Single-Tooth Replacement: Is a 3-Unit Fixed Partial Denture Still an Option? A 20-Year Retrospective Study

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Purpose: This study of 3-unit fixed partial dentures (FPDs) evaluated the long-term efficacy and determined the frequencies and causes of failures. ***Materials and Methods:*** A total of 134 FPDs made in an undergraduate university clinic for 98 patients were evaluated over a 20-year period. All patients were offered a supportive maintenance program. Failures of the FPDs were divided into irreversible (loss of FPDs) or reversible (FPDs intact after conservative treatment) complications and into biologic and technical/patient-related failures. ***Results:*** The overall survival rate was 73.1% after 20 years. There was a statistically significant difference (P = .036) between the survival rates in the mandible for the vital group (96.3%) versus the root canal–treated group (69.3%). Comparing the survival rate in the vital group for the restorations in the maxilla (70.2%) versus the mandible (96.3%), a statistically significant difference (P = .045) was found. The survival rate after 20 years for the 3-unit FPDs (73.1%) was significantly different from that of the FPDs with more than 3 units (61.5%) (P = .026). The main reason for failure was caries (38.1%). ***Conclusion:*** The survival of 3-unit FPDs over a 20-year period is favorable and should be compared with other single-tooth replacement treatment options. There is an indication that the occurrence of a reversible complication has a predictive value for an irreversible complication later on. *Int J Prosthodont 2006;19:567–573.*

Extracting a tooth means changing the anatomic features by altering the gingiva, periodontal tissues, and underlying bone. Replacing a missing tooth means restoring the function and creating esthetics in harmony with the adjacent tissues. Whenever it is possible to retain a functional tooth, this should be considered seriously before a decision is made. In some cases, a crown-lengthening procedure or orthodontic extrusion will be an appropriate treatment option. The reasons for losing a tooth are numerous. The ideal treatment is in most cases a conservative option, satisfying individual esthetic and functional requirements.

The treatment options available for the replacement of a single missing tooth have expanded over the last 2 decades. The edentulous space can be restored with a conventional 3-unit metal-ceramic fixed partial denture (FPD), a 3-unit full-ceramic FPD, or a 3-unit cantilevered FPD. These treatment options are optimal in cases where the adjacent teeth were previously extensively restored. Generally, function and esthetics are complementary. A resin-bonded FPD or splinting of the extracted tooth with a fiber-reinforced composite or a removable partial denture is an alternative for the replacement of the lost tooth. This immediate replacement (or within a few days) is for some patients a psychologically and socially preferable option. The adjacent teeth can be conserved because little preparation is needed. The procedures are minimally inva-

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sive and reversible. Orthodontic treatment (canine replacement), transplantation of premolars or impacted third molars, and solitary implant procedures are other possible treatment options to replace a single missing tooth. These latter options are conservative because no preparation of the adjacent teeth is needed. It is obvious that the critical decision of choosing the appropriate treatment is based on environmental factors.

Because of the variety of treatment options for single-tooth replacement, there is no literature covering all these treatments in a single survey. A few authors have reviewed data concerning multiple parts of the field of fixed prosthetics,[1–3] but most researchers focused on one topic. Studies on single-tooth implant rehabilitation and on single-tooth replacement with resin-bonded prostheses are well documented.[4,5] Results on 3-unit FPDs or short-span FPDs (3 or 4 units) have been reported only as part of a broader survey.[6–11] Statistics remain scarce and are limited to functional life spans or comments on failed FPDs. To the authors' knowledge, a survival study of only 3-unit FPDs has not been published previously.

In general, comparisons of the data on the survival of FPDs are difficult. The most substantial differences between studies are found in the definition of failure and the populations studied.[12–14] In these studies, prosthetic treatments have been carried out by general practitioners or senior undergraduate students in a specialized clinic or a dental school, by numerous clinicians, or by one operator. Creugers et al,[12] Scurria et al,[13] and Tan et al[14] all reported the need for standardization of the terminology and the consequent use of scientific rules in the design of the studies.

