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Survival time of cast post and cores: A 10-year retrospective study

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ABSTRACT

Objectives: The aim of this retrospective, longitudinal study was to examine the survival time of custom-fabricated, cast post and cores and to evaluate, which covariates influence the risk of failures over a period of up to 10 years based on a large patient collective.

Methods: The files of 565 patients, who had been fitted with a total of 802 custom-fabricated, cast post and cores using a standardised technique, were analysed. The following parameters were used in the evaluation: age of the post and cores, fabrication technique (direct, indirect), type of prosthetic restoration, location (upper, lower jaw), type of tooth (anterior, premolar, molar), number of root posts, luting material, post and core alloy and cause of failure. The survival probability was assessed using Kaplan–Meyer analysis. Cox regression was used to assess the risk of failure and identify possible covariates.

Results: The average survival time of the post and cores was 7.3 years. The cumulative failure rate was 11.2%. The most common complication was loss of retention of the post and cores. High-gold-content posts had a lower risk of failure than posts made from semi-precious alloy. The type of restoration fitted had a significant influence on the survival probability.

Conclusions: Post and cores custom-fabricated using a standardised fabrication technique have a good long-term prognosis. The most common cause of failure is loss of retention. The durability of posts with low friction at the try-in stage cannot be compensated for by using glass ionomer cement as the luting material.

1. Introduction

Prosthetic restoration of a root-filled tooth frequently requires preprosthetic treatment of the remaining tooth structure prior to fitting the permanent restoration. The reason for this is, that in general a root-filled tooth will already have considerable coronal hard-tissue defects before root filling [1] and the tooth structure is further reduced by the actual root canal treatment (preparation of access cavity, exposing the canals, preparing the canals).[2] The preprosthetic treatment of a root-filled tooth consists primarily of rebuilding lost tooth structure using an alloplastic material to provide a preparation with adequate frictional surfaces for retaining a crown or bridge. [1,3–6] If the remaining tooth structure is inadequate for permanent retention of a direct core build-up material, a root post must be used for retaining the core.[7–9] For this purpose, a prefabricated root post or an indirect, custom-fabricated post and core can be used. Custom-fabricated, cast post and cores are still regarded as the established technique or gold standard for restoring extensively damaged teeth.[1,10–12] In the basic evaluation of the therapeutic value of post and core treatment, survival time is an important parameter.

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Table 1 – Summary of the information from selected studies

Study	Sample size	Total number of posts	Custom made posts	OP	Prosthetic restoration	Statistical analysis used	Failures[a]
Aquilino and Caplan[13]	203	95	n.a.	10 Y	Crowns, no prosthetic restoration	Cox regression Kaplan-Meyer	n.a.
Bergman et al.[14]	96	96	96	6 Y	Crowns, Bridges	Fisher's test	10%
Ellner et al.[20]	50	50	14	10 Y	Crowns	Chi-square	0%
Ferrari et al.[23]	200	200	100	4 Y	Crowns	Actuarial life tables Mautel-Hauszel Comparison	14%
Hatzikyriakos et al.[19]	154	154	44	3 Y	Crowns, Bridges, RPD's	ANOVA	9.1%
Kerschbaum and Imm[22]	129	129	n.a.	5 Y	Crowns, Bridges	n.a.	11.6%
Mentink et al.[12]	516	516	0	10 Y	Crowns, Bridges, RPDs	Kaplan-Meyer	7.5%
Sorensen and Martinoff[7]	1273	1273	245	n.a.	n.a.	n.a.	12.7%
Torbjörner et al.[17]	788	788	456	6 Y	Crowns, Bridges, RPDs, combinations	Life-time method	10.5%
Valderhaug et al.[21]	397	106	106	25 Y	Crowns, Bridges	Kaplan-Meyer	20% failures after 10 y
Weine et al.[38]	138	138	0	10 Y	Onlays, Crowns	n.a.	n.a.

[a] Failures related to the custom made post and cores. OP = observation period. RPDs = removable partial dentures.

Several studies have been published (Table 1), which deal with the survival time of post and cores and of teeth that have been treated with post and cores, respectively.[7,12–23]

The study by Aquillino and Caplan[13] is one of the few studies that attempted to explain to what extent the survival time of root-filled teeth depended on possible covariates with the aid of a Kaplan–Meyer- and Cox regression analysis. The study did not, however, focus on teeth fitted with posts but on a general observation of root-filled teeth and did not differentiate between custom-fabricated and prefabricated post systems in the case of post and cores. A study by Bergman et al.[14] in 1989 has been frequently quoted. Bergman examined the success rate of cast post and cores over 6 years with 96 posts.

