Clinical Performance of Cements as Luting Agents for Telescopic Double Crown–Retained Removable Partial and Complete Overdentures

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Purpose: The aim of this study was to investigate the survival rates and technical failures of removable prostheses (RPs) supported by telescopic double crown (TDC)–retained abutment teeth luted with zinc-phosphate or glass-ionomer cement. ***Materials and Methods:*** Clinical records of 577 patients (288 women, 289 men) who received 577 TDC-retained RPs supported by 1,807 abutments at the Department of Prosthodontics of the University Hospital Regensburg, Regensburg, Germany, between 1984 and 2007 were analyzed. The 577 prostheses included 200 attached to telescopic crowns with friction fit (FFs), 62 to conical crowns (CCs), and 315 to parallel-sided telescopic crowns with clearance fit (CFs). Survival probabilities were evaluated for the RPs, loss of cementation of the inner copings, secondary caries, and abutment teeth that required endodontic treatment using the Kaplan-Meier method. A Cox regression analysis determined the impact of covariates such as sex, denture location (maxilla/mandible), Eichner classification, number of abutment teeth, and the type of double crown system used. ***Results***: The 10-year survival probability was 98.8% ± 0.09% for FFs, 92.9% ± 0.41% for CCs, and 86.6% ± 0.05% for CFs. During the observation period, loss of cementation was frequently observed (FFs: 32%, CCs: 53.2%, CFs: 21.3%). After 15 years, more than 75% of patients had experienced at least one "loss of cementation" event. In this respect, zinc-oxide phosphate and glass-ionomer cements did not show any significant difference. ***Conclusion:*** The long-term successful outcome of the RP experience was not compromised, although numerous clinical visits were required for maintenance. The predominant maintenance procedure was the need for recementation of the inner copings. *Int J Prosthodont 2009;22:479–487.*

Removable prostheses (RPs) retained by telescopic double crown (TDC) abutments have been extensively prescribed in spite of the limited literature on their efficacy and effectiveness. In fact, published reports seem to have only focused on the dentures' survival probability.[1–4] During their functional life span, RPs are likely to undergo various maintenance procedures, such as replacement of abutment teeth, relining, treatment of caries lesions, replacement of lost facings of abutment teeth, replacement of fractured artificial teeth, or repair of entire prosthesis components.[3,5] One of the most frequently occurring maintenance procedures is loss of cementation of the inner copings with loss of cementation of the primary crowns, reported for more than 20% of patients.[3,5] Loss of cementation has been suggested as one of the most frequent technical failures of double crown–retained prostheses, although no investigation has evaluated the potential risks of loss of cementation when different types of cement or double crowns are used. The hypothesis of this study was that cementation failure of inner copings, secondary caries lesions, or loss of abutment teeth are influenced by the type of cement and type of double crowns used (telescopic crowns with or without frictional fit, conical crowns, or clearance fit [Fig 1]), as well as by the construction and size of the denture base (Fig 2).

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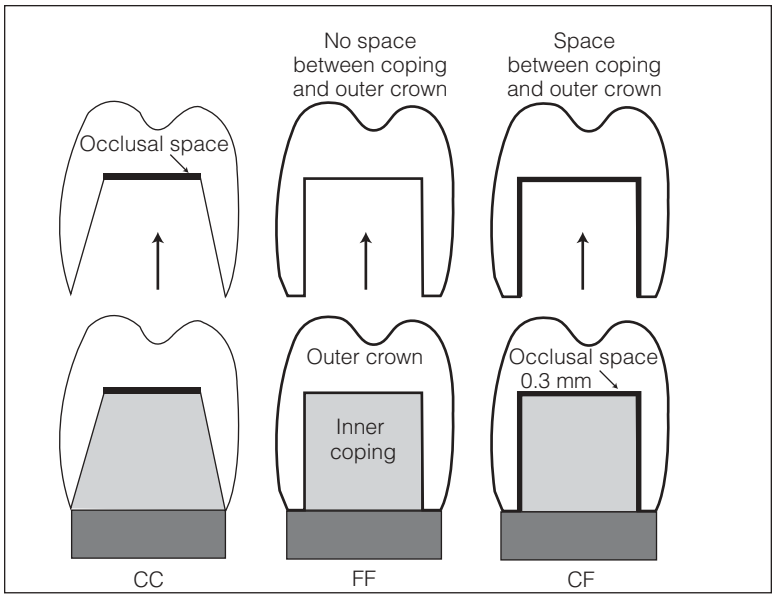

Fig1 Types of double crowns used. Double crowns consist of a luted inner coping (primary crown) and a removable outer crown. Conical crowns (CCs) are retained by wedging and friction fit crowns (FFs) by friction forces between the parallel-sided inner and outer crown. The resistant force against removal should be 5 to 10 N. Clearance fit double crowns (CFs) have a tiny space between both crowns, allowing a smooth gliding between the inner and outer crown without any retention.

