Survival of Complete Crowns and Periodontal Health: 18-Year Retrospective Study

Hein De Backer, DDS, MScD[a]/Georges Van Maele, PhD[b]/Nathalie De Moor, DDS[c]/
Linda Van den Berghe, DDS, MScD, PhD[d]

Purpose: This study investigated the survival of complete crowns in relation to periodontal variables on a long-term basis. ***Materials and Methods:*** A total of 1,037 complete crowns made in an undergraduate clinic for 456 patients were evaluated over an 18-year period. The study population was a mixture of periodontally affected and non-periodontally affected patients, which is comparable to the population group in a private practice. Patients were offered a supportive maintenance program. Periodontal variables were measured, including Plaque Index (PI), bleeding on probing (BOP), probing pocket depth (PPD), and attachment level. The Community Periodontal Index for Treatment Needs (CPITN) was calculated per sextant in a full-mouth assessment. ***Results:*** The estimated survival rate was 78% at year 18. For the surviving restorations, the improved PI over time was statistically significant ($P = .001$). Odds ratios were 1.00 for both PI and BOP. For the CPITN, odds ratios were 3.00 to 3.83. Caries was the most frequent reason for failure, followed by periodontal disease. ***Conclusion:*** PI and BOP were not directly related to the frequency of failures. Patients with a high CPITN at baseline had a 3.8 times greater likelihood of losing a complete crown (and abutment tooth) than patients with a low CPITN. The higher failure rate was related not only to periodontal disease, but also to a wide range of biologic and technical problems. In relation to complete crown survival, caution is needed in patients with a high CPITN at baseline. Prosthetic work should be preceded by periodontal examination and prophylactic and periodontal treatment if needed.
Int J Prosthodont 2007;20:151–158.

Restoring teeth means interfering with the precious relationship between the crown-root and periodontal structures. There is an anatomic correlation between tooth-supporting tissues, junctional epithelium, connective tissues, and alveolar bone. In this critical area, the marginal accuracy of a complete crown, location of the preparation margin in relation to the periodontal tissues, and quality of removal of the luting cement are of great importance. This interrelationship between periodontal structures and the placement of fixed restorations has been stressed in the literature.[1–11] These studies reported the gingival reactions to the supra- or subgingival marginal placement of complete crowns. Focusing on the relationship and location of the preparation margin and gingival tissues, studies from 1960 to 1995[1–6] concluded that there is a relationship between gingival inflammation and the location of the crown margin. A more precise philosophy (in studies from 1993 to 2006)[7–11] showed the relationship between the position of the crown margin and the biologic width.[12] Penetrating the epithelial attachment (mean: 0.97 mm) does not cause irreversible damage. Violation of the biologic width means that a restorative margin must be placed in the connective tissue attachment.[12] On the other hand, studies on the outcome of prosthetic treatment in patients with periodontal disease are rather scarce.[13–17] These surveys showed that, following periodontal treatment, periodontal health could be maintained in patients

[a]*Senior Researcher, Centre for Special Care, PaeCaMed Research, Unit of Gnathology and Temporomandibular Disorders, Dental School, Faculty of Medicine and Health Sciences, Ghent University, Belgium.*
[b]*Professor, Department of Medical Statistics, Faculty of Medicine and Health Sciences, Ghent University, Belgium.*
[c]*Private Practitioner and Researcher, Ghent, Belgium.*
[d]*Professor, Centre for Special Care, PaeCaMed Research, Unit of Gnathology and Temporomandibular Disorders, Dental School, Faculty of Medicine and Health Sciences, Ghent University, Belgium.*

Correspondence to: *Dr Hein De Backer, Hulststraat 8, 8700 Tielt, Belgium. E-mail: hein.debacker@skynet.be*

enrolled in a controlled oral hygiene program. Periodontal variables used in these studies were Plaque Index (PI), bleeding on probing (BOP), probing pocket depth (PPD), and attachment level. These variables can be combined in a periodontal index, the Community Periodontal Index for Treatment Needs (CPITN). The CPITN was proposed in 1977 as a tool to evaluate periodontal treatment needs.[18,19] This index scores the severity of periodontal disease in 6 segments of the mouth (sextants).

The aim of the present study was to evaluate the general periodontal status of patients treated with complete crowns using the periodontal variables PI, BOP, and CPITN in relation to the survival of the complete crowns.

