Clinical Performance of Cast Clasp-Retained Removable Partial Dentures: A Retrospective Study

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Purpose: This retrospective study investigated the survival rate of 174 clasp-retained removable partial dentures (CR-RPDs) made at the Department of Prosthodontics of the Regensburg University Medical Center over a 25-year period (1984 to 2009). ***Materials and Methods:*** The study analyzed the frequency of and time to the fracture of clasps, connectors, or denture bases; the occurrence of caries or periodontal lesions; the loss of abutment teeth; and the necessity of maintenance procedures such as relining or treatment of pressure areas. ***Results:*** The median follow-up time of 3 years was calculated using the inverse Kaplan-Meier method. The 5-year survival rate (time to renewal) of all CR-RPDs was 96.4%; the 10-year survival rate was 89.8%. Fractures most frequently occurred in clasps (n = 28, 16.1%) followed by major connectors (n = 9, 5.1%) and minor connectors (n = 6, 3.4%). The 5-year event-free rate for clasp fracture was 80.4%; the 10-year event-free rate was 76.9%. Caries lesions on abutment teeth were seen in 31.6% of patients, and 35.6% showed inflammation of the periodontal tissue surrounding the abutment teeth. The 5-year event-free rate for caries was 58.4%; the 10-year rate was 39.6%. A frequent complication was loss of abutment teeth (n = 15), but this complication was not age-dependent. After insertion of their prostheses, one-third of patients (n = 53, 30.5%) showed pressure areas of the mucosa. Significantly more ($P < .001$) pressure areas were caused by prostheses of the mandible (39.6%) than by those of the maxilla (12.5%). ***Conclusions:*** CR-RPDs showed a survival rate of approximately 90% after 10 years of oral service. The predominant complications during oral service were caries lesions, loss of abutment teeth, and fracture of clasps. *Int J Prosthodont 2012;25:138–144.*

Cobalt-chromium alloy to cast clasp-retained removable partial dentures (CR-RPDs) was first used by Erdle and Prange in 1932.[1] The denture base, major and minor connectors, and clasps of RPDs were made into a functional unit in one working cycle (Figs 1 and 2).[2] In the 1950s, the company Ney published a brochure entitled "Planned Partials" that described guidelines for constructing systematically cast claps or connectors of removable prostheses.[3] Over the following decades, cast CR-RPDs became a standard treatment procedure worldwide for replacing missing teeth for millions of patients. Although CR-RPDs represent a standard reconstruction, only a few articles report on the clinical outcomes.[4–6]

Many different CR-RPD design principles that have been published[7–12] are more often based on clinical experience than on scientific evidence. Therefore, various guidelines are available for constructing the basic elements of cast CR-RPDs. However, long-term observations or evidence-based reports on CR-RPDs are missing. This study aimed at narrowing this gap by evaluating retrospective data on CR-RPDs. The frequency of and time until facture of clasps, connectors, or denture bases are reported. Additionally, complications were investigated, such as caries of the abutment teeth or repair of the artificial acrylic resin teeth. Furthermore, the focus was set on maintenance procedures such as relining or treatment of pressure areas, which may be necessary to keep a denture in service. Finally, the survival rate of CR-RPDs was calculated.

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Fig 1 Maxillary CR-RPD.

Fig 2 Bonwill clasp of a mandibular CR-RPD.

Materials and Methods

A search tool for dental software (HighDent Plus, Koblenz) generated 220 cast CR-RPDs[9] inserted at the Department of Prosthodontics of the Regensburg University Medical Center, Regensburg, Germany, between 1984 and 2009. Excluded were cases with incomplete records as well as cases with an observation period of less than 6 months. If a patient had received CR-RPDs in both arches, only the first prosthesis mentioned in the record was considered for the investigation. This exclusion was necessary so that each prosthesis could be considered a statistically independent case. Thus, 174 patients remained in this investigation: 75 (43.1%) were women, 99 (56.9%) were men. The mean age of patients was 62 ± 12 years.

Based on clinical records, the authors analyzed the frequency and time from the date of prosthesis insertion to the time of occurrence of an event, eg, fracture of a clasp. Whenever more than one event was reported in the records, the first occurrence mentioned was chosen for statistical evaluation. Events included renewal of the entire denture, reline, pressure area of the mucosa, fracture of a clasp, fracture of major or minor connectors, acrylic resin denture base fracture, or loss of artificial teeth. Furthermore, caries or recurrent caries of the abutment teeth or periodontitis of the abutments were evaluated. Recurrent caries was diagnosed using metal probes, a caries detector (GC), or both. A case was rated as having periodontitis when the historic clinical data stated a Bleeding Index value or any treatment typically conducted in cases of periodontitis.