It is not the purpose of this article to comment on and compare all kinds of single-tooth replacement procedures. Instead, the aim was to evaluate the survival of only conventional 3-unit FPDs to determine the frequencies and causes of failures, as well as the effect of post-and-core abutments, for these restorations.

Materials and Methods

Materials

A total of 165 FPDs were made over a period of 20 years, between 1974 and 1992, in the undergraduate clinic of the former Department of Fixed Prosthodontics and Periodontology, Ghent University, Belgium. Cantilevered FPDs were not included in the present study. This group of 3-unit FPDs was part of a larger study of FPDs at the same department.[15] A total of 397 FPDs were made during that period. The investigated group represented 322 FPDs in 193 patients. For the current study, complete treatment and follow-up records of 98 patients (59.2% women and 40.8% men), with a mean age of 61.2 years (range: 33.6 to 93.6) and 134 FPDs, were available for analysis, representing 81% of the total number. The dropout rate of 19% was the result of the following reasons: patients chose a private practitioner for maintenance, moved to another city, could not be reached, or died during the follow-up period. None of the patients in the dropout group were contacted by telephone and no questionnaires were sent to these patients or to their former or current clinicians to collect supplementary information.

The FPDs consisted of porcelain-fused-to-gold or gold retainers. Retainers in the anterior region were always covered with porcelain. Retainers 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, most retainers had a supragingivally located margin. For esthetic reasons, the retainer margin in the anterior region was located at the gingival margin. No special root canal preparation for the post-and-core abutment teeth was used, to avoid excessive removal of dentin substance. A standard ferrule of 2 mm was preferred, but in many cases this could not be obtained. Many of the post-and-core preparations had a limited ferrule. No direct restorative techniques or special burs with prefabricated posts were used. At least 10 mm of root canal filling was removed (range: 7 to 15 mm), according to standard protocol. The impression of the prepared tooth was always made with the same polyether material (Impregum, 3M ESPE). The impression of the root canal was made with the help of a lentulo, but no other devices, such as burnout posts, were used. All cast-gold posts and cores on the abutment teeth in the 3-unit FPDs were made separate from their retainer. Posts and cores were made of the same gold alloys (Degudent U, Degussa) used for the retainers and pontics. No posts and cores made with a direct buildup technique were included in this study. Additional parapulpal pins to increase retention were never used. All retentive surfaces of the restorations were sandblasted (50 μm) prior to cementation. All 3-unit FPDs were cemented with the same zinc phosphate cement (Harvard, Richmond Harvard) under the same strict conditions. The study was approved by the Ethics Committee of University Hospital, Ghent, Belgium.

Methods

All patients were offered a regular supportive maintenance program on a 6-month basis. The purpose of these maintenance sessions was extensively described in a previous report.[15] Only patients who agreed to attend the supportive maintenance program were evaluated, as long as they were present on a regular basis. The

survival rate was calculated using the Kaplan-Meier method.[16] Failures were divided into biologic or technical/patient-related failures and into reversible or irreversible complications. Caries, periodontal problems, fracture of the abutment tooth, and endodontic problems were biologic failures. Loss of retention, fracture of the framework, and removal of the FPDs for extension of a new fixed partial restoration were technical/patient-related failures. Failures were defined as irreversible complications if the FPD or a tooth were lost and as reversible complications if recementation following loss of retention or endodontic treatment/fillings on an abutment tooth was performed with the FPD still intact. An FPD may have had a reversible complication but ended up in the surviving group at last evaluation, or it may have had a reversible complication followed by an irreversible complication, thus ending up in the failing group.

Statistical Analysis

The survival rates were calculated using the Kaplan-Meier method.[16] The log-rank test was used to discover whether some survival functions differed between groups.[17] Statistical significance of differences was calculated using the chi-square test. The significance level was set at $\alpha = .05$.