Materials and Methods

Subjects

A total of 1,312 complete crowns were made during an 18-year period, between 1974 and 1992, in the undergraduate clinic of the former department of Fixed Prosthodontics and Periodontology, Ghent University, Belgium.[20] The patient group was a mixture of periodontically affected and non-periodontally affected patients. The crowns consisted of full-cast crowns, porcelain-fused-to-gold crowns, and post-core crowns. Complete crowns in the visible (anterior) region were always covered with porcelain. Complete crowns on molars were gold or porcelain-fused-to-gold restorations, depending on the esthetic choice of the patient or the technical preference of the practitioner. In the posterior region, all crowns had a supragingivally located margin. For esthetic reasons, the crown margin in the anterior region was located at the gingival margin. The impressions were made with a polyether material. Posts were made of gold alloys. All crowns were cemented with zinc phosphate (Harvard, Richmond Harvard) and had a high-quality margin. The aim was to leave no cement debris at the crown preparation margin. Treatment and follow-up records of 456 patients (60.5% women and 39.5% men), with a mean age of 41 years (range: 18 to 82 years), mean survival evaluation time of 10 years (range: 0.3 to 25.0 years), and 1,037 complete crowns were available for analysis. This represents 79% of the total number of complete crowns. The dropout rate of 21% was the result of the following reasons: patients chose a private practitioner, moved to another city, could not be located, or died during the observation period. No patients in the dropout group were contacted by telephone, and no questionnaires were sent to these patients or former or current clinicians of these patients to collect supplementary information. The study was approved by the Ethics Committee at the University Hospital, Ghent, Belgium.

Methods

Before prosthetic treatment, all patients went through a periodontal screening. Non-periodontally affected patients were treated immediately with complete crowns. Periodontally affected patients were scheduled for periodontal treatment and enrolled in an oral hygiene program. At reevaluation, 6 months after scaling and root planing, the decision to either start prosthetic treatment or perform further periodontal treatment was made. For some patients, crown treatment started 1 year after periodontal treatment. After prosthetic treatment, all patients were offered participation in a regular supportive maintenance program, on a 6-month basis. During these maintenance sessions, a number of diagnostic and therapeutic steps were carried out: whole-mouth PI evaluation after staining, with a dichotomous reading; BOP of the gingival sulcus; periapical radiographs; recording of new caries lesions or secondary caries; control of the retention of the restoration; control of the marginal accuracy; and recording of mechanical failures. PPD and attachment level at 6 or 8 sites per tooth were recorded using a Michigan periodontal probe. During maintenance sessions, plaque and supra- and subgingival calculus were removed, and oral hygiene instructions were given. Patients were scheduled for scaling and root planing whenever periodontal disease was present.

The data at the first recall visit after cementation (within 1 month) were used as baseline and were confirmed by the data at first screening for the non-periodontally affected patients and at a 6- or 12-month control visit after periodontal treatment for periodontally affected patients. Using the PPD, BOP, and presence of calculus, the CPITN score was calculated. A full-mouth periodontal screening was performed but focused only on the sextant in which the complete crown was placed (site specific). However, the score of this sextant had to be confirmed with the same score in at least 1 of the other sextants. If the complete-crown sextant score was the highest and could not be confirmed by another sextant score, the second highest score was taken as the final score. The CPITN scores range from 0 to 4: CPITN 0 = the crown sextant is healthy; CPTIN 1 = the crown sextant shows BOP; CPITN 2 = similar to index 1, but calculus is also detected; CPITN 3 = similar to index 2, but at least 1 site has PPD of 4 to 5 mm; CPITN 4 = PPD is 6 mm or more. Because of the period of the study (1974 to 1992), not all values for calculating the CPITN (Bleeding Index, PI, and PPD) were mentioned in the files.

At final evaluation or time of failure, the study population was divided into 3 groups according to past caries experience, reflecting caries sensitivity during

each patient's life, not just when the restorations were in situ: group 1 = caries nonsensitive, with a maximum of 5 filled teeth, no proximal sites filled, and no root canal–treated teeth as a result of caries; group 2 = moderately caries sensitive, with a maximum of 10 teeth filled and 2 root canal–treated teeth as a result of caries; group 3 = caries sensitive, with more than 10 restorations and/or more than 2 root canal–treated teeth as a result of caries.[20]

Prosthetic failures were divided into 2 groups: *irreversible complications* if the crown or tooth was lost and *reversible complication*s if recementation was performed following loss of retention, endodontic treatment, or filling of the abutment tooth, with the full crown still intact. A complete crown could have a reversible complication but still end up in the surviving group at the final evaluation, or it could have a reversible complication followed by an irreversible complication, thus ending up in the failure group.

Statistical Analysis

The Kaplan-Meier survival estimation method with a 95% confidence interval was used.[21] The log-rank test was used to determine whether some survival functions differed between groups.[22] The Wilcoxon matched-pairs signed rank test was used for comparison between PI and BOP versus failing or surviving restorations. The McNemar test was used for cross tabulations of the CPITN at baseline and reevaluation. A logistic regression analysis with failure as the dependent variable was used in correlation with PI, BOP, and CPITN. Univariate analysis was performed using the chi-square test. The significance level was set at $\alpha = .05$.