All CR-RPDs were made according to the design recommendations of Spiekermann and Gruendler published in 1977.[12] One hundred sixty-nine (97.1%) prostheses were cast using cobalt-chromium alloy, 3 (1.7%) were made of noble alloys, and 2 (1.1%) of titanium. Fifty-eight (33.3%) maxillary and 116 (66.7%) mandibular dentures were investigated. Figure 3 lists the distribution of the supporting dentition according to the Eichner Index (Class A to C).[13] The Eichner Index characterizes the decay of dentition according to the loss of occlusal support zones. Class A of the index contains four occlusal support zones, which means that at least one tooth is in contact between the maxilla and mandible in both the premolar and molar areas on each side. Class B involves three (B1), two (B2), or one (B3) support zones in the premolar and molar areas or support in the anterior area only (B4). Eichner Class C shows no antagonist occlusal contacts in the dentition. Table 1 provides the distribution of Eichner classification for the 174 subjects included in the study sample.

Statistical Analysis

Survival times of the prostheses were estimated by means of the Kaplan-Meier analysis.[14–16] Survival was defined as the time interval between the date of prosthesis insertion and the date of renewal from any cause. A case was rated termination due to failure (event) when a denture lost its function and a new one had to be made. Prostheses were not replaced until their last observation had been classified as censored. A few patients had several events, but only the interval to the first event mentioned in the record was used for analysis. Univariate Cox regression analysis determined the impact of the covariate "age of the patient" for the event "loss of abutment teeth." Because of the small number of cases with increasing observation times and the small event rate, other covariates, eg, connector fracture, were not analyzed using Cox regression.

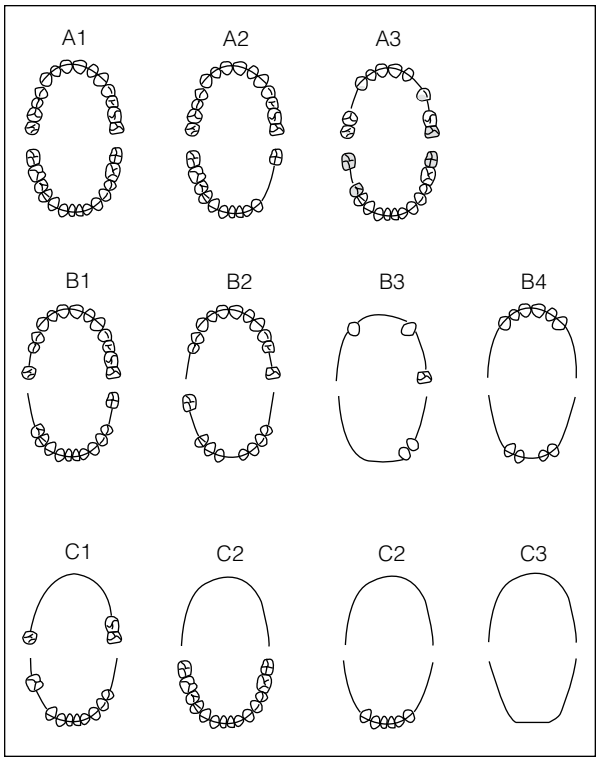

Table 1 Distribution of Eichner Classification for the Study Sample

Eichner class	n	%
A3	13	7.5
B1	30	17.2
B2	37	21.3
B3	36	20.7
B4	3	1.7
C1	35	20.1
C2	20	11.5
Total	174	100.0

Fig 3 *(left)* Eichner classification of dentition decay according to occlusal support zones (Class A to C, see text for description). (Reprinted from Eichner et al[13] with permission.)

Example: First year interval

$f_1 = \Sigma TTE_{\text{first year}} = ET_{\text{cases with event}}$
$F_1 = \Sigma TTC_{\text{first year}} + n_{\text{remaining cases after 1 year}} \times 12 = ET_{\text{cases without event in first year}}$
d_1 = no. of events in first year

Total exposure during the first year for all patients = $f_1 + F_1$

Hazard rate: $\lambda_1 = \frac{d_1}{(f_1 + F_1)}$ (ie, the risk of having an event in 1 month under the condition of being event-free at the beginning of this month for the first year).