The failure rate was established in relation to the type of prosthetic restoration (crown, bridge), type of tooth (anterior, premolar, molar), the jaw (upper, lower) etc. There was a 10% failure rate after 6 years. In their prospective study of 50 posts in 31 patients, Ellner et al.[20] recorded a success rate of 100% for the group with custom-fabricated post and cores with an excellent success probability in the observation period of 10 years. The patient collective was, however, highly selective and had only been treated with single crowns. Ferrari et al.[23] compared in their study custom-fabricated post and cores with fiber posts. After 4 years in service, custom-fabricated post and cores showed a failure rate of 14%. Hatzikyriakos et al.[19] examined the failure rate with 154 post and cores involving prefabricated, screw-retained, custom-fabricated, cemented post and cores under crowns, bridges and removable dentures. The cumulative failure rate was 9.1% for custom-fabricated post and cores after a period of 3 years. The number of cases in each group was, however, too small to draw any further conclusions from the findings. Sorensen and Martinoff [7] examined the failure rate with 1273 root-filled teeth in relation to the postendodontic treatment (no post and core versus different post systems). In this study, the majority of teeth (65.4%) had not been treated with a post and core and only 19.2% had been fitted with a cast post and core. The failure rate recorded for the latter group was 12.7%, but no information was provided about the time in situ. The success rate of two different post designs (paraposts versus custom-fabricated, cast posts) was examined in a 6-year study by Torbjörner et al.[17]. The 456 cast post and cores exhibited a failure rate of 10.5% during the observation period. The study established a relationship between the survival rate of the fitted restoration, the jaw and the type of tooth. In this study, there was no detailed information available about the type of attachment of the removable partial dentures (RPDs), which restricted interpretation of the data in relation to this criterion. In a study, by Valderhaug et al.[21] the periapical status of crowned teeth was examined over a 25-year period.

About 106 of the 397 teeth initially treated were root filled and fitted with cast post and cores. 101 teeth were still able to be checked after the observation period. The failure rate of teeth treated with posts did not differ from that of vital teeth and was 20% after 10 years.

A meta-analysis by Creugers et al.[15] in 1993, a review by Heydecke and Peters[24] in 2001 and a literature review by Torbjörner and Fransson[25] also provide an excellent overview of the existing literature. In his analysis Creugers pointed out that in many publications inadequate information was provided relating to the method and analysis, making a comparison of data difficult or impossible. In the relevant literature there were no clinical studies on cast post and cores based on a large patient collective that used multivariate analysis to examine to what extent the survival rate of cast post and cores depends on the type of prosthetic restoration, while taking into account other covariates.

The aim of this retrospective longitudinal study was therefore to examine the survival time of cast post and cores based on a large patient collective over a period up to 10 years and to identify possible covariates, which affect the risk of failure.

2. Material and methods

This retrospective longitudinal study used patient files of the Department of Prosthetic Dentistry (Dental Clinic, Justus-Liebig-University, Giessen, Germany) to acquire data relevant for the results of the study.

2.1. *Data acquisition*

The data were acquired from the patient files of 604 patients who had been treated with cast post and cores during the period from 1995 to 2004. Patients with serious general or systemic illnesses were not included in the study. Patients, who had post and cores fabricated using a non-precious metal alloy or had the post and core retained with resin-based cement or did not have a permanent prosthetic restoration fitted after insertion of a post, were also excluded because of the small number of cases.

The patient files of the remaining 565 patients were analysed using a standardised case report form in which the following information was recorded for statistical analysis along with general demographic data (age and gender of the patients):

- observation period (date of cementation/date of the final observation)
- status (success/failure)
- in the case of failure (see below for definition): type of failure
- location (upper/lower jaw)
- type of tooth (anterior/premolar/molar)
- type of prosthetic restoration on the post and core (crown/bridge/telescopic crown retained RPDs)
- luting material used (phosphate cement/glass ionomer cement)
- fabrication technique for the post and core (direct/indirect)
- post and core alloy (high-gold-content/semi-precious)
- type of post (post and core with a single root post/sectional post and core with two root posts).