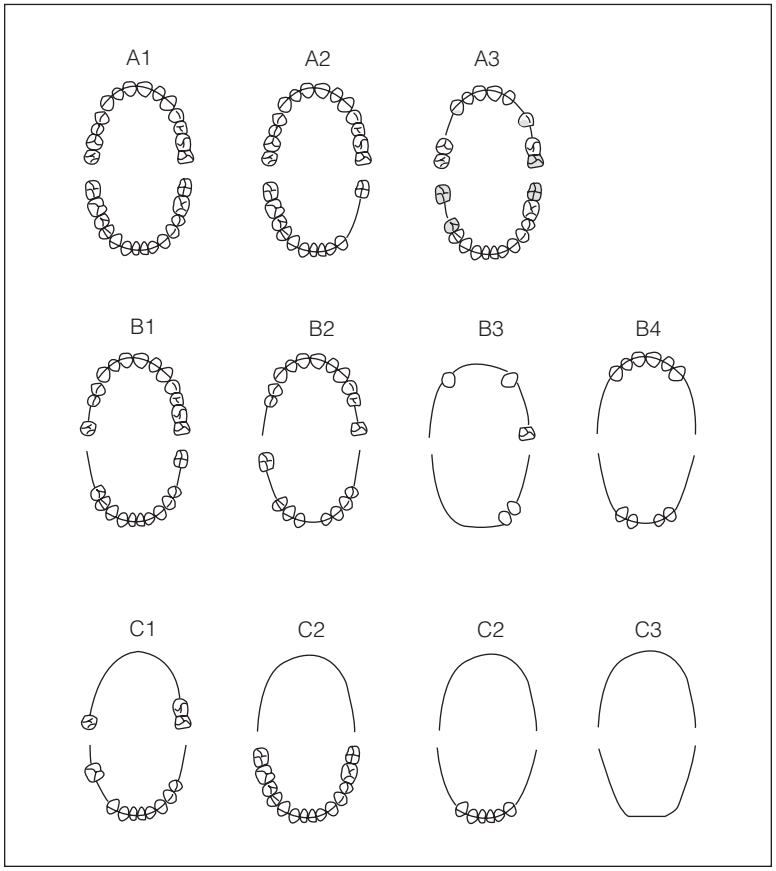

Fig 2 Classifications by Eichner. Class A of the Eichner index contains four occlusal support zones, which means that at least one tooth is in contact between the maxilla and mandible in both bilateral premolar and molar areas. Class B involves three (B1), two (B2), or one (B3) support zones, or support in the anterior area only (B4). Eichner class C shows no opposing occlusal contacts in the dentition. (From Jüde HD, Kühl W, Roßbach A. Einführung in die Zahnärztliche Prothetik, ed 2. Köln, Germany: Dt. Ärzteverlag, 1979:132. Reproduced with permission.)

Materials and Methods

The clinical records of 577 patients (288 females, 289 males) who had received 577 RPs retained by 1,807 TDC abutments (Figs 3a to 3e) at the Department of Prosthodontics of the University Hospital Regensburg, Regensburg, Germany, between 1984 and 2007 were studied. Only patients with complete and accessible data from the department's treatment pool were included in the study. Consequently, 34 patients were excluded from the original total of 611 patients. Maxillary RPs were made for 291 patients and the mandibular

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Fig 3a Removable partial denture (RPD) of the maxilla fixed by five telescopic double crowns *(arrows)*.

Fig 3b View inside the outer crowns of a mandibular RPD.

Fig 3c Complete mandibular overdenture with three telescopic crowns *(arrows)*.

Fig 3d View inside the outer crowns and denture base of a mandibular overdenture.

Fig 3e Example of an inner coping of telescopic double crowns.

