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Oral hygiene, periodontal conditions and carious lesions in patients treated with dental bridges

A 15-year clinical and radiographic follow-up study

J. Valderhaug[1], J. E. Ellingsen[1] and A. Jokstad[2]

Departments of [1]Prosthetic Dentistry and Stomatognathic Physiology, and [2]Anatomy, Dental Faculty, University of Oslo, Oslo, Norway

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Abstract. A longitudinal study, extending over a period of 15 years, was carried out in a group of 102 patients who received 108 bridges made by the senior students at the Dental Faculty, University of Oslo, in 1967/68. The study included 343 abutment teeth, and the remaining teeth in the same jaw which received the restoration, 525 in all, served as control. The oral hygiene, gingival condition, pocket depth, caries on crowned teeth, location of crown margins and changes of alveolar bone level were recorded during the study. During the first 10 years, the patients received oral hygiene prophylaxis every 6 months. The mean age of the patients at the beginning of the study was 48 years. Of the original group of 102 patients, 88 attended the clinical examination after 5 years, 71 after 10 years, and 55 after 15 years. The amount of plaque did not differ between the crowned teeth and the control teeth during the observation period, while GI score 2 and 3 was more frequent in crowned teeth than in the control teeth during this period. This was mainly observed when the crown margins were located sub-gingivally. A slight increase in mean pocket depth was recorded in the crowned teeth while the mean pocket depth for the control teeth remained at the same level during the 15 years. Caries lesions were recorded in 3.3% of the abutment tooth surfaces at the 5th year, in 10.0% at the 10th year and in 12.0% at the 15th year examination. No statistical differences in bone loss could be detected between the control teeth and the crowned teeth.

Key words: fixed prostheses; clinical study; longitudinal; bone loss.

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Insertion of fixed partial dentures may influence the periodontal conditions and the risk for caries. Clinical observations show that the gingiva supporting prosthodontically treated teeth often is inflamed and that pocket formation and recession of gingiva may occur. The potentially injurious effect of dental restorations on the gingiva has been the subject of several histological and clinical investigations (Karlsen 1970, Renggli 1974, Valderhaug 1980, Bader & Rotzier 1991). In histological studies in dogs, Marcum (1967) observed the best gingival response when the crown margins were located at the gingival crest compared to either sub-gingival or supragingival placement, while Karlsen (1970) in dogs as well observed this in supra-gingival cases. In clinical studies in human an unfavorable reaction in the gingival tissue and a slight increase in loss of attachment have primarily been observed when the margin of the restoration have been located subgingivally (Silness 1970, Valderhaug 1980, Lang et al. 1989). Regular oral health maintenance programmes for patients receiving fixed prosthodontics has in clinical studies, been documented to reduce gingival inflammation and recession (Suomi et al. 1971, Nyman & Lindhe 1979). Caries have also been observed to be one of the main reasons for crown and bridge failure (Schwartz et al. 1970, Karlson 1989, Valderhaug 1991). However, the protective effect against caries of sub-gingivally located crown margins has been questioned (Valderhaug 1980). Therefore, to observe the long term effect of the location of crown margins to the gingival margin concerning periodontal reaction,

Table 1. No of patients in the different age group at the basis observation

age groups (years)	20–29	30–39	40–49	50–59	60–69
no. patients	5	15	34	29	19

Table 2. Reasons for not attending the clinical examination at the different observation periods

	No. patients			
Reasons	5th year	10th year	15th year	Total
died	4	4	8	16
illness		2		2
moved	5	2		7
not interested		2		2
no response	1		3	4
bridge failure	4	7	5	16
total	14	17	16	47

caries in crowned teeth as well as alveolar bone-loss is of great clinical value in crown and bridge therapy.

The aim of the present study was to assess the level of oral hygiene, periodontal conditions, changes of alveolar bone level and prevalence of caries in a group of patients who had received regular oral prophylaxis following the insertion of fixed partial dentures. Differences of these indices when the crown margins initially were located sub-gingivally, at the gingiva or supra-gingivally were also recorded.