Results

Of the 1,037 complete crowns, 72.4% were placed in the maxilla and 27.6% in the mandible. The most common reasons for crown preparation were extensive loss of crown substance as a result of caries (65.9%), replacement of an existing restoration (12.2%), trauma (7.7%), endodontic problems (6.3%), or esthetic reasons (5.4%). Table 1 shows the number of complete crowns placed per patient, the number of failed or surviving restorations within each patient, and the frequency distribution. Eight patients lost a combined 27 of the 116 failing complete crowns, which is 23.3% of the total failure rate. The reasons for failure in this group of 8 patients were of biologic origin 74.1% of the time, but no specific patterns of failure could be seen in patients with multiple losses.

The Kaplan-Meier survival curves for all restorations are shown in Fig 1. There was no statistically significant difference ($P = .150$) between the estimated survival at year 18 in the maxilla (78.1% [95% CI: 73% to 83%]) and mandible (78.2% [69% to 88%]).

Table 1 Frequency Distribution of Complete Crowns (CC) Placed Per Patient and the No. of Failed or Surviving CCs Within the Same Patient

CC per patient	No. failed	No. of patients
1 (48.5%)	0	189
	1	32
2 (21.5%)	0	84
	1	11
	2	3
3 (12.5%)	0	43
	1	9
	2	3
	3	2
4 (7.0%)	0	28
	1	1
	2	2
	4	1
5 (3.7%)	0	9
	1	6
	3	2
6 (2.6%)	0	7
	1	4
	2	1
7 (1.3%)	0	4
	1	1
	3	1
8 (1.3%)	0	2
	1	1
	2	1
	3	1
	5	1
9 (0.4%)	0	1
	1	1
10 (0.7%)	0	2
	2	1
11 (0.2%)	1	1
15 (0.2%)	0	1

The caries sensitivity of the whole patient group is shown in Fig 2 and revealed a rather caries-sensitive population. The study population was divided into a caries-nonsensitive group (group 1, 27.6%), a moderately caries-sensitive group (group 2, 18.6%), and a caries-sensitive group (group 3, 53.8%).

The biologic reasons for removal of a complete crown or tooth were caries (24.3%), periodontal problems (17.2%), fracture of the abutment tooth (12.9%), and endodontic problems (12.0%). Thus, these biologic factors accounted for 66.4% of the total losses. Technical and patient-related failures, such as porcelain fracture (8.7%), loss of retention (6.0%), post fracture (4.3%), teeth needed as abutments for a fixed partial restoration (11.2%), and trauma (1.7%), represented 31.9% of the complete crowns lost. In the remaining 1.7% of failures, the reason was unknown. These results are in contrast with the reversible complications, 83% of which were technical problems, such as loss of retention (69%) and porcelain fracture (14%).

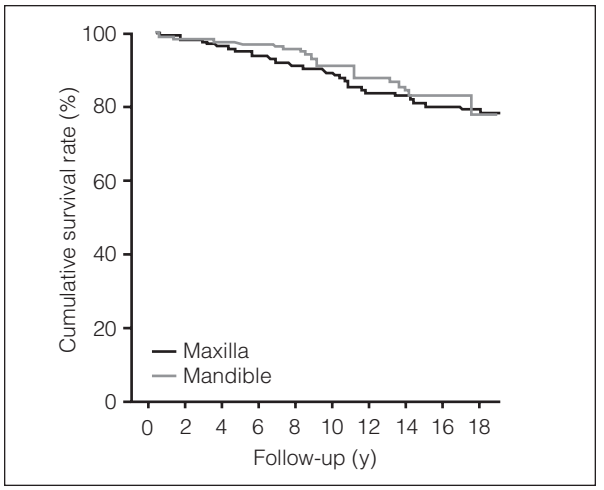

Fig 1 Kaplan-Meier survival curves for all restorations in the maxilla and mandible ($P = .150$).

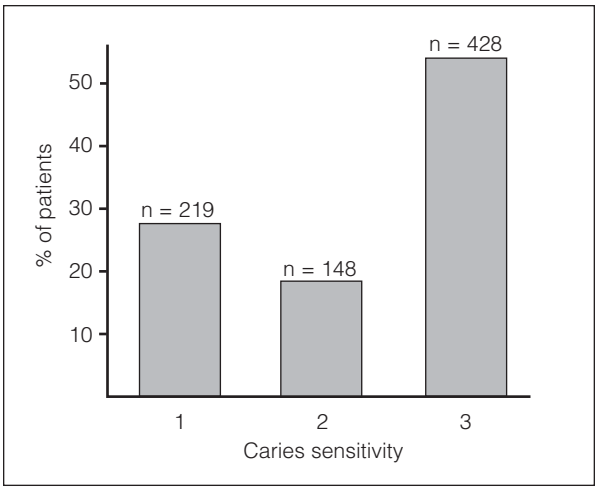

Fig 2 Past caries sensitivity recorded at evaluation: 1 = caries nonsensitive; 2 = moderately caries sensitive; 3 = caries sensitive.