Table 1 Distribution of Type of Telescoping Double Crown–Retaining Systems Related to the Number of Abutments

No. of abutments	Parallel-sided telescopic crowns with friction fit	Parallel-sided telescopic crowns with clearance fit	Conical crowns with friction fit
1	–	65	–
2	25	103	4
3	55	100	16
4	69	31	22
5	34	13	10
6	10	3	6
7	6	–	3
8	1	–	1

Table 2 Eichner Classification of Dentures (Maxilla/Mandible)

Eichner classification	Telescopic crowns with friction fit	Telescopic crowns with clearance fit	Conical crowns	Total
A3	1/0	–	1/0	2/0
B1	8/7	–	1/2	9/9
B2	24/22	3/1	5/9	32/32
B3	25/25	40/10	9/8	74/43
B4	39/33	79/40	8/6	126/79
C1	0/1	35/25	–	35/26
C2	0/15	12/70	1/12	13/97
Total	97/103	169/146	25/37	291/286

ones numbered 286. Telescopic crowns with friction fit (FFs) helped retain 200 RPs, 62 RPs were retained by conical crowns (CCs), and 315 by parallel-sided telescopic crowns with clearance fit (CFs). Altogether, 1,807 abutment teeth were evaluated. Table 1 provides an overview of the number of abutment teeth per double crown–retaining system; Table 2 lists the distribution of the Eichner classification (A through C)[6] for both treated arches and types of abutments selected. The Eichner index characterizes the status of a dentition according to the loss of occlusal support zones (see Fig 2): class A 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 area on each side; class B involves three (B1), two (B2), or one (B3) support zones, or support in the anterior area only (B4); class C shows no opposing occlusal contacts.

All prostheses were made by experienced full-time professors according to standardized departmental protocol (Table 3). Only teeth with a sound periodontal ligament and tooth mobility of grade 1 or less were selected for FFs or CCs. Complete overdentures (Figs 3c and 3d) were made whenever a periodontally

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Table 3 Treatment Protocol

	FFs	CFs	CCs
Indication	RPD with sound periodontal ligament of abutment teeth	RPD with up to 3 remaining teeth in a dental arch with damaged periodontal ligament	RPD with sound periodontal ligament of abutment teeth
Double crown preparation	6-deg taper if possible, chamfer finish line	6-deg taper if possible, chamfer finish line	6-deg taper if possible, chamfer finish line
Core build-up material	Glass ionomer for small decay, composite for greater decay (> 1/3 of the tooth substance)	Glass ionomer for small decay, composite for greater decay (> 1/3 of the tooth substance)	Glass ionomer for small decay, composite for greater decay (> 1/3 of the tooth substance)
Impression	Polyether or silicone	Polyether or silicone	Polyether or silicone
Double crown construction	Precious alloy, Degussa milling machine	Precious alloy, Degussa milling machine	Precious alloy, Degussa milling machine
Denture base connectors	Cobalt-chromium alloy	Cobalt-chromium alloy	Cobalt-chromium alloy
Outer crown-denture base connector	Until 1999 soldering, then tribo-chemical silica coating and gluing	Mechanical retention, tribochemical coating silica and gluing	Until 1999 soldering, then tribochemical silica coating and gluing
Facing material of double crowns	Tribochemical silica coating, composite veneering material	Tribochemical silica coating, composite veneering material	Tribochemical silica coating, composite veneering material
Replaced teeth	Acrylic resin teeth	Acrylic resin teeth	Acrylic resin teeth
Luting procedure	Dry using cotton rolls, clean abutment teeth with a slurry of pumice powder, clean inner surface of inner crowns using alcohol, insulate inner and outer crowns using Vaseline, inner copings individually cemented with subsequent placement of denture	Dry using cotton rolls, clean abutment teeth with a slurry of pumice powder, clean inner surface of inner crowns using alcohol, insulate inner and outer crowns using Vaseline, inner copings individually cemented with subsequent placement of denture	Dry using cotton rolls, clean abutment teeth with a slurry of pumice powder, clean inner surface of inner crowns using alcohol, insulatie inner and outer crowns using Vaseline, inner copings individually cemented with subsequent placement of denture

FFs = telescopic crowns with friction fit; CFs = telescopic crowns with clearance fit; CCs = conical crowns; RPD = removable partial denture.

compromised tooth mobility higher than grade 1 was present in at least one abutment tooth. This protocol was also followed whenever an unfavorable distribution of the abutment teeth in a dental arch was encountered. A space of about 0.3 mm (presumed to simulate the amount of mucosal resiliency encountered when the unsupported denture parts are compressed during occlusal load application) was created between the outer crown and inner coping. The only task of the TDCs in a complete overdenture is to stabilize it against horizontal loading. The retention against vertical force is achieved in the same way as for conventional complete dentures. This design is presumed to facilitate a patient's transition to an eventual complete denture wearing experience.