Material and Methods

102 patients (73 women and 29 men), received a total of 108 fixed partial dentures on 343 abutment teeth. The remaining teeth in the same jaws which received the restorations, 525 in all, served as control. Patients who could foresee that they would not be able to attend yearly re-examination during a 5-year period and those who were more than 70 years old were not included in this study. The age distribution of the patients at the start of the study is shown in Table 1. The youngest patient was 25 years, the oldest 69 years and the mean age was 48 years. The patients had an average of 9.5 teeth in the maxilla and 10.6 in the mandible. Prior to the prosthetic treatment the patients received periodontal prophylaxis and surgical elimination of deepened pockets. The bridges were made by the senior students at the Dental Faculty, University of Oslo in the academic year 1967/68. All bridges were made in Type 3 casting gold (Gamma gold, K. A. Rasmussen, Hamar, Norway), and heat cured acrylic veneering (Hue-Lone, L. D. Chaulk Comp., Toronto, Canada) and cemented with zinkphosphate cement following standard procedures. 77% of the retainers were made in gold/acrylic, 12% were partial crowns, and 11% were full crowns in gold.

Further descriptions have been presented in a previous paper (Valderhaug 1991).

Basis observation

Before commencing the prosthetic treatment, the periodontal condition was examined on all tooth surfaces in the jaw that was going to receive the restoration. The oral hygiene and the gingival health were recorded according to the Plaque Index (PII) system (Silness & Löe 1964) and the Gingival Index (GI) system (Löe & Silness 1963), respectively. The pocket depth was measured using a periodontal probe (Ramfjord 1959). The gingival margin of the crowns were placed supra-gingivally in all cases where this was possible considering retention, aesthetics and earlier restorations. The location of the abutment teeth is shown in Fig. 1. 1 to 4 weeks after cementation of the bridges, the distance from the gingival margin of the crown to the bottom of the gingival pocket was measured using the periodontal probe. Sub-gingivally located crown margins were defined as being located 1 mm below the gingival margin.

The 5-, 10- and 15-year observation

Of the original group of 102 patients, 88 attended the clinical examination after 5 years, 71 after 10 years and 55 after 15 years. The reasons for not attending the examinations are listed in Table 2. After 15 years, 16 patients had dropped out of the study because the bridges had

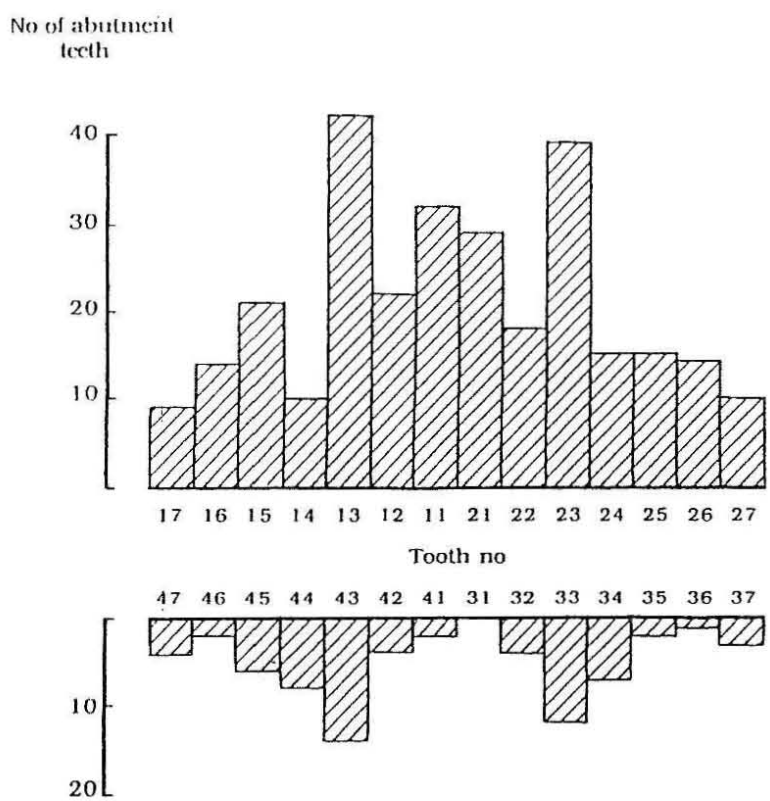

Fig. 1. Number and location of abutment teeth in 102 patients at the basis observation.

been lost or had to be remade due to failure. Table 3 shows the number of patients, bridges, abutment teeth and ratio abutments/pontics at the baseline observation and at the different observation times.