Results

Descriptive Data

The 134 investigated FPDs represent 81% of the total number of FPDs made for 98 patients. The mean survival follow-up time was 11.6 years (range: 2.8 to 24.7). Table 1 shows the distribution of all the 3-unit FPDs. In the maxilla, 1 FPD was placed in the anterior region (incisors to canine) and 56 FPDs were placed in the posterior region (canine to molars). In the mandible, 12 FPDs were located in the anterior region and 65 FPDs in the posterior region. The antagonist was natural dentition in 57.1% of the patients, an FPD in 37.8%, and a complete denture or an edentulous space in 5.1%.

Of the group with at least 1 root canal–treated (RCT) abutment, 76.1% (n = 51) had 1 RCT abutment and 23.9% (n = 16) had 2 RCT abutments. Regarding the number of prostheses, 70.4% (n = 69) of patients received one 3-unit FPD, 24.5% (n = 24) received two 3-unit FPDs, 3.1% (n = 3) received three 3-unit FPDs, and 2.0% (n = 2) received four 3-unit FPDs.

Only 15.7% (n = 21) of the FPDs placed in this investigated group failed, and 19.4% of the patients had 1 or 2 failing FPDs. Two patients (10.5%) had 2 failing FPDs, while 17 patients (89.5%) had only 1 failing FPD. Complications were not more likely in any particular patient.

Table 1 Distribution of 3-Unit FPDs in the Maxilla and Mandible for FPDs in the Vital and RCT Groups

	Vital (%)	RCT (%)	Total
Maxilla	33 (49.3)	24 (37.3)	57
Mandible	34 (50.7)	43 (62.7)	77
Total	67	67	134 (100)

Kaplan-Meier Survival Curves

The Kaplan-Meier survival rate of all restorations was 95.1% after 5 years, 88.8% after 10 years, 77.8% after 15 years, and 73.1% after 20 years.

Figures 1a to 1c show the Kaplan-Meier survival curves for the vital and RCT groups overall and in the maxilla and mandible. For the overall estimation (Fig 1a), there was no statistically significant difference (log-rank $P = .108$) between the vital and RCT groups after 20 years of function. The survival rate for the vital group was 94.9% after 5 years, 90.2% after 10 years, and 83.2% after 15 and 20 years. For the RCT group, the survival rate was 95.2% after 5 years, 84.9% after 10 years, 76.1% after 15 years, and 60.5% after 20 years. Regarding the survival rates in the maxilla (Fig 1b), there was no significant difference between the groups ($P = .670$). The survival rate for the vital group in the maxilla was 93.5% after 5 years, 88.9% after 10 years, and 70.2% after 15 and 20 years. For the RCT group in the maxilla, the survival rate was 100% after 5 years, 88.2% after 10 years, 63.0% after 15 years, and 47.3% after 20 years. Regarding the survival estimation for the mandible (Fig 1c), there was a significant difference between the groups ($P = .036$). The survival rate for the vital group in the mandible was 100% after 5 years and 96.3% after 10, 15, and 20 years. For the RCT group in the mandible, the survival rate was 92.5% after 5 years, 83.1% after 10 years, 76.2% after 15 years, and 69.3% after 20 years.

Figures 2a to 2c show the Kaplan-Meier survival curves of the maxilla and the mandible overall and for the vital and RCT groups. For the overall estimation (Fig 2a), there was no statistically significant difference ($P = .236$) between the vital and RCT groups after 20 years of function. The survival rate in the maxilla was 96.2% after 5 years, 88.8% after 10 years, 68.1% after 15 years, and 62.5% after 20 years. In the mandible, the survival rate was 95.7% after 5 years, 88.9% after 10 years, 85.4% after 15 years, and 81.6% after 20 years. The survival estimation for the vital group (Fig 2b) between the maxilla and the mandible was significantly different ($P = .045$). These survival rates were already mentioned above. Regarding the survival estimation for