Abutment teeth were prepared using diamond burs, with an objective of less than a 6-degree taper to achieve retention for the inner copings. All double crowns were made of precious alloys in certified dental laboratories. Double crowns were fabricated according to the protocols provided by Böttger and Gründler[7] for telescopic crowns and Körber[8] for CCs (see Fig 1). The framework of the denture base consisted of a stellite alloy. Secondary crowns and the metal denture base were fixed by soldering or adhesive fixation (Figs 3a and 3b). The marginal soft tissues surrounding the abutments remained free of immediate prosthesis contact irrespective of whether the dentures were retained by FFs or CCs. In contrast, dentures covered the marginal periodontium if CFs were inserted (Figs 3c and 3d).

Denture extensions or saddles were made of methacrylate copolymer resin base material. The replaced teeth were acrylic resin denture teeth, while facings for double crowns in the anterior area were made of laboratory composite resins. RPs of patients with complete dentures in the opposing arch were designed to respect the bilaterally balanced occlusal concept, whereas all others were provided with cuspid guidance.

Inner copings were mainly luted conventionally by using either zinc oxide phosphate or glass-ionomer cement. Table 4 depicts the distribution of luting agents used.

Statistical Analysis

Using Kaplan-Meier analysis,[9,10] survival probabilities were evaluated for dentures, loss of cementation of the inner copings, and abutment teeth that required endodontic treatment. Statistical differences between the subgroup levels were determined using the log-rank test ($\alpha = .05$).

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Table 4 Distribution of Luting Agents Related to the Double Crown System

Luting agent	Parallel-sided telescopic crowns with friction fit	Parallel-sided telescopic crowns with clearance fit	Conical crowns with friction fit
Zinc oxide phosphate (Harvard, Richter & Hoffmann)	111	179	41
Glass ionomer (Ketac-Cem, 3M ESPE)	70	97	13
Zinc oxide–eugenol (TempBond, Kerr Dental)	3	5	4
Self-adhesive composite cement (RelyX Unicem, 3M ESPE)	1	3	–
Other	14	31	4

Overall Survival Rate of Dentures

A case was rated "termination due to failure" when a denture lost its function and a new one had to be fabricated. Those dentures that were not replaced or failed at their final examination were classified as censored. This examination included dentures with maintenance treatments such as repair of the denture body or facings, recementation, relining, or enlargement of the denture because of loss of abutments.

Probability of Loss of Cementation

With respect to the survival of the cementation of the inner copings, a case was rated "termination due to failure" if recementation of at least one inner coping became necessary. In a few cases, this event occurred several times. However, only the first event was considered for risk analysis. The probability of loss of cementation was calculated for the following subgroups: *(1)* different types of double crowns (FFs, CCs, and CFs), *(2)* different Eichner classifications, and *(3)* the number of artificial teeth.

A Cox regression analysis[11] determined the impact of covariates such as sex, denture location (maxilla/mandible), Eichner classification, number of abutment teeth, and type of double crown system used (FF, CF, or CC). Subcategories involving fewer than 10 cases were excluded.

Probability of Requiring Endodontic Treatment

Endodontic treatment of abutment teeth may become necessary if secondary caries lesions or pulp damage caused by trauma during the cementation procedure occur. Glass ionomer is claimed to protect teeth from secondary caries by releasing fluoride. Furthermore, in contrast to the highly acidic reaction of zinc oxide phosphate cements, glass ionomer should protect the dental pulp against acidic trauma during cement setting. Therefore, Kaplan-Meier estimation was assessed using cement type as a subgroup. A case was rated "termination due to failure" if endodontic treatment of at least one inner coping became necessary.[9–11]

Results

TDC-retained dentures demonstrated a 10-year survival probability of 98.8% ± 0.09% for FFs, 92.9% ± 0.41% for CCs, and 86.6% ± 0.05% for CFs (Fig 4). During the study period, loss of cementation occurred frequently and was noted for all three systems of double crowns (FFs: 32%, CCs: 53.2%, CFs: 21.3%). After 15 years, more than 75% of patients were expected to have had at least one loss of cementation (Fig 5). Zinc-oxide and glass-ionomer cements did not show any significant differences with regard to loss of cementation events in FFs (Fig 6), CFs (Fig 7), or CCs (Fig 8). Only crowns fixed with zinc oxide–eugenol cement (Temp Bond) showed higher rates of debonding (Fig 6). The Cox regression analysis (Table 5) demonstrated that the covariates sex, type of double crown, number of abutment teeth, maxilla or mandible, Eichner classification, or the opposing occlusion concept had no impact on loss of cementation influenced only by the type of cement. A significant influence could only be calculated for zinc oxide phosphate cement (Table 5).