$\lambda_1 \times 12$ is the hazard rate on an annual basis for the first year

Fig 4 Calculation of the hazard rate (λ) on an annual basis. TTE = time to event (in months); TTC = time to censoring (in months); ET = exposure time (in months).

Because clinicians should also know the period of time to the development of clinical or technical complications of a reconstruction, the 5-year event-free rate was calculated for the events renewal of the entire denture; reline; pressure area of the mucosa; fracture of a clasp, major connectors, minor connectors, or acrylic resin denture base; loss of artificial teeth; caries or recurrent caries of the abutment teeth; and periodontitis by means of Kaplan-Meier analysis.

The hazard rate (λ)[16] was estimated on an annual basis within specific time intervals by dividing the total survival period into time segments, counting the number of events during the time segment, and dividing the number of events by the number of patients at risk during that segment (Fig 4).

Data entry and all calculations were done using the software package SPSS 17.0 (IBM). All reported *P* values were two-sided, and a *P* value of .05 was set as the threshold for statistical significance. Since this investigation was an exploratory study, no adjustments were made for multiple testing.[14–16]

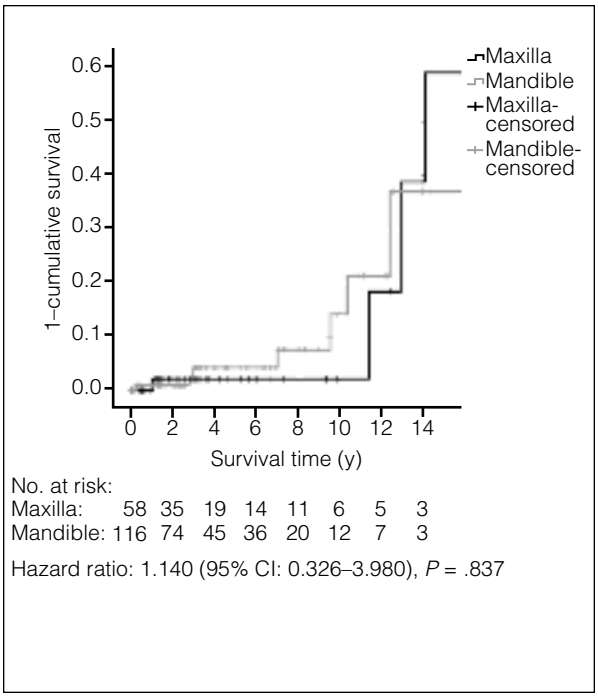

Fig 5 One minus the cumulative survival for CR-RPDs of the maxilla and mandible to the event "renewal of the prosthesis."

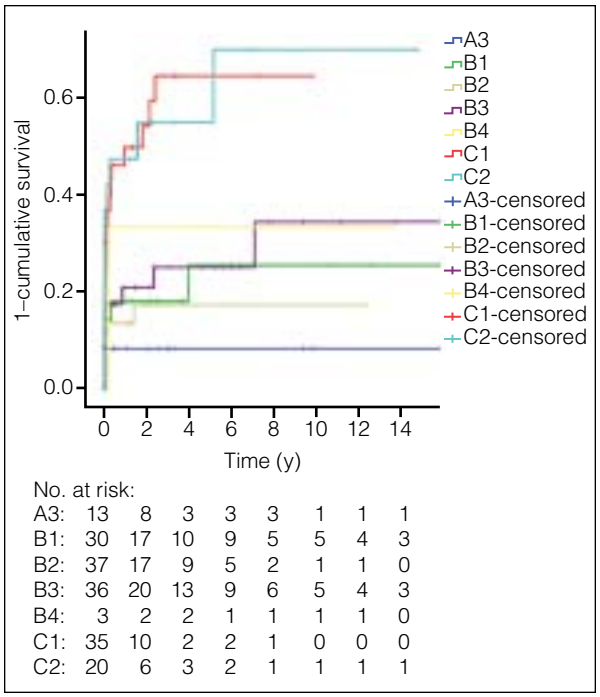

Fig 6 One minus the cumulative survival for CR-RPDs of the maxilla and mandible to the event "pressure area" according to the Eichner Index of dentures.

Results

Survival Rate

The median follow-up time of 3 years was calculated using the inverse Kaplan-Meier method. The 5-year survival rate (time to renewal) of all CR-RPDs was 96.4%; the 10-year survival rate was 89.8%. No differences were found between prostheses in the maxilla and mandible (Fig 5).