During the first 10 years, the patients received oral hygiene prophylaxis by a dental hygienist every 6 months. Each year during the first 10 years and at the 15th year examination, the oral hygiene and periodontal condition were recorded on all teeth in the jaw which had received the restorations. The incidence of plaque, gingivitis and pocket depths were assessed for each surface. The location of the crown margins related to the gingival margin and the presence of caries on crowned teeth were also recorded. Statistical differences between the data from the basis and the 5th, 10th and 15th years observations were estimated by Wilcoxon matched-pair test (Siegel 1956) with $p<0.05$ as the significance level. All the clinical examinations were performed by one of the authors (JV).

Radiographic assessments

Periapical roentgenographs were made of each patient before the treatment started and at the basis observation using a conventional radiographic technique, and by using a periodically identical technique at the latter observations (Eggen 1969). Radiographic measurements were made under 10× magnification to the nearest 0.5 mm mesially and distally to all present teeth at the base-line and 5th, 10th and 15th years. The alveolar bone level was defined as the vertical distance between a reference point and the root surface at which the periodontal ligament space appeared normal (Bjørn et al. 1969). In the control teeth, the cemento-enamel junction was chosen as the reference point, whereas the cervical limit of the crowns served as reference point in the test group. A site was regarded non-readable if the alveolar bone level or the cemento-enamel junction could not be determined. All measurements were made by the same examiner (JEE). The intra-examiner variability for determination of the alveolar bone level was determined on a test set of 75 randomly chosen radiographic sites. The mean difference between replicate pairs of measurements was 0.20 mm (S.D. = 2.7), giving a standard measured error = 0.31 mm. This measurement error was considered to be within the range of previous relevant studies (Benn 1990).

The differences in alveolar bone level between the crowned teeth and the control teeth were analyzed by Kaplan-Meier survival analyses (1958).

Results

Plaque and gingivitis

During the observation period the amount of plaque did not differ between the crowned teeth and the control teeth (Table 4). In both groups visible plaque (score 2 and 3) was recorded on 21% of the surfaces at the basis observation. At the 15-year observation, this had increased to 27% in both groups.

The GI score 2 and 3 (bleeding by probing) was more frequent in the crowned teeth than in the control teeth. This difference was mainly observed at the 5-year examination (Table 5). When the frequencies of GI score 2 and 3 were related to the location of the crown margin a marked shift in the distribution of the scores was seen at the 5-year observation compared to the base line data. The incidence of score 2 and 3 was higher when the crown margins were located sub-gingivally (Fig. 2).

Pocket depth

The mean pocket depths for all surfaces in crowned teeth and control teeth at the different observation times are listed in Table 6.

In the crowned teeth, a slight increase in the mean pocket depth was observed at the 5-year observation. However, this increase was mainly observed in those cases where the crown margin was located sub-gingivally or at the gingiva at the time of observation (Fig. 3). This increase in mean pocket depth at the 5-year observation was recorded in all tooth surfaces (Table 7).

At the basis observation there was no marked variation in the pocket depths as related to the location of the crown margin (Fig. 4). A pocket depth of 2 mm or less was found in 79% of these tooth surfaces, while a pocket depth of 4 mm or more was recorded in 4% of the surfaces. At the 15-year observation, 57% of the gingival pockets were 2 mm or less while 3% measured 4 mm or more (Fig. 5). The buccal surfaces were on an average recorded with a slightly smaller pocket depth compared to the three other surfaces. This difference in mean pocket depth between the buccal, and the mesial, lingual and distal sur-

Table 3. No. patients, bridges and abutments and ratio abutment/pontic at the different times of observation

Time of observation	No. patients	No. bridges	No. abutments	Ratio abutment/pontic
basis observation	102	108	343	1.3:1
5th year	88	92	282	1.3:1
10th year	71	77	236	1.3:1
15th year	55	59	187	1.2:1

Table 4. Mean frequencies (%) of PII scores at the different observation periods

	Crowned teeth (years)				Control teeth (years)			
PII	0	5	10	15	0	5	10	15
0	12	30	35	33	11	29	35	38
1	68	53	42	40	68	52	39	36
2	19	17	21	27	19	18	24	26
3	2	1	2	0	2	1	2	1
total	101	101	100	100	100	100	100	101

Table 5. Mean frequencies (%) of GI scores at the different observation periods

	Crowned teeth (years)				Control teeth (years)			
GI	0	5	10	15	0	5	10	15
0	7	17	18	24	9	27	28	41
1	51	39	47	47	53	42	42	37
2	40	40	33	30	38	29	29	22
3	1	4	1	0	0	3	2	0
total	99	100	99	101	100	101	101	100