Endodontic treatment was required by 13.9% of double crowns luted with zinc oxide phosphate and 10.9% of double crowns luted with glass ionomer. Secondary caries lesions were found in 9.8% of double crowns cemented with zinc oxide phosphate and in 8.5% of double crowns cemented with glass ionomer. Using Kaplan-Meier estimation, the probability of secondary caries lesions after 10 years was 16.4% for zinc oxide phosphate and 13.5% for glass-ionomer cement (Fig 9). The log-rank test showed no significant differences ($P = .733$). The probability for requiring endodontic treatment after 10 years was 81.6% for zinc oxide phosphate and 87.2% for glass-ionomer cement (Fig 10). No statistical differences were found (log-rank test: $P = .124$).

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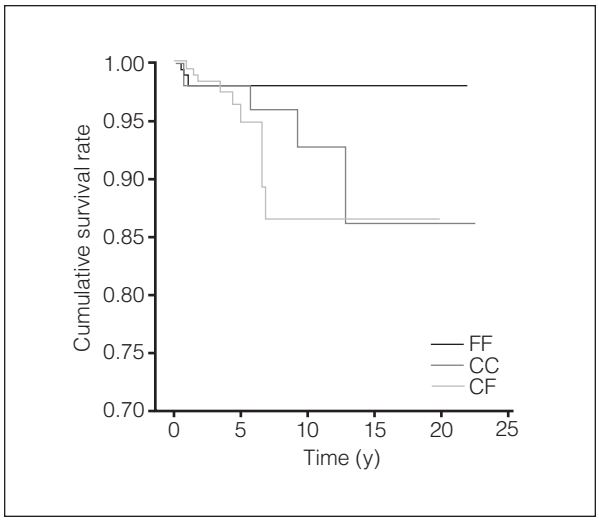

Fig 4 Kaplan-Meier survival curve for all dentures (n = 577). FF = telescopic crown with friction fit; CC = conical crown; CF = telescopic crown with clearance fit.

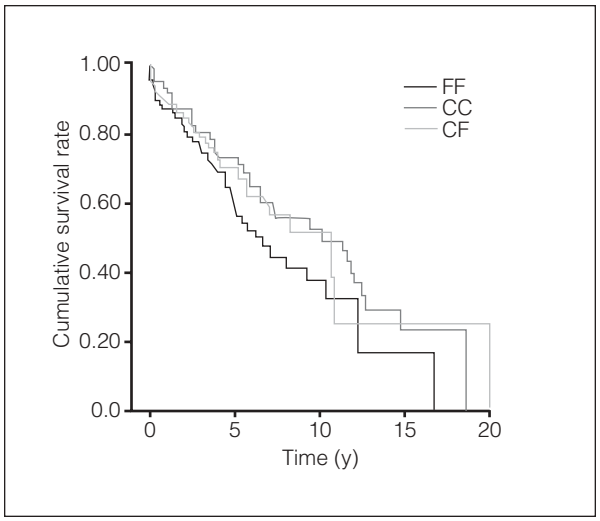

Fig 5 Kaplan-Meier curve for the event "loss of cementation" (n = 577). FF = telescopic crown with friction fit; CC = conical crown; CF = telescopic crown with clearance fit.

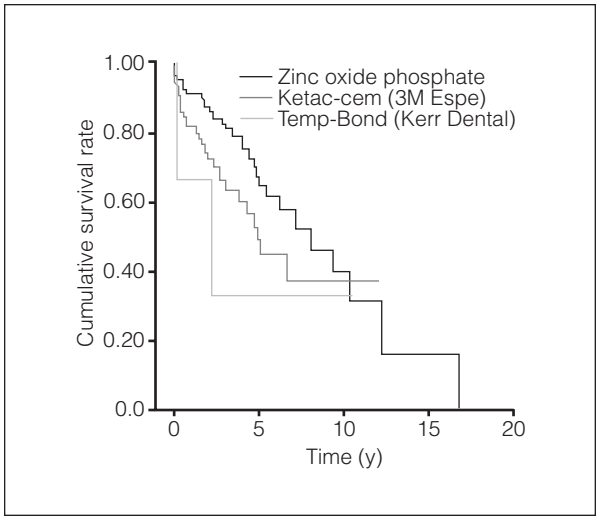

Fig 6 Kaplan-Meier estimation of double crowns with friction fit. Event: loss of cementation (n = 200), log-rank test: $P = .03$.