Maintenance Procedures

After prosthesis insertion, one-third of patients (n = 53, 30.5%) noted pressure areas of the mucosa. Women and men were affected equally. According to log-rank analysis, prostheses of the mandible showed significantly greater event rates of pressure areas than those of the maxilla ($P < .001$). Pressure areas most often were noted during the first 12 months after prosthesis delivery. Prostheses with reduced occlusal supporting zones, such as Eichner Class C1 or C2, resulted in pressure areas significantly more often than Class B1 to B4 or A3 prostheses ($P < .001$) (Fig 6 and Table 2). The overall 5-year event-free rates for pressure area were 84.4% in the maxilla and 56.8% in the mandible. The 10-year event-free rates were 84.4% and 50.1%, respectively.

Table 2 Pairwise Comparisons of the Occurence of Pressure Areas According to the Eichner Index[13]

	A3	B1	B2	B3	B4
C1	$P = .006$	$P = .003$	$P = .001$	$P = .006$	$P = .367$
C2	$P = .008$	$P = .008$	$P = .002$	$P = .011$	$P = .384$

For 18.3% (n = 32) of patients, a reline of the acrylic resin denture base was necessary. The log-rank test did not show any statistically significant differences between maxillary or mandibular prostheses ($P = .235$) (Fig 7). The demand for reline procedures was equally frequent for women and men. Reline procedures were continuously required during the oral service of prostheses.

Fractures

Fractures occurred during the observation period. Fractures occurred most frequently in clasps (Fig 8) (n = 28, 16.1%) followed by major connectors (n = 9, 5.1%; maxilla: n = 4, mandible: n = 5) and minor connectors (n = 6, 3.4%). The 5-year event-free rate for clasp fracture was 80.4%; it was 76.9% for 10 years. Minor or major connector fractures did not have

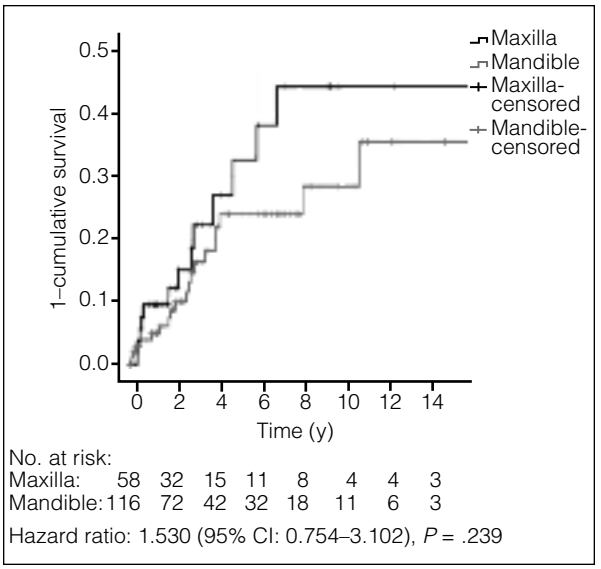

Fig 7 One minus the cumulative survival for CR-RPDs of the maxilla and mandible to the event "reline."

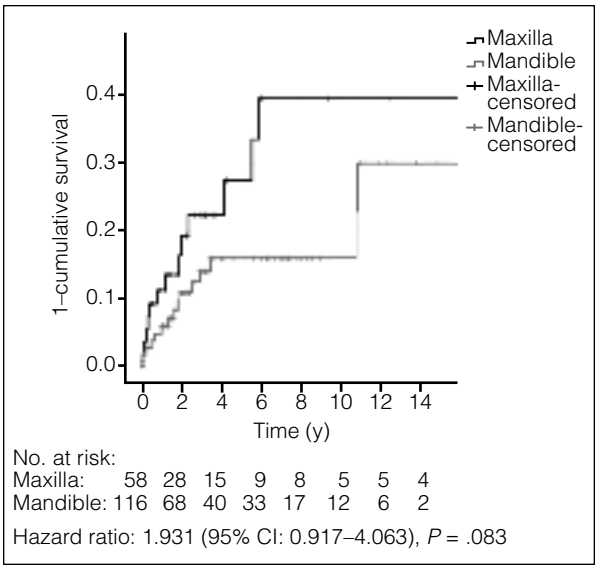

Fig 8 One minus the cumulative survival for CR-RPDs of the maxilla and mandible to the event "clasp fracture."