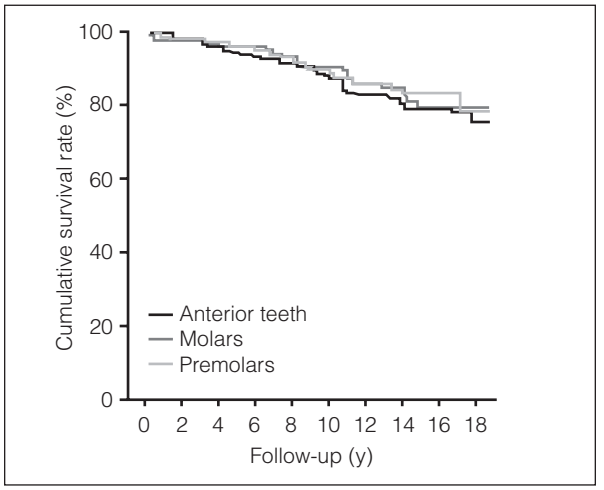

Fig 3 Kaplan-Meier survival curves for restorations on molars, premolars, and anterior teeth ($P = .671$).

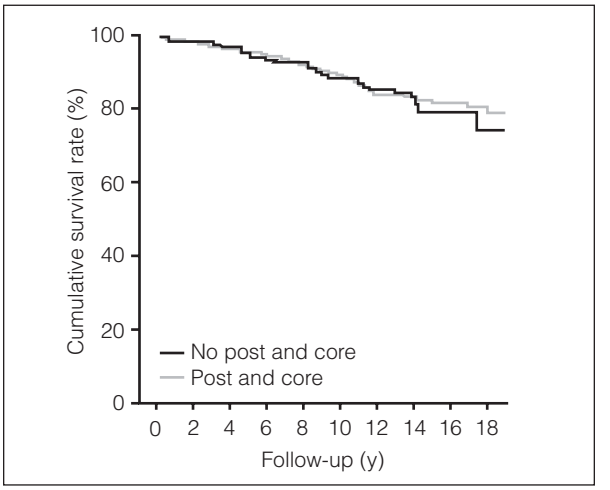

Fig 4 Kaplan-Meier survival curves for complete crowns with and without posts and cores ($P = .602$).

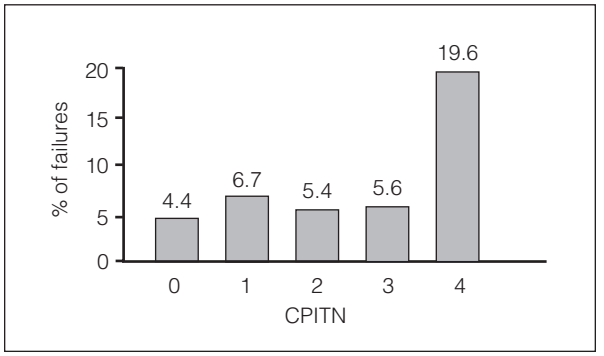

Fig 5 Percentage of failed restorations in the different CPITN groups based on the data at baseline ($P = .001$).

Caries and endodontic problems were found in 17% of the reversible complications.

Figure 3 shows the Kaplan-Meier survival curves for restorations on molars, premolars, and anterior teeth. At year 18, the estimated survival was 80.3% (72% to 88%) for molars, 78.6% (70% to 87%) for premolars, and 76.1% (68% to 84%) for anterior teeth. The differences between the groups were not statistically significant ($P = .671$). A comparison of the survival rates of the different types of teeth showed no statistically significant difference ($P = .850$). The survival rates were 88.9% for incisors, 85.5% for canines, 88.8% for premolars, and 89.4% for molars. No distinction was made between maxillary and mandibular teeth.

Figure 4 shows the survival estimations at year 18: 79.4% (74% to 85%) for post-and-core crowns compared to 74.9% (66% to 84%) for the complete crowns without a post and core. The difference between the 2 groups was not statistically significant ($P = .602$). Cox regression model was used to control for covariates such as age, gender, regular attendance at the 6-month recalls, and presence of previous crowns. None of the reported results were influenced by these variables.