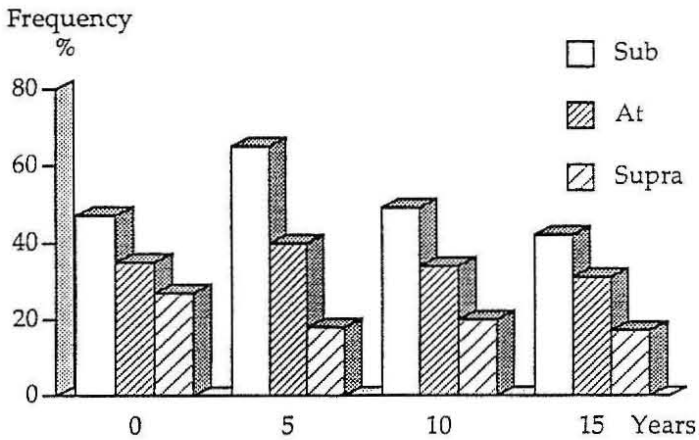

Fig. 2. GI score 2 and 3. Crown margins located sub-, at or supra-gingivally.

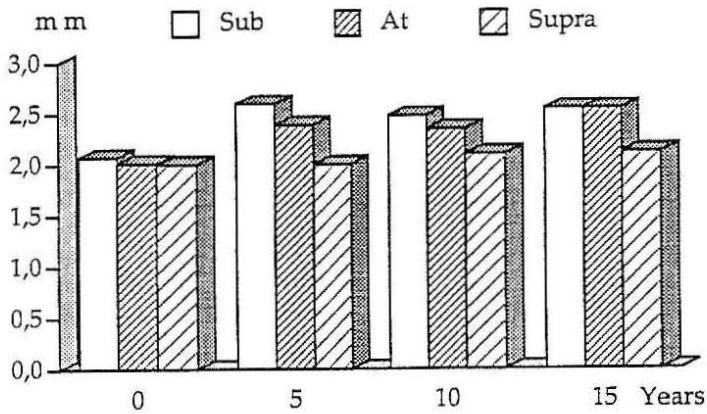

Fig. 3. Mean pocket depth in crowned teeth with crown margins located sub-, at or supra-gingivally at the time of observation.

faces remained during the observation period (Table 7).

Location of crown margins

Location of the crown margins relative to the gingival margins at the different observation time is listed in Table 8. During the observation period, the percentage of crown margins located sub-gingivally decreased from 64% at the basis observation to 36% at the 15-year observation. These changes were mainly observed on the buccal surfaces, where 68% of the crown margins initially were located sub-gingivally at the basis observation while only 27% remained sub-gingivally at the 15-year observation.

Caries lesions

Caries lesions were recorded in 3.3% of the abutment tooth surfaces at the 5th year, in 10.0% at the 10th year, and in 12.0% at the 15-year examination (Table 9). The caries incidence during the 15-year observation could not be related to the placement of the crown margin at the baseline. 38 percent of the caries lesions were recorded on the buccal, 23% on the mesial, 29% on the lingual and 10% on the distal surfaces.

Bone loss

No statistical differences in bone loss could be detected between the control teeth and the crowned teeth (Fig. 6). Nor could the bone loss be related to the location of the crown margin at the time of placement (Fig. 7).

Discussion

The patients included in this study did not differ essentially from other patients receiving treatment in the department at that time, and the selection bias due to absentees can be considered to be small (Valderhaug & Karlsen 1976). The frequency of dropout patients and the reasons for not attending the 15-year clinical examination were fairly identical to the data after 5 and 10 years and has been reported previously (Valderhaug 1991).

It is obvious that the diagnostic criteria may change over time, a circumstance that could have influenced the findings of the present study. The annual examination were, however, carried out within a few weeks, which favor an even criteria level during the observation period.