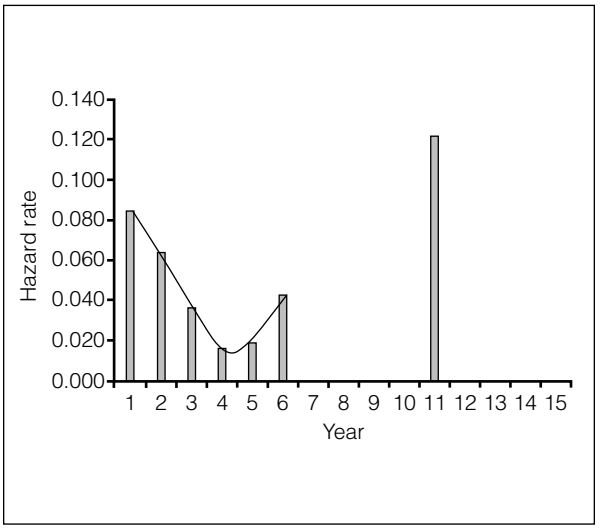

Fig 9 Hazard rate of clasp fracture on an annual basis. The hazard rate in the first year was 0.084, which means that approximately 8 of 100 person-years of exposure showed clasp fracture.

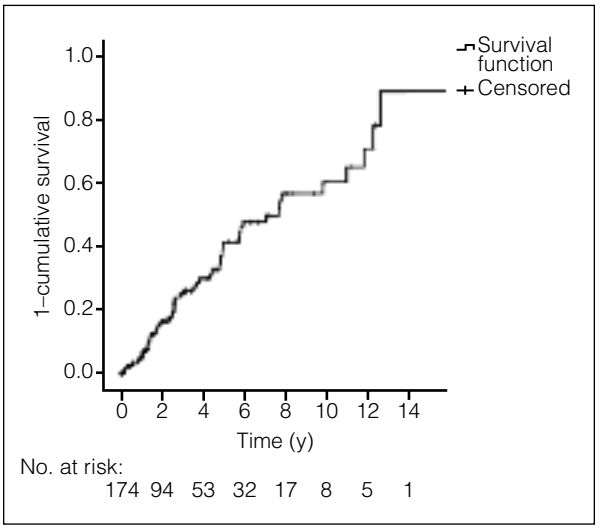

Fig 10 One minus cumulative survival for CR-RPDs to the event "caries lesion."

5- and 10-year event-free rates calculated because of the small number of events. The annual hazard rate of clasp fractures in the first year was 0.084, ie, 8 of 100 person-years of exposure showed clasp fracture (Fig 9). In the following years, the hazard rate dropped to 0.064 and 0.036, and to 0.016 in the fourth year. Then, the hazard rate slightly increased to 0.019 in the fifth year and to 0.043 in the sixth year.

Artificial acrylic resin teeth were lost in 4.6% (n = 8) of cases. Six patients (3.4%) showed considerable wear of acrylic resin teeth, which were replaced.

Biologic Complications

Caries lesions on abutment teeth were seen in 31.6% of patients (Fig 10), and 35.6% showed inflammation of the periodontal tissues surrounding the abutment teeth. No differences were found between sexes, locations (maxilla or mandible), age groups, or among the groups of the Eichner Index. Caries lesions continuously occurred throughout the entire observation period. The 5- and 10-year event-free rates for caries were 58.4% and 39.6%, respectively.

A frequent complication was loss of abutment teeth (n = 15, 8.6%). The 5- and 10-year event-free rates for loss of abutment teeth were 88% and 80.7%, respectively. The Cox regression analysis showed that loss of abutment teeth was slightly age-dependent ($P = .047$). However, a hazard ratio of 0.987 (95% confidence interval: 0.973 to 1.000) indicated a negligible impact of age on the event "loss of abutment teeth."

Discussion

A retrospective study has some disadvantages since the quality of its data is based on the quality of the clinical records available. After denture insertion, every patient was advised to attend a follow-up appointment at least once a year; however, not all patients followed this advice.

The clinicians participating in this study varied with regard to their education levels as well as their opinions on how to treat a patient in a specific situation. Such biases may be reduced by designing a treatment protocol. In this study, all CR-RPDs were made according to the design and treatment recommendations given by Spiekermann and Gruendler.[12] Their book describes step-by-step chairside and laboratory procedures to construct and insert cast CR-RPDs.

A further limitation of this study is the low number of patients and the steadily decreasing number of patients at risk during the observation period, which limits the use of statistical methods. For example, after 10 years, only 18 patients were still at risk.