Table 2 No. of Patients with Changes in CPITN at Baseline and at Reevaluation for Surviving Restorations ($P < .001$)

	Reevaluation		
Baseline	0–2	3	4
0–2	266 (62.7%)	128 (30.2%)	30 (7.1%)
3	69 (34.0%)	102 (50.2%)	32 (15.8%)
4	9 (22.5%)	10 (25.0%)	21 (52.5%)

Table 3 No. of Patients with Changes in CPITN at Baseline and at Time of Failure ($P = .359$)

	Time of failure		
Baseline	0–2	3	4
0–2	16 (61.5%)	7 (27.0%)	3 (11.5%)
3	6 (50.0%)	4 (33.3%)	2 (16.7%)
4	0 (0.0%)	1 (14.3%)	6 (85.7%)

Table 4 Cross Tabulation of Reason for Irreversible Failure Versus Tooth Loss ($P = .024$)

	Irreversible complication		
Tooth loss	Biologic	Technical	Total
No (%)	23 (53.5)	20 (46.5)	43 (37.1)
Yes (%)	54 (74.0)	19 (26.0)	73 (62.9)
Total (%)	77 (66.4)	39 (33.6)	116 (100.0)

Table 5 Cross Tabulation of CPITN at Failure (Crown and/or Tooth) Versus Reason for Failure ($P = .148$)

	Failure		
CPITN	Biologic	Technical	Total
0-2	19	15	34
3	15	5	20
4	18	5	23
Total	52	25	77

Table 6 Cross Tabulation of CPITN at Failure (Crown and/or Tooth) Versus Surviving and Failed Restorations ($P = .050$)

CPITN	Surviving (%)	Failed (%)*
0–2	395 (92.3)	33 (7.7)
3	299 (94.6)	17 (5.4)
4	99 (87.6)	14 (12.4)

*Periodontal failures not included.

The Wilcoxon matched-pairs signed rank test revealed that PI ($P = .831$) and BOP ($P = .276$) at baseline were not significantly associated with the frequency of failure. For the surviving restorations, PI ($P < .001$) was significantly correlated, but BOP ($P = .645$) was not.

Changes in CPITN for surviving and failing crowns between baseline and reevaluation are shown in Tables 2 and 3. For the surviving restorations, 62.7% of the patients with CPITN scores 0 to 2 at baseline had the same score at reevaluation, 30.2% scored worse, and 7.1% even deteriorated to a score of 4. Of the patients with a CPITN score 4 at baseline, 22.5% improved to scores 0 to 2, and 25.0% improved to score 3, but 52.5% remained at score 4. These results are statistically significant ($P < .001$). In the cross tabulation with failed restorations (Table 3), the results are similar, except with CPITN 4. In this group, 86% remained at score 4, only 14% shifted to score 3, and none improved to scores 0 to 2. However, there was no significant difference ($P = .359$), partly due to the small number of failing complete crowns.

A logistic regression analysis with PI and BOP, with failure as dependant variable, revealed no statistically significantly correlation. Both odds ratios were 1.00. A statistically significantly association was found with the CPITN scores, with an odds ratio of 3.78 ($P < .001$). The percentages of failing crowns in the different CPITN groups recorded at baseline are given in Fig 5. In those with CPITN 4, more than 19% of the full crowns failed ($P = .001$). Therefore, crowns with CPITN 0 to 3 were pooled (group A), with a mean failure rate of 6%. The odds ratio was 3.83 for failure in group B (CPITN 4). The percentages of failing crowns recorded at the final date (recall or failure) are 7.2% for group A and 18.9% for group B ($P < .001$). The odds ratio was 3.00 for failure in group B.

Table 4 shows a cross tabulation of reason for irreversible complication versus tooth loss, in which failure of the crown only or failure of the crown and/or tooth is specified. Nearly 63% (n = 73) of the irreversible complications were failures of both the crown and tooth, while only 37% (n = 43) of the teeth were able to receive a new prosthetic restoration. About 74% (n = 54) of the failures of crowns and/or teeth were of a biologic origin, and only 26% (n = 19) of a technical origin, which is statistically significant ($P = .024$). Of the 116 irreversible complications, 17.2% showed periodontal disease and had both crown and tooth loss. The cross tabulation (Table 5) of CPITN at failure of the crown and/or tooth versus reason for failure ($P = .148$) showed that patients with CPITN 0 to 2 had 34 failures (1 for periodontal reasons). In patients with CPITN 3, 20 single restorations and/or teeth were lost (3 for periodontal reasons). In those with CPITN 4, 23 complete crowns and/or teeth were lost, 9 (39.1%) of which for periodontal reasons. Also in this group, 9 crowns had

other biologic complications, such as caries (n = 4, 17.4%), apical problems (n = 2, 8.7%), and fracture of the abutment tooth (n = 3, 13.1%). Five crowns (21.7%) had technical problems. Table 6 shows the cross tabulation of CPITN at failure of surviving complete crowns versus failing complete crowns (periodontal failures not included). Patients with CPITN 4 still showed the highest number of failures (12.4%), which is statistically significant ($P = .050$).

