). *Deutsche Zahnärztliche Zeitschrift* **36**, 432–434.

Leon, A. R. (1977) The periodontium and restorative procedures. A critical review. *Journal of Oral Rehabilitation* **4**, 105–117.

Löe, H. & Silness, J. (1963) Periodontal disease in pregnancy. Prevalence and severity. *Acta Odontologica Scandinavica* **21**, 533–551.

Löe, H. (1967) The gingival index, the plaque index and the retention index systems. *Journal of Periodontology* **36**, 610–616.

Löe, H., Ånerud, Å., Boysen, H. & Smith, M. (1978a) The natural history of periodontal disease in man. Study design and baseline data. *Journal of Periodontal Research* **13**, 550–562.

Löe, H., Ånerud, Å., Boysen, H. & Smith M (1978b) The natural history of periodontal disease in man. Tooth mortality rates before 40 years of age. *Journal of Periodontal Research* **13**, 563–572.

Löe, H., Ånerud, Å., Boysen, H. & Smith, M. (1978c) The natural history of periodontal disease in man: The rate of periodontal destruction before 40 years of age. *Journal of Periodontology* **49**, 607–620.

Markitziu, A. (1987) A ten-year follow-up study of alveolar bone loss influenced by two dissimilar Class II amalgam restorations. *Journal of Oral Rehabilitation* **14**, 23–25.

Renggli, H. H. & Regolati B (1972) Gingival inflammation and plaque accumulation by well-adapted supragingival and subgingival proximal restorations. *Helvetica Odontologica Acta* **16**, 99–101.

Rodriguez-Ferrer, H. J., Strahan, J. D. & Newman H. N. (1980) Effect of gingival health of removing overhanging margins of interproximal subgingival amalgam restorations. *Journal of Clinical Periodontology* **7**, 457–462.

Silness, J. & Löe, H. (1964) Periodontal disease in Pregnancy. II. Correlation between oral hygiene and periodontal condition. *Acta Odontologica Scandinavica* **22**, 121–135.

Silness, J. (1970a) Periodontal conditions in patients treated with dental bridges. *Journal of Periodontal Research* **5**, 60–68.

Silness, J. (1970b) Periodontal conditions in patients treated with dental bridges (III). The relationship between the location of the crown margin and the periodontal condition. *Journal of Periodontal Research* **5**, 225–229.

Silness, J. & Ohm, E. (1974) Periodontal conditions in patients treated with dental bridges (V). Effect of splinting adjacent abutment teeth. *Journal of Periodontal Research* **9**, 121–126.

Than, A., Duguid, R., & McKendrick, A. J. W. (1982) Relationship between restorations and the level of the periodontal attachment. *Journal of Clinical Periodontology* **9**, 193–202.

Valderhaug, J. & Birkeland, J. M. (1976) Periodontal conditions in the patients five years following insertion of fixed prosthesis. *Journal of Oral Rehabilitation* **3**, 237–243.

Valderhaug, J. (1980) Periodontal conditions and carious lesions following the insertion of fixed prostheses: a 10-year follow-up study. *International Dental Journal* **30**, 296–304.

Valderhaug, J., Ellingsen, J. E., Jokstad, A. (1993) Periodontal conditions and carious lesions in patients treated with dental bridges. A 15-year clinical and radiographic follow-up study. *Journal of Clinical Periodontology* **20**, 482–489.

Waerhaug, J. (1960) Histological considerations which govern where the margin of restorations should be located in relation to the gingiva. *Dental Clinics of North America* March, 160–176.

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