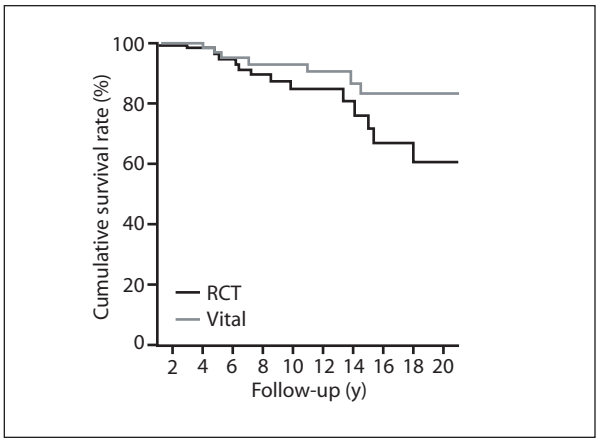

Fig 1a Kaplan-Meier survival curves for the vital and RCT groups overall ($P = .108$).

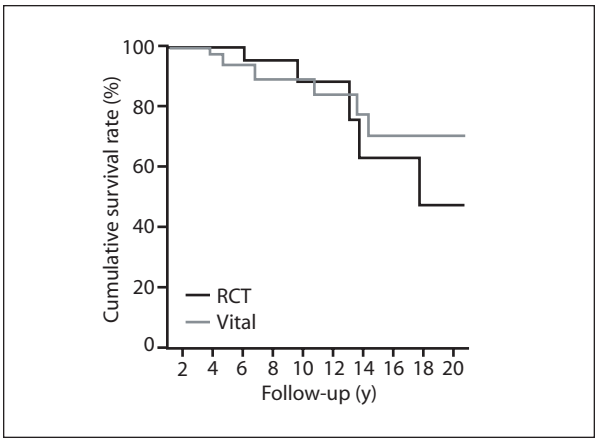

Fig 1b Kaplan-Meier survival curves for the vital and RCT groups in the maxilla ($P = .670$).

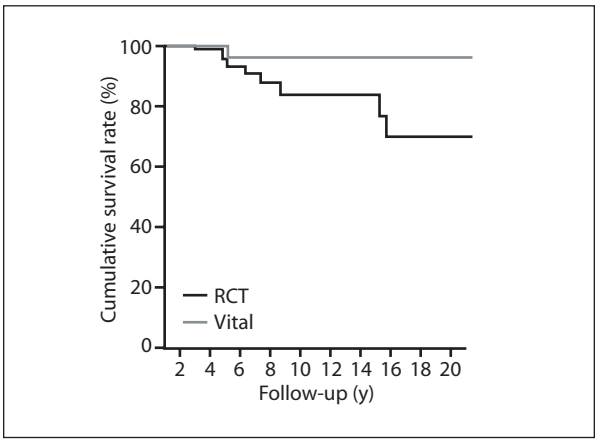

Fig 1c Kaplan-Meier survival curves for the vital and RCT groups in the mandible ($P = .036$).

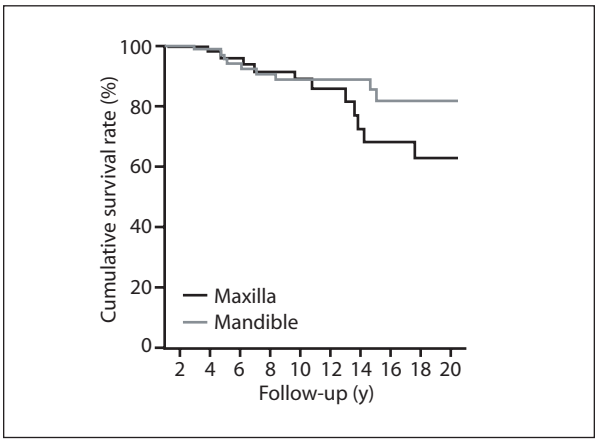

Fig 2a Kaplan-Meier survival curves for the maxilla and mandible overall ($P = .236$).