2.2. *Patients population*

About 279 (49.4%) of the 565 patients were male and 286 (50.6 %) were female. The average age of the patients was 50.1 years with a range from 16–89 years. Patients were treated by students in the Department of Prosthetic Dentistry under strict supervision of experienced dentists or by the dentists themselves following a standardised procedure.

2.3. *Post and cores*

Root treatment on teeth to be fitted with post and cores had been carried out a maximum of 3 months before cementation of the posts. After ensuring that the root-filled tooth was prosthetically viable, it was examined clinically (degree of tooth movement, percussion test, probing depth) and radiologically (periapical radiograph) to verify that there were no symptoms before fitting the post and core. The root canal was prepared according to a standardised procedure.[26] The existing root-canal filling was reduced so that a minimum of 3–4 mm root filling material was left in the apical third of the tooth. The length of the post was at least 2/3 that of the root. The root canal was prepared using the ER-Post system (Gebr. Brasseler GmbH, Lemgo, Germany). Any undercuts on the pulp cavity walls in molars and premolars were removed with a finishing diamond. The post and cores (*N* = 802) were fabricated either directly intraorally (*N* = 37) or indirectly in the dental laboratory (*N* = 765) on a stone model. After applying separating agent to the tooth structure intraorally, *direct post and cores* were fabricated using Palavit G (Heraeus Kulzer, Hanau, Germany) and a burnout plastic post and then invested and cast. A one-step putty-wash impression was taken of the prepared root canal for fabricating *indirect post and cores*. Post and cores were waxed up on the high-strength dental stone model. The posts were cast either in a high-gold-content (89%) or semi-precious (11%) alloy to avoid problems with corrosion in the root canal.

Table 2 – Location and type of tooth with post and core

Type of tooth	Upper jaw	Lower jaw	Total
Anterior	35.3	10.6	45.9
Premolar	17.5	17.8	35.3
Molar	7.6	11.2	18.8
Total	60.4	39.6	100.0

Distribution in percent (*N* = 802).

The finished post and cores were permanently cemented in the root canal after try-in and minor adjustments. If in the opinion of the dentist the friction of the post was high during try-in in the root canal, phosphate cement (83.9%) was used for fitting the post: in all other cases the post was inserted using glass ionomer cement (16.1%). The majority of post and cores (*N* = 783) only had single root retention, while 19 sectional post and cores were retained in two roots. Table 2 illustrates the distribution of post and cores for the different types of teeth and jaw. The number of post and cores per patient varied between 1 and 5.

2.4. *Prosthetic treatment*

After cementation of the post and core, the abutment tooth was prepared with a shoulder preparation for fitting the permanent prosthetic restoration using a preparation set according to Marxkors (Gebr. Brasseler GmbH, Lemgo, Germany). The preparation margin was always placed at least 1.5–2 mm apically to the post and core/tooth interface to attain the ferrule effect, which has been proved to reduce the risk of tooth fracture.[1,2,9,25,27–31]

Table 3 – Type of prosthetic restoration after post insertion with regard to the type of tooth in percent (*N* = 802)

Type of Tooth	Type of prosthetic restoration			Total
	Crown	Bridge	Telescopic Crown	
Anterior	18.2	5.6	22.1	45.9
Premolar	20.0	8.6	6.7	35.3
Molar	13.2	5.2	0.4	18.8
Total	51.4	19.4	29.2	100.0

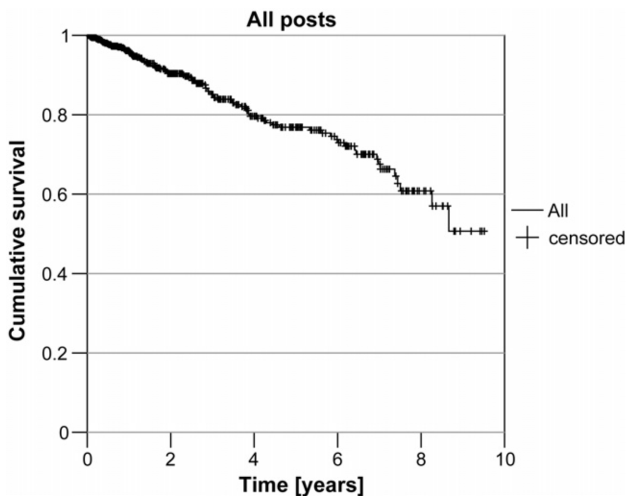

Fig. 1 – Kaplan–Meyer survival-curve for all post and cores (*N* = 802).