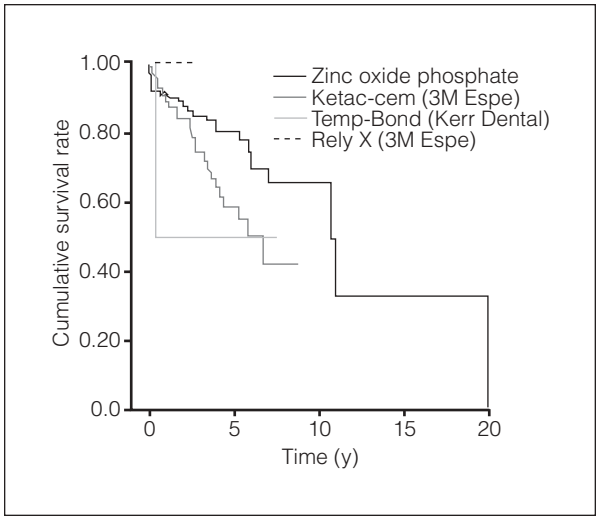

Fig 7 Kaplan-Meier estimation of double crowns with clearance fit (cover denture). Event: loss of cementation (n = 315), log-rank test: $P = .012$.

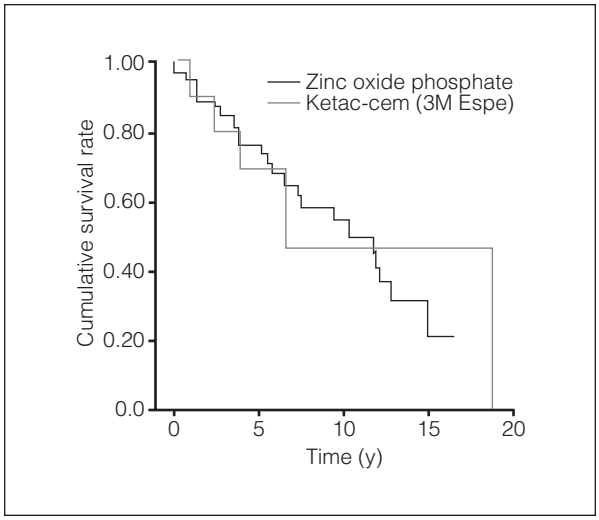

Fig 8 Kaplan-Meier estimation of conical double crowns. Event: loss of cementation (n = 62), log-rank test: $P = .051$.

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Table 5 Results of Cox Regression Analysis for Type of Cement

	B	SE	Wald	*df*	Significance	Exp (B)*	95% CI
Sex	.080	.161	.247	1	.619	1.084	.790–1.487
Type of double crown	.020	.028	.493	1	.483	.981	.928–1.036
Cement			17.429	5	.004		
Zinc-phospate cement	−1.299	.523	6.177	1	.013	.273	.098–.951
Glass-ionomer cement	−.807	.53	2.324	1	.127	.446	.158–1.259
Number of abutment teeth	.029	.068	.181	1	.670	1.029	.901–1.176
Maxilla/mandible	.182	.160	1.303	1	.254	1.200	.878–1.640
Eichner classification	−.070	.094	.560	1	.454	1.073	.983–1.289
Opposite occlusal concept	−.080	.175	.211	1	.646	.923	.655–1.300

*The hazard rate for a unit increase in the covariate. For example, an additional abutment tooth increased the hazard rate for the event "loss of retention" by 2.9%.

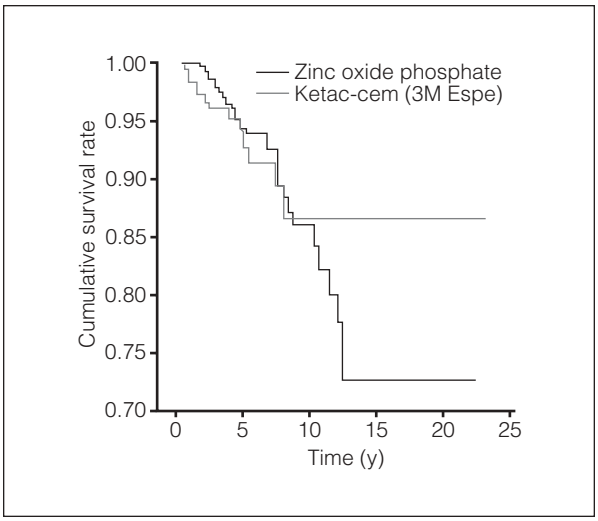

Fig 9 Kaplan-Meier curve of the event "secondary caries lesions" for all dentures (n = 577). Log-rank test: $P = .733$.