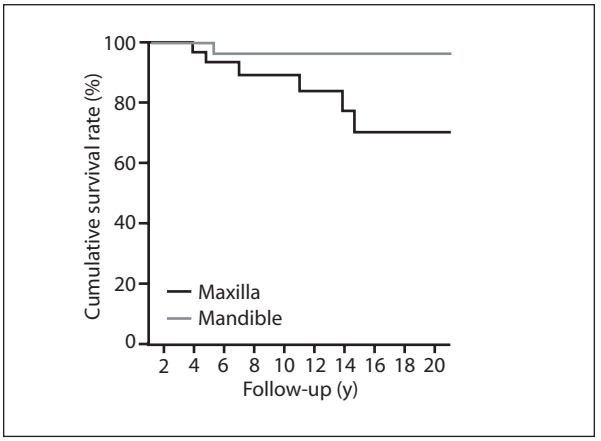

Fig 2b Kaplan-Meier survival curves for the maxilla and mandible in the vital group ($P = .045$).

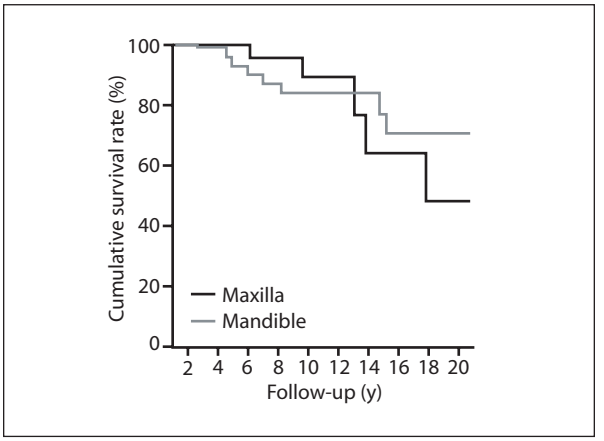

Fig 2c Kaplan-Meier survival curves for the maxilla and mandible in the RCT group ($P = .885$).

Table 2 Twenty-Year Survival Rates (%) in the Maxilla and Mandible Between the Vital and RCT Groups

	Vital	RCT	*P*
Maxilla	70.2	47.3	.670
Mandible	96.3	69.3	.036
P	.045	.885	

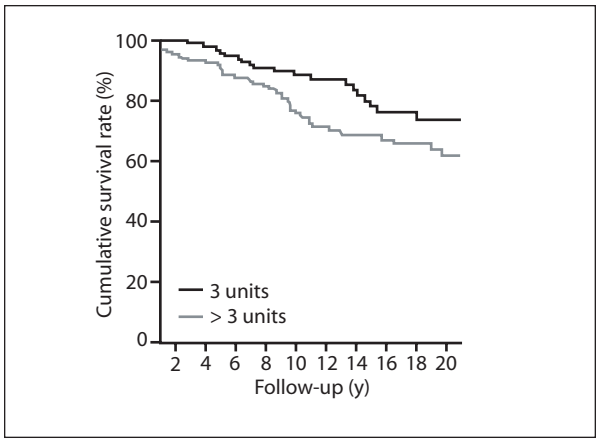

Fig 3 *(right)* Kaplan-Meier survival curves for the 3-unit FPDs and FPDs with more than 3 units ($P = .026$).

the RCT group (Fig 2c), no significant differences were found between the maxilla and mandible ($P = .885$). These survival rates were already mentioned above. Table 2 summarizes the results of Figs 1b and 1c and 2b and 2c, showing a statistically significant difference for the vital group in the mandible.

Figure 3 displays the Kaplan-Meier survival curves of the 3-unit FPDs and the FPDs with more than 3 units. The survival estimation for the 3-unit FPDs compared to the more-than-3-unit group was significantly different ($P = .026$). For the latter group (> 3 units), the survival rate was 89.7% after 5 years, 76.1% after 10 years, 67.3%, after 15 years, and 61.5% after 20 years.