Discussion

The aim of this study was to evaluate the periodontal status (site specific) of patients treated with dental prostheses, using the periodontal variables PI, BOP, and CPITN in relation to the survival rate, while taking into account the importance of the delicate relationship between the gingival complex and the location of the preparation margin. In the current study, all crown margins were of high quality, located supragingivally or at the gingival margin, and controlled at each maintenance session. These precautions were taken to minimize the influence of the crown margin on the gingival tissue response, and are in correspondence with a study by Valderhaug et al.[8] Nevertheless, some authors believe that there are no differences in failures as long as the biologic width is not violated.[7–12]

Previous studies of the relationship between periodontal health and survival rates of complete crowns have examined only periodontally affected patients.[13–17] The present study population was a mixture of periodontally and non-periodontally affected patients, which is comparable to patients in a private practice. The results show that, in a population offered a regular supportive maintenance program on a 6-month basis, estimated survival rates were equal for periodontally and non-periodontally affected subjects, as long as the patient's CPITN score was within 0 to 3. Patients with CPITN 4 at baseline had a 3.8 times greater chance of crown and/or abutment failure than patients with a lower score. This is not only related to periodontal disease, but also to a wider range of biologic problems. Even after excluding periodontal failures (Table 6), patients with CPITN 4 had the highest failure rate, and the difference was statistically significant. The results show an interrelationship between periodontal health and the survival rate of complete crowns. During the observation period, the CPITN score decreased in most subjects. Only a small group got worse. CPITN values can be used as an easy tool for general practitioners to inform and educate patients on the need for prosthetic treatment. CPITN values provide patients with simple and direct evidence of their periodontal status. For clinicians, these values are useful during diagnosis and treatment planning.

The studied patient group was not divided into subgroups, such as anterior versus posterior teeth, because there were no statistically significant differences between these groups. The CPITN has been used extensively in periodontal surveys and was intended for screening large populations to determine treatment needs and facilitate preventive and therapeutic strategies.[19] Over the last 2 decades, the CPITN has been used in a large number of epidemiologic surveys on nearly every contintent.[23] Recently, however, it has also been used for clinical studies,[24–26] as well as in a review by Hujoel et al,[27] who found ecologic evidence suggesting that periodontitis prevalence is not dependent on access to traditional personal oral hygiene tools. Using this index, prevalence and severity of periodontitis can be studied, but it is important not to under- or overestimate the results.[28,29] In the present survey, PI, BOP, and PPD were based on a full-mouth score, but the CPITN score was based only on the crown sextant. The score of this sextant was confirmed with the same score in at least 1 of the other sextants. There is a high correlation between full-mouth and partial recording systems because of the apparent symmetry of periodontal conditions in the mouth.[30] While whole-mouth examinations are the gold standard for a complete assessment, Dowsett et al[31] showed that a half-mouth examination provided maximal clinical information. Thomson and Williams[32] compared full-mouth examinations with examinations by quadrant. The difference was small for attachment level and PPD but not for gingival recession.

Odds ratios for PI and BOP on a full-mouth assessment were 1.00. These clinical periodontal parameters were not related to irreversible loss of a complete crown and/or tooth. BOP has been shown to have a low positive predictive value. BOP and PI do not appear to be strong indicators of future disease progression.[33] Nevertheless, the improvement in PI from baseline to reevaluation was statistically significantly correlated with survival. This result is confirmed in a study of the survival of fixed partial dentures[34] and is in accordance with the results of the CPITN cross tabulation for the surviving restorations (see Table 2).

The data from the first recall after cementation (within 1 month) were used as baseline. These data were confirmed by the data from the first screening of the non-periodontally affected patients and with the data from a 6- or 12-month control visit after periodontal treatment for the periodontally affected patients.

The choice of baseline is comparable with the situation in a general practice. Non-periodontally affected patients will generally have prosthetic treatment immediately. Periodontally affected patients will be referred for periodontal treatment, with prosthetic treatment starting 6 to 12 months after periodontal therapy.

All patients were offered a maintenance program offering both diagnostic and therapeutic aspects. In periodontally affected patients, mechanical debridement reduces inflammation and disturbs the bacterial biofilm. This is key in disease control, including prevention of disease progression.[35] Regardless of whether patients receive periodontal maintenance in a specialist periodontal clinic or in the practice of the referring general practitioner, there is a tendency for plaque control to deteriorate between recall visits.[36] But there is no randomized controlled trial evidence indicating that improved personal oral hygiene prevents or controls chronic periodontitis.[27]

Root-canal teeth treated with a post-and-core crown represented 79.2% of the study group. This percentage reflects the high past caries sensitivity of this study population (groups 2 and 3, 72.4%). Three of the most common reasons for crown preparation were extensive loss of crown substance caused by caries (65.9%), trauma (7.7%), and endodontic problems (6.3%). Caries, periodontal problems, fracture of the abutment tooth, and endodontic problems—all of a biologic origin—were responsible for 66% of the removals. Several authors found caries development to be the most frequent complication in fixed prosthetic restorations.[37–40] Likewise, in this study, caries (24%) was the primary factor for failure. Loss of retention, which is frequently combined with caries, occurred in 6%. Most striking is the fact that the 4 most frequent factors for failures were of a biologic origin. Valderhaug[41] and Sundh and Ödman[37] found similar results.