On the other hand, Kelly[17] emphasized that randomized controlled trials may not always be the most adequate study design when treatment outcomes are not primarily patient-based.[17] Here, stratified cohort designs may be more realistic. These concerns extend to studies for which controls are difficult to define or for which the placebo effect should be ruled out. For instance, for a study investigating the impact of a drug, the randomized controlled trial design should be the first choice. However, treatment effects in dentistry are often related to materials or reconstructions, hence retrospective studies are justified.[17]

CR-RPDs are meant to have a high incidence of loss of abutment teeth, caries defects, or periodontal diseases of the abutment teeth and often show fractures of clasps or artificial teeth. Therefore, CR-RPDs are said to lose their function after a relatively short period of service.[4–6,18,19] In this study, the 5-year survival rate (time to renewal) of all CR-RPDs was 96.4%; the 10-year survival rate was 89.8%. Grundström et al reported that after an 8-year follow-up, 42% of prostheses were still in use.[6] The main reason for the termination of use was dislike of the denture by the patient. Bergman et al[5] found 65% of RPDs still in service after 25 years (in this study, it was approximately 50.4%), and Carlsson et al[4] found the number to be approximately 37% (calculated on the data given) after 13 years. These studies only showed a few cases that were at risk during follow-up, but it is not clear how many prostheses were available at a specific time interval. Since most studies included more than one denture per patient in their statistical analysis, no statistical independence of the considered cases existed. Furthermore, the studies did not use statistical methods such as Kaplan-Meier analysis. Therefore, no reliable data are available for comparing survival rates of CR-RPDs.

Clinical investigations involving CR-RPDs have reported a high frequency of damage to the oral tissue.[4–6,19] Such damage is likely to be attributed to increased plaque accumulation or excessive nonaxially distributed occlusal loading forces of the abutment teeth.[11,19] Specific clasp and connector designs with undercuts may be responsible for easier plaque accumulation at abutment teeth than on teeth not covered by prostheses.[10–12,18,19] Therefore, more than one-third of patients in this study showed caries lesions or periodontal diseases. Unfortunately, the data did not allow a more detailed specification of the periodontal alterations. Only 58.4% of patients were free of caries lesions after 5 years, and only 39.6% after 10 years. Bergman et al showed comparable results after 10 years of observation.[5] They found 45.8% of tooth surfaces without any caries lesions, and Carlsson et al[4] reported 43% of patients without caries lesions after 13 years of wearing prostheses (calculated based on data given in the tables). In this study, caries did not occur in correlation with factors such as sex, location (maxilla or mandible), age group, or the Eichner Index. This study did not support the opinion that CR-RPDs per se will cause caries lesions. The authors agree with Bergman et al's statement that "with carefully planned prosthetic treatment and adequate checks on oral and denture hygiene, little or no damage will be caused to the remaining teeth."[5]

Lack of oral hygiene and health care management may be the cause of loss of abutment teeth for elderly patients. However, the risk of loss of abutment teeth of CR-RPDs only slightly correlated with age. This result was in agreement with the frequencies of caries or periodontal lesions, which were also found to be age-independent.

Clinical records showed a high number of maintenance procedures necessary during oral service. Pressure areas are typical for removable prostheses. Not surprisingly, this study found more pressure areas in the mandible as well as a significant correlation

between reduced abutment supporting zones of the denture and the occurrence of pressure areas.

The frequency of clasp fractures in this study (16.1%) was remarkable, whereas fractures of the minor or major connectors, the denture base, or acrylic resin teeth were rare (< 5%). After 10 years of service, 23.1% of patients had at least one clasp fracture. Grundström et al reported clasp fracture as the most common technical complication of CR-RPDs.[6] However, no further data regarding clasp fractures were found in the literature. Carlsson et al only mentioned that 8 of 22 prostheses were repaired during 13 years of observation.[4] On the other hand, some authors conducted finite element analyses[20] or yield strength tests[21] to analyze the fatigue behavior of cast clasps; this analysis indicated that retainer fracture seemed to be a clinical issue. Reasons for the frequent fractures could be the clasp design,[11] the undersized cross section,[20–22] or misfit between the rest seat and the prepared rest seat caused by casting shrinkage.[22] The data of this study failed to clarify the true reason for the fracture.

Conclusions

The 10-year survival rate (time to renewal) of all CR-RPDs was approximately 90%. However, one-third of patients showed caries or periodontal lesions. The loss of abutment teeth increased with age. Typical technical complications of CR-RPDs included clasp fracture, which was found in 16.1% of patients. Other complications, such as fracture of connectors and denture bases or loss of acrylic resin teeth, were rare.

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