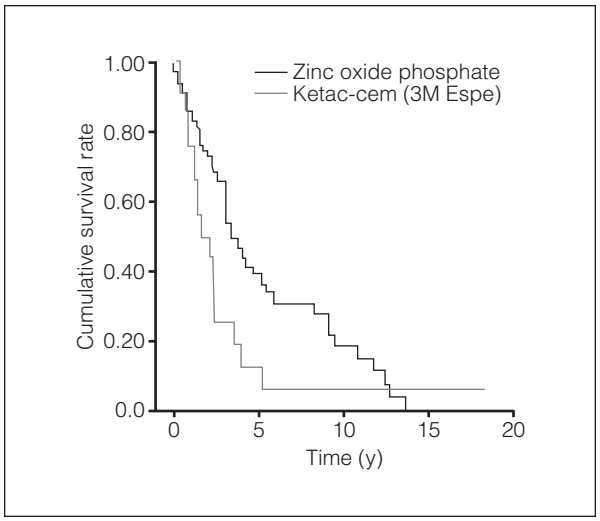

Fig 10 Kaplan-Meier curve of the event "requiring endodontic treatment" for all dentures (n = 577). Log-rank test: $P = .124$.

Discussion

Study Design

The presumed and reported clinical advantages of TDC-retained dentures have been reported, although only a few publications include rigorous clinical long-term data for more than 10 years.[3] Consequently, this retrospective study offers a limited perspective because it is based on data that already exist and does not conform to today's standard of evidence-based clinical outcome trials. It does however offer valuable insight into the clinical behavior of an ingenious technique and a scope for designing future longitudinal studies, especially ones of a comparative nature. For example, the time-dependent difference between telescopic and conical crown efficacy and effectiveness outcomes as related to the required power for a sample of scrupulously followed patients cannot be ascertained with this particular study design. However, this study focuses on a comparison of loss of cementation events, which in this case occurred frequently in either retentive design system. Another focus was a comparison between the clinical performance of zinc oxide phosphate and glass-ionomer cements in TDC-retained dentures. Moreover, the use of a standard treatment protocol for the construction of the dentures and the continuous calibration between the investigators provided a high degree of reproducibility. An additional weakness of this study is the lack of recording of rigorous periodontal parameters for each patient, which may have been useful in evaluating the clinical performance of luting agents.

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Data Interpretation

One overview about the survival rates of TDC-retained dentures is given by Wenz et al,[2] who reported rates between 71% and 85% after 10 years. However, a comparison of the data proves difficult because of the variety of study designs used and the different definitions of the term "survival." This study defines survival as the period of time the denture was worn by a patient, independent of technical or clinical events necessary to maintain the denture's function. In this study, survival rates ranged from 86.6% for CFs up to 92.8% for CCs and 98.9% for FFs. The rate for CFs is lower because the clinical indication for this type of denture is given for abutment teeth with compromised prognoses. Usually, patients with complete overdentures have fewer than four diametrically distributed teeth on the alveolar arch with a mobility higher than grade 1 or a reduced attachment and a reduced height of the alveolar bone. Therefore, the potential risk of failure is higher in this type of denture, which explains the lower survival rate of the entire reconstruction. No difference in survival rates was found in the literature for CC- or FF-retained dentures.[2] This study calculated a lower survival rate for CCs with increasing observation time. Two reasons may explain this difference. On one hand, the difference may be caused by the bias of this retrospective study, in which the data for FFs and CCs had been collected during different times, and because CCs and FFs had different means in the observation period. On the other hand, FF dentures may be revised to CF dentures if abutment teeth are reduced in number or show tooth mobility higher than grade 1. These factors may prolong the survival rate of FFs in contrast to CC-retained dentures.