Conclusion

This study shows that complete-crown prosthetic treatment is fairly successful, with a survival rate of 78% after 18 years. Caries was the most common reason for failure, followed by periodontal problems. Biologic reasons accounted for 66% of failures. For PI and BOP, only PI showed a significant correlation with the surviving restorations. Failure rates in patients with CPITN 0 to 3 were comparable. Precaution is needed in patients with CPITN 4 at baseline in relation to complete-crown survival (odds ratio: 3.8). Prosthetic treatment should not be performed without prior thorough periodontal examination and prophylactic or periodontal treatment if needed.

Acknowledgments

The authors are very thankful to Jan De Boever for his comments and his permission to gather the data. Thanks as well to Frank Herrebout and Veerle Decock for their valuable help.

References

1. Waerhaug J. Histological considerations which govern where the margins of restorations should be located in relation to the gingiva. Dent Clin North Am 1960;4:161–176.
2. Marcum JS. The effect of crown marginal depth upon gingival tissue. J Prosthet Dent 1967;17:479–487.
3. Newcomb GM. The relationship between the location of subgingival crown margins and inflammation. J Periodontol 1974;45:151–154.
4. Lang NP, Kiel RA, Anderhalden K. Clinical and microbiological effects of subgingival restorations with overhanging or clinical perfect margins. J Clin Periodontol 1983;10:563–578.
5. Flores-De-Jacoby L, Zafiropoulos GG, Cianco S. The effect of crown margin location on plaque and periodontal health. Int J Periodontics Restorative Dent 1989;9:197–205.
6. Lang NP. Periodontal considerations in prosthetic dentistry. Periodontology 2000 1995;9:118–131.
7. Page L, Ginsberg Halpern B. Restorative dentistry. Interactions with periodontics. Dent Clin North Am 1993;37:457–463.
8. Valderhaug J, Ellingsen JE, Jokstad A. Oral hygiene, periodontal conditions and carious lesions in patients treated with dental bridges. A 15-year clinical and radiographic follow-up study. J Clin Periodontol 1993;20:482–489.
9. Kois J. The restorative-periodontal interface: Biological parameters. Periodontol 2000 1996;11:29–38.
10. Gracis S, Fradeani M, Celletti R, Bracchetti G. Biological integration of aesthetic restorations: Factors influencing appearance and long-term success. Periodontol 2000 2001;27:29–44.
11. Donovan TE, Cho GC. Predictable aesthetics with metal-ceramic and all-ceramic crowns: The critical importance of soft-tissue management. Periodontol 2000 2001;27:121–130.
12. Ingber JS, Rose LF, Coslet JG. The "biologic width" —A concept in periodontics and restorative dentistry. Alpha Omegan 1977;70:62–65.
13. Söderfeldt B, Palmqvist S. A multilevel analysis of factors affecting the longevity of fixed partial dentures, retainers and abutments. J Oral Rehabil 1998;25:245–252.
14. Silness J. Periodontal conditions in patients treated with dental bridges. J Periodontal Res 1974;9:50–55.
15. Lundgren D, Nyman S, Heijl L, Carlsson GE. Functional analysis of fixed bridges on abutment teeth with reduced periodontal support. J Oral Rehabil 1976;3:237–243.
16. Nyman S, Lindhe J. A longitudinal study of combined periodontal and prosthetic treatment of patients with advanced periodontal disease. J Periodontol 1979;50:163–169.
17. Yi S-W, Ericsson I, Carlsson GE, Wennström JL. Long-term follow-up of cross-arch fixed partial dentures in patients with advanced periodontal destruction. Acta Odontol Scand 1995;53:242–248.
18. Ainamo J, Bay I. Problems and proposals for recording gingivitis and plaque. Int Dent J 1975;25:229–235.
19. Ainamo J, Ainamo A. Development of oral health during studies in India and Finland. Int Dent J 1978;28:427–433.
20. De Backer H, Van Maele G, De Moor N, Van den Berghe L, De Boever J. An 18-year retrospective survival study of full crowns with or without posts. Int J Prosthodont 2006;19:136–142.
21. Kaplan EL, Meier P. Non parametric estimation from incomplete observations. J Am Stat Assoc 1958;53:457–481.
22. Kalbfleish JD, Prentice RL. The Statistical Analysis of Failure Time Data. New York: John Wiley, 1980.
23. Albandar JM, Rams TE. Global epidemiology of periodontal diseases. Periodontol 2000 2002;29:31–152.
24. Bakhshandeh S, Murtomaa H, Mofid R, Vehkalahti MM, Suomalaien K. Periodontal treatment needs of diabetic adults. J Clin Periodontol 2007;34:53–57.