Reasons for Failure

The main reason for an irreversible complication was caries (38.1% of failures). Loss of retention caused 9.5% of failures. In 14.3%, both caries and loss of retention were observed. The mean survival time for this group (61.9%) of irreversible complications was 11.4 years. Fracture of the framework accounted for 9.5% of failures, and abutment fracture occurred in 4.8%. Periodontal and apical problems each represented 4.8% of the failures. In 9.5%, the FPDs had to be removed for the extension of a new FPD. In 4.8%, the reason for failure was unknown.

Table 3 presents a cross-tabulation of the surviving restorations versus the failing restorations, with reversible complications as the dependent variable. In the surviving group, only 7.1% had a reversible complication. In the failing group, 14.3% had a reversible complication. There was a borderline nonsignificant difference ($P = .076$). These reversible complications were divided into an early reversible complication group (failure within 2 years) and a late reversible complication group (failure occurring after 2 years). For the failing restorations, the mean survival time of the early reversible complication group was 8 years, while the mean survival time of the late reversible complication group was 15 years, with a borderline nonsignificant difference ($P = .059$).

Table 3 Cross-Tabulation of Surviving Restorations Versus Failed Restorations, with Reversible Complications as the Dependent Variable*

	Reversible complications (%)		
	No	Yes	Total
Surviving	105 (92.9)	8 (7.1)	113
Failed	18 (85.7)	3 (14.3)	21

*$P = .076$.

Discussion

The aim of the present study was to evaluate the survival of conventional 3-unit FPDs and determine the frequencies and causes of failures, to compare these results to other single-tooth replacement treatment options. Results on cantilevered FPDs were not included, because combining research groups of 2 different treatment modalities would give a misrepresented picture of the results. The survival of single-tooth replacement treatment procedures can only be compared with general survival studies of FPDs[8,9,15,18–25] and meta-analyses of FPDs.[12–14] In the survival studies, only functional life spans or life spans before failure of 3- and 4-unit FPDs were mentioned. No other topics were addressed. Most of the authors pooled the 3- and 4-unit FPDs in their results,[6–10] but drew different conclusions. Only 1 survey[9] mentioned survival rates of 2 population groups: one with 92.2% after 10 years and 86.8% after 12 years for a pooled 3- and 4-unit group, with results derived from private

practices; and another with 90.0% after 8 years for 3- and 4-unit FPDs, with results extracted from insurance documents. Other failure-related studies[6,7,10,11] mentioned average life spans before failure from 5.7 years to 12.3 years, in 3-unit FPDs or pooled 3- and 4-unit FPDs. In this survey of conventional 3-unit FPDs, the survival rate was 95.1% after 5 years, 88.8% after 10 years, 77.8% after 15 years, and 73.1% after 20 years. This positive result would be even higher if the lost FPDs in which the FPDs were removed for the extension of a new FPD (9.5%) were not taken into consideration.

In the current study, the survival rates of 3-unit FPDs and FPDs with more than 3 units were significantly different. Most of the studies[7,9–11,18] found no relationship between the duration of service of the FPD and the number of units. Reuter and Brose[19] concluded that a tendency for failures appeared to be associated with longer FPDs. Only 2 surveys[6,15] found a clear relationship between the life span and the number of units in an FPD (short span versus long span).

In this study population, no statistically significant difference was found between the overall survival in the maxilla and mandible. This is in agreement with most of the general studies.[8,15,20] Subdividing this overall group into vital and RCT groups revealed a significant difference between the vital group in the maxilla (70.2%) and the mandible (96.3%) after 20 years. Both groups were equally distributed, and the distribution between anterior and posterior regions was comparable. For the RCT group, there was no statistically significant difference. These results are confirmed by the same authors in another survival study of FPDs.[15] All retentive surfaces of the restorations were sandblasted prior to cementation. All 3-unit FPDs were cemented with the same zinc phosphate cement under the same strict conditions.