The results in the present study conform to most clinical studies concluding that crown margins placed in the gingival pocket can be associated with an increased frequency or degree of damage to the periodontal tissues. The higher average GI score observed when

Table 6. Mean pocket depth in mm (SD) at the different observation periods

Years	Crowned teeth	S.D.	No. teeth	Control teeth	S.D.	No. teeth
0	2.1	±0.72	343	2.3	±0.83	525
5	2.4	±0.73	282	2.2	±0.86	470
10	2.3	±0.74	236	2.2	±0.76	359
15	2.4	±0.80	187	2.2	±0.77	276

Table 7. Mean pocket depths in mm (SD) for the buccal, mesial, lingual and distal surfaces of crowned teeth at the different observation periods

	Year			
	0	5	10	15
buccal	1.6±0.6	2.0±0.7	1.9±0.7	1.9±0.6
mesial	2.2±0.7	2.5±0.7	2.5±0.7	2.6±0.8
lingual	2.1±0.6	2.4±0.7	2.3±0.6	2.5±0.8
distal	2.3±0.7	2.5±0.7	2.6±0.8	2.7±0.7
surfaces *n*=	1207	1137	934	719

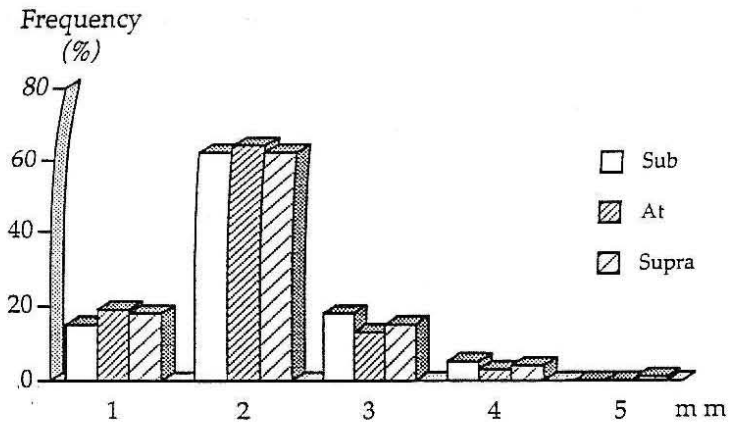

Fig. 4. Frequency distribution of pocket depth (mm) in crowned teeth with crown margins located sub-, at or supra-gingivally at the basis observation.

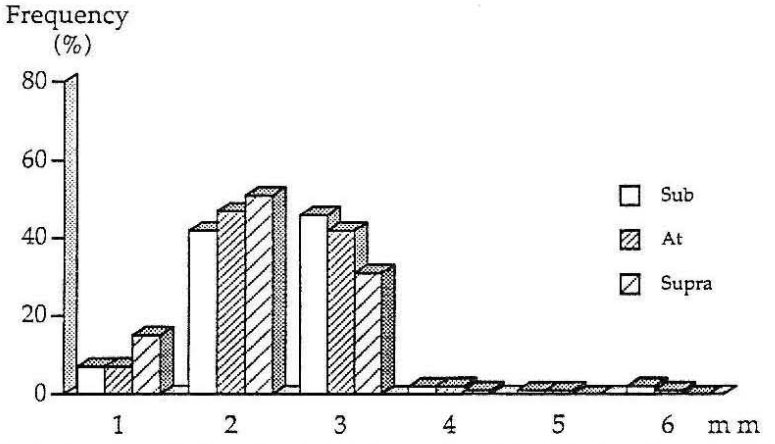

Fig. 5. Frequency distribution of pocket depth (mm) in crowned teeth with crown margins located sub-, at or supra-gingivally at the 15th year observation.

the crown margins were located subgingivally were mainly observed after one year (Valderhaug & Heløe 1977). This reaction was most likely due to the plaque retaining properties of the rough-surface areas brought into the gingival pocket when the crowns were cemented (Silness & Hegdahl 1970, Renggli 1974).

Most reports on the relationship between periodontal disease and crowns have focused on the axio-gingival placement of the margins (Leon 1977). These and other studies conclude that there is no such thing as a smooth transition between a dental restoration and the tooth (Wærhaug 1960, Silness & Hegdahl 1970). However, other possible parameters relating adverse effect of dental restorations on the supportive tissue have also been identified, like the quality (Suomi et al. 1971), the contour (Kandelmann et al. 1974, Nevins 1982, Grosso et al. 1984), the plaque retentive ability and the surface roughness of the crown (Glantz 1969, Sørensen 1989) or the cement (Ørstavik & Ørstavik 1976). To what extent these factors have influenced the present results is uncertain. All the technical work was made at one dental laboratory only, and the use of material and production procedures were identical for all bridges. One would therefore assume that the quality and dimensions of the material would be of the same standard for all bridges. All treatment procedures were made at the dental school, and required faculty approval. It is therefore presumed that the morphology of the prostheses and the margin adaptation met the criteria of acceptability, although there are no records of any quality scoring of the prostheses made before cementation.