The prepared tooth was used as a single abutment for fitting a crown, as a bridge abutment or abutment for fitting a primary crown in the case of telescopic crown retained RPDs (Table 3). The *bridges* were exclusively non-cantilever bridges. The *telescopic crown retained RPDs* were retained on a minimum of two abutment teeth using parallel milled primary crowns.

2.5. *Statistical analysis*

Survival probability was assessed using Kaplan–Meyer analysis.[32] As an event-driven longitudinal procedure, Kaplan–Meyer analysis provides a better means of assessment for determining the survival time than cross-sectional tests.[33] It allows assessment of the survival probability of an object over a given period (*t*).[34] In this study, only those post and cores in which the post was in situ at the final examination *without any adjustments* were rated as ''censored cases'' (=success). In all other cases (loss of retention, tooth fracture, periodontal problems etc.) the post and core was rated as ''termination due to failure'' (= failure), even though the post and core might have been recemented, e.g., in the case of loss of retention. The log rank test ($p = 0.05$) was used to estimate statistically significant differences between two or more survival curves of individual sub-groups (e.g., type of fitted restoration, jaw, type of tooth). A multivariate analysis (Cox regression analysis) was used to evaluate the influence of covariates.

The following influencing variables were defined as categorical covariates:

- jaw
- type of tooth
- type of prosthetic restoration
- luting material
- post and core alloy
- fabrication and type of post.

The influence of the covariates was evaluated using the forward stepwise logistic regression method based on the likelihood ratio. This method only included covariates in the analysis that had a significant influence (χ^2: $p = 0.05$) on the failure probability.

3. Results

The observation time for the post and cores ranged from 1 month to 9.51 years with a mean observation period of 2.1 years. The average survival time of all 802 post and cores was 7.3 years with a standard error of 0.2 years (Fig. 1). Failures were recorded in 90 cases (11.2%) at the time of the final examination, though this did not necessarily involve a new prosthetic restoration. Table 4 illustrates the distribution of failures based on the different causes of failure over time. The most common cause of failure was loss of retention of the post and core (43.3%). In all cases with loss of retention the post was recemented. These cases should therefore be regarded as relative failures. In most of the other type of failures, a new prosthetic restoration had to be fabricated. A frequent occurrence (47.8%) of failures was during the first two years following insertion of the post.

The Kaplan–Meyer survival time curves (Fig. 2 and Table 5) indicate that the fitted restoration had a significant influence (log rank test $p < 0.001$). The survival probability of the post and core was greatest in the case of a crown or bridge restoration. In contrast, there were no statistically significant differences between the different types of teeth (Fig. 3) with regard to survival time (log rank test $p > 0.05$), with only a tendency for a higher survival probability evident with molars.

Table 4 – Frequency and type of failure over time in relation to the total number of failures (*N* = 90)

Type of failure	Time until failure in years									Total
	1	2	3	4	5	6	7	8	9	
Loss of retention (post)	14.4	13.3	6.7	6.7	1.1	0.0	0.0	1.1	0.0	43.33
Periapical inflammation	5.6	3.3	2.2	2.2	0.0	1.1	1.1	0.0	0.0	15.56
Loss of periodontal attachment	0.0	1.1	2.2	2.2	0.0	0.0	3.3	0.0	1.1	10.00
Longitudinal root fracture	1.1	3.3	0.0	1.1	1.1	1.1	0.0	0.0	1.1	8.89
Secondary caries	0.0	0.0	2.2	0.0	2.2	1.1	0.0	1.1	0.0	6.67
Transverse root fracture	0.0	1.1	1.1	1.1	0.0	1.1	1.1	1.1	0.0	6.67
Partial crown fracture	0.0	2.2	1.1	0.0	0.0	0.0	0.0	1.1	0.0	4.44
Post fracture	1.1	0.0	0.0	0.0	1.1	1.1	0.0	0.0	0.0	3.33
Other	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.11