During the observation time, many technical failures of double crown–retained prostheses were reported. Typical failures were loss of cementation, secondary caries lesions, or loss of abutment teeth. For CCs, Bergman et al[1] reported an 18% incidence rate of caries lesions (n = 18), a reluting rate of about 30% of the inner copings, and an extraction rate of 7.1% of the former 84 abutments. In a 10-year follow-up of CCs, Igarashi and Goto[12] described secondary caries lesions at a rate of about 10% and an abutment loss of 10%. Loss of cementation was not mentioned in either investigation. Comparable results of FF-retained dentures were noted by Widbom et al,[13] who reported a loss of abutment teeth in 7%, the necessity of endodontic treatment in 6%, and secondary caries lesions in about 10% of patients. However, the most frequent complication was the loss of the inner coping cementation in 16% of patients. Wöstmann et al[3] found a higher retention loss, ie, 20.6%, of the inner copings for FFs. This study did not differentiate between caries lesions, endodontic treatment, or extraction of abutments. Altogether, these events occurred in 15.8% of patients.

Similar reports neither focused on the cementation process nor even mentioned the type of cement used.[1,12] However, the Cox regression analysis in this study showed that the variable "cement" had a significant impact on the high loss of retention rate of the inner copings, in contrast to other variables such as Eichner classification, number of abutment teeth, type of double crown (FF, CC, or CF), maxilla or mandible, and type of opposing dentition. Figure 7 shows that debonding with zinc phosphate and glass ionomer occurs immediately after insertion of the crowns. Inner copings luted with the self-adhesive resin cement RelyX Unicem (3M ESPE) showed no loss of bonding during the first 2.5 years of observation. However, these data are not confident because of the low number of cases and the short observation time.

Conventional zinc-phosphate and glass-ionomer cements are expected to show different results in the long-term. The former is described as highly soluble with poor mechanical properties and it may harm the pulp by acid setting reactions.[14] In contrast, glass-ionomer cement is marketed as protecting teeth by releasing fluoride, having a lower acidic setting reaction, less solubility, and better mechanical properties.[14,15] However, reports on their efficacy for single crowns suggest that their long-term luting effectiveness differences may not be significant. Moreover, the presumed special effect of the fluoride content of glass ionomer is far from robustly documented.[16]

Conclusion

Within the limitations of this report's design and duration, it can be stated that the number of necessary maintenance procedures for the described clinical technique was significant. However, most of the observed failures could be rectified so that the construction of a new denture was necessary for only a few patients. Therefore, the long-term performance of TDC-retained removable dentures was not significantly impeded by technical complications. On the other hand, both conventional cements used—zinc phosphate and glass ionomer—may be responsible for the significant number of loss of cementation events of the inner copings. Cements with a better retention performance are recommended for luting double crowns, independent of the friction fit concept used.

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Literature Abstract

Case-control study of human papillomavirus and oropharyngeal cancer

The purpose of this case-control nested longitudinal cohort study was to determine if exposure to human papillomavirus (HPV) is associated with increased oropharyngeal cancer. Three hundred eligible subjects were recruited; subjects were either newly diagnosed with oropharyngeal squamous cell carcinoma (n = 100) or had no history of cancer at the same clinic with benign conditions (n = 200). Two benign patients were matched according to sex and 5-year age group to each case patient. All patients took a computer-assisted survey to obtain background information including demographics, medical history, and lifestyle habits (drugs, alcohol, sexual history, oral care routine). Available tumor specimens were collected from case patients. Samples from benign patients were collected using an oral saline rinse and the aid of a cytology brush. Formalin-fixed or paraffin-embedded tumor specimens were analyzed with in situ hybridization and stained for the presence of HPV-16. Oral mucosal specimens and fresh-frozen tumor DNA were purified and analyzed for 37 types of HPV using multiplex PCR assay. The presence of HPV-16 was determined with the use of a real time PCR assay that targeted the E6 coding region. Demographic and lifestyle data were compared. Odds ratios and confidence intervals (CIs) were calculated using unconditional multivariate logistic regression. Biologically relevant variables were kept in the model and variables of interest were eliminated one by one to create the multivariate models. Results of this study suggest that having a high lifetime number of sexual partners ($\geq$ 26) or oral sexual partners ($\geq$ 6) is associated with an increased prevalence of oropharyngeal squamous cell cancer (odds ratio: 3.1 and 3.4; 95% CI: 1.5 to 6.5 and 1.3 to 8.8, respectively). Results show a trend that suggests that the higher the number of vaginal and oral sexual partners, the greater the association with oropharyngeal cancer (P = .002 and P = .009, respectively). The authors suggest that HPV vaccination for boys and continuing to administer it to girls may reduce the incidence of oropharyngeal cancer.

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