In general, the data corroborate the observations made at 5 years (Valderhaug & Birkeland 1976, Valderhaug & Heløe 1977), and after 10 years (Valderhaug 1980). The crowned teeth compared to the control teeth had identical PI scores (Table 4), and a tendency of higher GI scores (Table 5) and pocket depths (Table 6). These data agree with results from several epidemiological (Grasso et al. 1984, Bader et al. 1991), cross-sectional (Larato 1969, Silness 1970, Koth 1982, Orkin et al. 1987), and other longitudinal studies (Silness & Ohm 1974, Reichen-Graden & Lang 1989). However, the differences were not statistically significant, and the loss of bone was similar when comparing the crowned and the control teeth. Some lack of differences may be because the control teeth either were not restoration-free at the time of cementation, or were not maintained restoration-free during the observation period. The periodontium of the control teeth was thus also probably influenced by the restorations. On the other hand, there are clinical studies showing that the gingival conditions may be unaffected by crowns, even when they are located subgingivally (Richter & Ueno 1973, Kerschbaum & Meier 1978).

The variation of the different indices of periodontal disease depending on the location of the crown margins with poorer periodontal conditions along subgingival compared to supragingival crown margins is also in general agreement with other longitudinal (Silness 1970) and cross-sectional studies (Orkin et al.). The differences between the supra and subgingival located margins in the present study were perhaps not as much as expected. The reason may be that the crown margins were defined as subgingival when located cervically to the gingival margin. The extension into the gingival pocket was thus not estimated. It is possible that larger dif-

Table 8. Location of crown margins (%) at the different observation periods

	Time of observation (years)			
location of crown margin	0	5	10	15
sub-gingivally	64	43	38	36
at the gingiva	14	27	27	25
supra-gingivally	21	31	35	39
no. tooth surfaces	1207	1137	934	719

Table 9. No. and % of caries lesions at the different observation periods according to the location of the crown margins at the basis observation

	5th year observation			10th year observation			15th year observation		
	No. car.surf.	No. surf.	% of car. surf.	No. car. surf.	No. surf.	% of car. surf.	No. car. surf.	No. surf.	% of car. surf.
sub.	24	702	3.4	60	559	10.7	47	461	10.2
at	4	190	2.1	13	172	7.6	19	120	15.8
supra	9	245	3.7	20	203	9.9	20	138	14.5
Total	37	1137	3.3	93	934	10.0	86	719	12.0

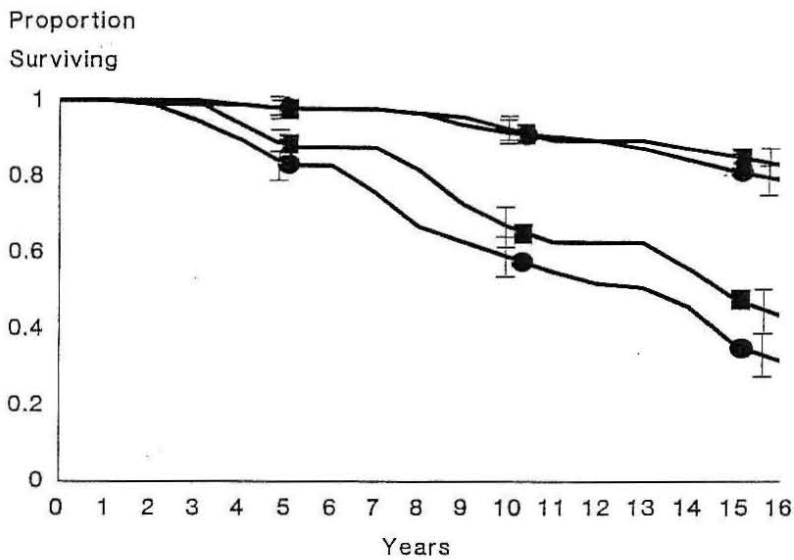

Fig. 6. The cumulative survival curves based upon radiographic measurement of decreased bone level for crowned (circles) and control (squares) teeth. After 15 years, bone loss <2 mm (upper lines) is estimated on 0.86 control teeth and 0.82 crowned teeth, and bone loss <1 mm (lower lines) on 0.48 and 0.38. Vertical bars indicate 95% confidence intervals (±1.96 SE).