The overall survival of restorations in the vital group compared with the RCT group revealed no significant difference after 20 years of function. Thus, the use of a nonvital abutment does not lead to significantly more failures of the FPDs. These results are comparable with some reported data,[21,26] different but without statistical confirmation from others,[20,22] and statistically different from a few studies.[18,23,24] Subdividing this overall group into the maxilla and mandible, a significant difference in the mandible was found between the vital (96.3%) and RCT (69.3%) groups after 20 years. In the maxilla, no statistical difference was found. These results are confirmed by the same authors in another survival study of FPDs.[15] FPDs in the mandible in the vital group performed significantly better than both FPDs in the maxilla from the same group and FPDs in the mandible from the RCT group. A 3-unit FPD without RCT abutments in the mandible had the smallest number of irreversible complications.

While mechanical problems are, in general, more directly under the influence of the clinician, biologic problems are less easily controlled and in some instances are unrelated to the prosthetic treatment. Biologic problems may be a consequence of the treatment procedures (pulpal problems) or influenced by the form and gingival relation of the restorations (secondary caries, gingivitis, or periodontal destruction). In a previous publication,[15] the authors hypothesized that when more abutment teeth were used to replace an equal number of missing teeth (ie, a lower pontic/abutment ratio), the higher the percentage of retention loss would be, sometimes in combination with a lower percentage of caries. In the current study, all FPDs had only 2 abutments (instead of 3 or 4) replacing 1 missing tooth. The failure rates attributed to caries (38.1%) and loss of retention (9.5%) could confirm this hypothesis. Comparing these results with previously published results[15] on FPDs with more units in function but a high pontic/abutment ratio, the percentages for caries (22.2%) and loss of retention (15.3%) still confirm this hypothesis. This result was comparable with the results of other studies that show caries as the main cause of failure.[5,15,22,24–28] Comparing these results with those of a study by Palmqvist and Swartz[20]—and most studies based on the Swedish National Dental Insurance Program[31–33] (except Randow et al[27])—on FPDs with more abutments in function for an equal number of missing teeth, loss of retention was found to be the main cause (50%) of failure. If caries was detected, it was assumed to be a secondary problem caused by the loose retainer. Further information on the minimum height of the abutments and the taper of the preparation would be an interesting topic for further investigations of the long-term survival. Zidan and Ferguson[34] concluded that the difference in retention of crowns was significant between a 6-degree or 12-degree taper and a 24-degree taper. It remains difficult to differentiate these complications from each other.

In the present study, failure was divided into 2 groups: irreversible and reversible complications. In previous studies,[15,35] the occurrence of a reversible complication had a predictive value for irreversible complications later on. In the current study, the mean survival time of the early ($<$ 2 years) reversible complication group was 8 years, while the mean survival time of the late ($>$ 2 years) reversible complication group was 15 years ($P = .059$). In this study group, the results barely missed statistical significance, because of a lack of power in this part of the study. Nevertheless, this result is still an indication that the occurrence of a reversible complication seems to have a predictive value for an irreversible complication later on.

Conclusions

The survival rate of conventional 3-unit FPDs after 20 years is 73.1%, which was significantly different from FPDs with more than 3 units. For the 3-unit group overall, there was no significant difference between survival in the maxilla and in the mandible, or in the vital versus RCT groups. There was no significant difference for the 3-unit group in the maxilla between the vital and RCT groups, or for the 3-unit RCT group between the maxilla and the mandible. There was a significant difference for the 3-unit group in the mandible between the vital and the RCT groups, and for the 3-unit vital group between the maxilla and mandible. The most common reason for an irreversible complication was caries (38.1%). Loss of retention caused 9.5% of failures. A 3-unit FPD without RCT abutments in the posterior region of the mandible was the fixed restoration with the smallest number of irreversible complications. There is an indication that the occurrence of a reversible complication seems to have a predictive value for an irreversible complication later on. A reversible complication within the first 2 years will probably lead to an early irreversible complication, with a mean survival rate of 8 years.

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