25. Miyaki K, Masaki K, Naito T, et al. Periodontal disease and atherosclerosis from the viewpoint of the relationship between community periodontal index of treatment needs and brachial-ankle pulse wave velocity. BMC Public Health 2006:6:131–135.
26. Orozco AH, Franco AM, Ramirez-Yanez GO. Periodontal treatment needs in a native island community in Colombia determined with CPITN. Int Dent J 2004;54:73–76.
27. Hujoel PP, Cunha-Cruz J, Loesche WJ, Robertson PB. Personal oral hygiene and chronic periodontitis: A systematic review. Periodontol 2000 2005;37:29–34.
28. Persson GR. Site-based versus subject-based periodontal diagnosis. Periodontol 2000 2005;39:145–163.
29. Borrell LN, Papapanou PN. Analytical epidemiology of periodontitis. J Clin Periodontol 2005;32(suppl 6):132–158.
30. Diamanti-Kipioti A, Papapanou PN, Moraitaki-Tsami A, Lindhe J, Mitsis F. Comparative estimation of periodontal conditions by means of different index systems. J Clin Periodontol 1993;20:656–661.
31. Dowsett SA, Eckert GJ, Kowolik MJ. The applicability of half-mouth examination to periodontal disease assessment in untreated adult populations. J Periodontol 2002;73:975–981.
32. Thomson WM, Williams SM. Partial- or full-mouth approaches to assessing the prevalence of and risk factors for periodontal disease in young adults. J Periodontol 2002;73:1010–1014.
33. Mombelli A. Clinical parameters: Biological validity and clinical utility. Periodontol 2000 2005;39:30–39.
34. De Backer H, Van Maele G, De Moor N, Van den Berghe L, De Boever J. A 20-year retrospective survival study of fixed partial dentures. Int J Prosthodont 2006;19:143–153.
35. Pershaw PM, Heasman PA. Periodontal maintenance in a specialist periodontal clinic and in general dental practice. J Clin Periodontol 2005;32:280–286.
36. Suvan JE. Effectiveness of mechanical nonsurgical pocket therapy. Periodontol 2000 2005;37:48–71.
37. Sundh B, Ödman P. A study of fixed prosthodontics performed at a university clinic 18 years after insertion. Int J Prosthodont 1997;10:513–519.
38. Schwartz N, Whitsett L, Berry T, Stewart J. Unserviceable crowns and fixed partial dentures: Life-span and causes for loss of serviceability. J Am Dent Assoc 1970;81:1395–1401.
39. Walton J, Gardner F, Agar J. A survey of crown and fixed partial denture failures: Length of service and reasons for replacement. J Prosthet Dent 1986;56:416–421.
40. Libby G, Arcuri M, LaVelle W, Hebl L. Longevity of fixed partial dentures. J Prosthet Dent 1997;78:127–131.
41. Valderhaug J. A 15-year clinical evaluation of fixed prostheses. Acta Odontol Scand 1991;49:35–40.

Literature Abstract

Treatment concepts for restoration of endodontically treated teeth: A nationwide survey of dentists in Germany

The purpose of this study was to determine current opinions, techniques, and materials used for the restoration of endodontically treated teeth in Germany. A survey containing 18 multiple choice questions regarding treatment principles, type of posts, and type of core foundations was mailed to 36,500 general dentists in Germany. A total of 6,029 questionnaires were completed and returned. The results showed that *(1)* irrespective of occupational experience; 52% of the surveyed dentists consider post placement for almost every endodontically treated tooth; *(2)* 54% believe that a post reinforces the teeth; *(3)* 55% use cast posts and cores; *(4)* 34% use prefabricated posts; *(5)* screw posts are the most popular prefabricated post type (47% of dentists); *(6)* 51% preferred resin composite for core foundation, 26% preferred glass-ionomer cements, and 0.5% used amalgam; *(7)* 51% of the posts were placed with zinc phosphate cement and 38% with glass-ionomer cement. The treatment philosophy of German dentists is not in agreement with recommendations found in the literature. Opinions concerning the restoration of endodontically treated teeth still vary. A variety of techniques and materials are being used. It would be interesting to see this study repeated in other countries.

Naumann M, Kiessling S, Seemann R. *J Prosthet Dent* 2006;96:332–338. **References:** 59. **Reprints:** Dr Michael Naumann, Department of Prosthodontics and Geriatric Dentistry, Charite, University Medical School, Campus Virchow, Föhrerstr 15, D-13353 Berlin, Germany. Fax: 49 0 30 450 562900—*Ansgar C. Cheng, Singapore*