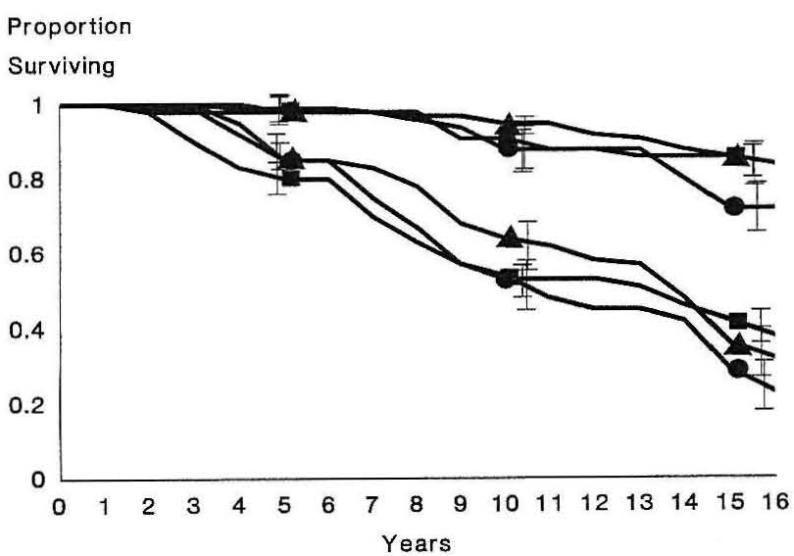

Fig. 7. The cumulative survival curves based upon radiographic measurements of decreased bone levels for crowned teeth. Crown margins placed supragingivally (squares), at the gingiva (circles) and subgingivally (triangles). After 15 years, bone loss <2 mm (upper lines) is estimated on 0.71 to 0.86 of all crowned teeth, while bone loss <1 mm (lower lines) vary between 0.29 and 0.47. Vertical bars indicate 95% confidence interval (±1.96 SE).

ferences could have been registered between the supragingival and the deepest subgingival crown margins. This was reported in a study where the crown margin location was assessed relative to the base of the crevice (Newcomb 1974). However, the authors found it practically difficult to assess the exact subgingival location of the margins.

Previous studies have shown that the pocket depths on the proximal surfaces relative to the pocket depths of the other surfaces remain unchanged after temporary or permanent crowning of the tooth. The present results confirmed that the uneven distribution of the mean pocket depths remain throughout the 15 years (Table 7). The varying pocket depths were also noted on the abutments with subgingivally placed margins.

There are very few radiographic studies addressing the long-term association between fixed dental prostheses and bone loss. One cross-sectional study reported significantly lower bone height associated with metal restorations with more than 0.2 mm overhangs, but no differences when the overhangs were smaller or when the margins were deficit (Bjørn & Bjørn 1969). Another cross-sectional study reported a significantly higher annual bone loss for teeth bearing crowns compared to sound teeth (Rohner et al. 1983).

The differences in rates of bone loss in the control teeth and the abutments were mainly confined to the first 0–5 year observation period. These data resemble the observations made in an experimental animal study, where ligatures induced periodontitis in monkeys (Kornman & Holt 1981). The data thus suggest that crowns may cause an initial loss of periodontal attachment, which later subside.

The reports after 5 and 10 years concluded that the patients had maintained healthy periodontal conditions and relatively low caries incidence on the abutment teeth over many years. The authors attributed this result to the reg-

ulary professional prophylaxis received every 6 months. These 6-month controls ended after 10 years. Although a slightly higher prevalence of PI1 was seen at the 15-year examination, there were no changes of pattern of the patients' gingival or periodontal conditions (Table 4–8). This may show that the patients after receiving professional oral prophylaxis twice a year during the first 10 years themselves had adopted a high standard of dental care.

A further result of the relatively good oral hygiene exerted by the patients is that the periodontal conditions of the abutments and the control teeth were more similar than it would have been if the oral hygiene had been poor (Silness & Ohm 1974).

Zusammenfassung

Mundhygiene, parodontale Verhältnisse und Kariesläsionen bei mit dentalen Brücken behandelten Patienten. Eine klinische und röntgenographische Langzeitstudie

Bei einer Gruppe von 102 Patienten, die in den Jahren 1967/68 an der zahnärztlichen Fakultät der Universität in Oslo von Studenten der höheren Semester mit 108 Brücken behandelt worden waren, wurde eine 15 Jahre andauernde Langzeit-Nachsorgestudie durchgeführt. Im Rahmen dieser Studie wurden 343 Pfeilerzähne beobachtet. Die übrigen Zähne der Kiefer, an denen die Rehabilitation mit Brückenprothesen vorgenommen worden war – alles in allem 525 Zähne – kamen als Kontrolleinheiten in Betracht. Im Laufe der Untersuchung wurden Mundhygiene, Gesundheit der Gingiva, Taschentiefe, Karies an überkronten Zähnen, Lokalisation der Kronenränder und Veränderungen des alveolären Knochenniveaus registriert. Während der ersten 10 Jahre wurden die Patienten in Abständen von 6 Monaten mit Mundhygieneprophylaxe behandelt. Das mittlere Alter der Patienten war zu Beginn der Studie 48 Jahre. Von der ursprünglichen Patientengruppe von 102 Patienten, stellten sich 88 zur klinischen Untersuchung nach 5 Jahren ein, 71 nach 10 Jahren und 55 nach 15 Jahren. Während der Beobachtungszeit wurde zwischen der Plaquemenge an überkronten und Kontrollzähnen kein Unterschied gesehen. Die GI-Scores 2 und 3 (Beurteilungseinheiten des Gingivalindex) kamen in dieser Zeit allerdings häufiger bei überkronten als bei Kontrollzähnen vor. Dieses wurde vor allem dann beobachtet, wenn sich die Kronenränder subgingival befanden. Bei den mit Kronen versehenen Zähnen wurde eine leichte Vertiefung der mittleren Taschentiefe registriert, währenddessen die mittlere Taschentiefe der Kontrollzähne während der 15 Beobachtungsjahre etwa konstant verblieb. Im 5. Beobachtungsjahr wurde an 3.3% der Pfeilerzahnoberflächen Karies registriert, im 10. Jahr an 10% und bei der Nachuntersuchung im 15. Beobachtungsjahr an 12%. In bezug auf Knochenverlust wurde ein statistisch abgesicherter Unterschied zwischen Kontroll- und überkronten Zähnen nicht beobachtet.

Résumé

Hygiène buccale, conditions parondontales et lésions carieuses chez des patients traités par bridges. Une étude clinique et radiologique suivie pendant quinze années

Une étude longitudinale s'étendant sur une période de quinze années a été menée dans un groupe de 102 patients qui avaient reçus 108 bridges fabriqués par les étudiants de dernière année de la Faculté Dentaire de l'Université d'Oslo en 1967–68. Cette étude incluait 343 dents piliers. Les 525 dents restantes situées dans la même mâchoire ont servi de contrôle. L'hygiène buccale, la condition gingivale, la profondeur de poche, les caries sur les dents couronnées, la localisation des bords de la couronne et les variations dans la hauteur osseuse alvéolaire ont été enregistrées durant toute l'étude. Durant les dix premières années, les patients ont reçu une prophylaxie dentaire tous les six mois. L'âge moyen de tous les patients au début de l'étude était de 48 ans. Des 102 patients formant le groupe de départ, 88 se sont présentés lors de l'examen après cinq ans, 71 après 10 ans et 55 après 15 ans. La quantité de plaque dentaire était semblable sur les dents couronnées et les contrôles tandis que l'indice gingival avec des scores de 2 et 3 était plus fréquent au niveau des dents couronnées qu'au niveau des contrôles. Ceci était spécialement observé lorsque les bords des couronnes étaient situés en sous-gingival. Une petite augmentation de la profondeur moyenne des poches a été enregistrée au niveau des dents couronnées tandis que la moyenne des profondeurs de poches au niveau des dents contrôles restait au même niveau durant les quinze années. Des lésions carieuses ont été notées dans 3.3% des surfaces des dents piliers après la cinquième année, dans 10.0% après 10 ans et dans 12.0% lors de l'examen final. En ce qui concerne la perte osseuse, aucune différence statistique n'a pu être décelée entre les dents tests et contrôles.

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Address:

Jakob Valderhaug
Department of Prosthetic Dentistry and Stomatognathic Physiology
Dental Faculty,
University of Oslo
Box 1109, Blindern
0317 Oslo
Norway