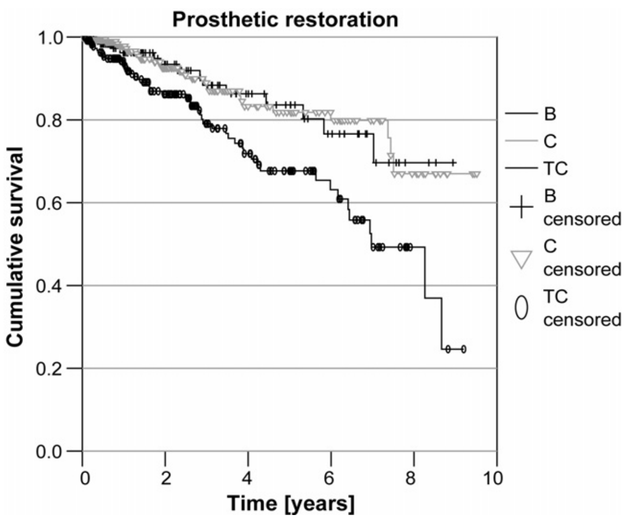

Fig. 2 – Kaplan–Meyer survival-curves for the post and cores, subdivided according to the prosthetic restoration. B: bridges; C: crowns; TC: telescopic crown retained RPDs.

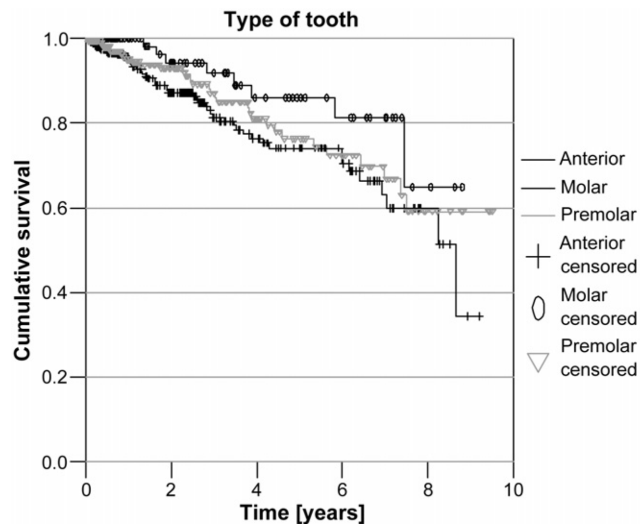

Fig. 3 – Kaplan–Meyer survival-curves for the post and cores, subdivided according to the type of tooth.

In Fig. 4 the Kaplan–Meyer survival time curves of the post and cores are shown in relation to the jaw treated. No statistically significant differences were ascertained between the upper and lower jaw (log rank test $p > 0.05$). Analysis of the survival time curves of the post and cores based on different luting materials (Fig. 5) ascertained statistically significant differences between the two types of cement (log rank test $p < 0.05$). It should be noted that glass ionomer cements were used for cementing posts that had low friction at the try-in stage. Post and cores fabricated from high-gold-content alloys (Fig. 6) had a significantly higher survival probability compared with posts fabricated from a semi-precious alloy (log rank test $p < 0.01$). The survival time curves for the subgroups, type of post fabrication (direct versus indirect) and number of root posts (single root post versus sectional post and cores with two root posts), were not evaluated graphically because of the small number of cases. Data relating to the average survival times are included in Table 5 and indicates wide confidence intervals for the groups with a small number. Directly fabricated post and cores exhibited a significantly lower survival probability compared with indirectly fabricated posts (log rank test $p < 0.01$). Care must be taken, however, when analysing the data because of the small number of cases in the group with directly fabricated posts.

In the Cox regression analysis with the forward stepwise selection procedure based on the likelihood ratio, significant differences were only recorded for the covariates, "type of prosthetic restoration" (Chi-square test: $p < 0.05$) and "luting material" (Chi-square test: $p < 0.001$). Table 6 provides an overview of the Cox regression analysis results. The category

Table 5 – Mean survival time in years, standard error and confidence interval

Sub-group	Mean survival time (years)	S.E.	95% Confidence interval	
			Upper	Lower
All posts	7.32	0.20	6.93	7.71
Upper jaw	7.32	0.26	6.81	7.84
Lower jaw	7.31	0.29	6.74	7.88
Anteriors	6.84	0.28	6.30	7.38
Premolars	7.42	0.31	6.81	8.04
Molars	7.58	0.39	6.83	8.34
Crowns	7.90	0.28	7.35	8.45
Bridges	7.51	0.34	6.83	8.18
Telescopic crown retained RPDs	6.30	0.31	5.69	6.90
Phosphate cement	7.61	0.22	7.18	8.04
Glass ionomer cement	6.16	0.45	5.27	7.05
High-gold-content alloy	7.65	0.21	7.24	8.07
Semi-precious alloy	6.18	0.41	5.38	6.97
Indirect post	7.45	0.20	7.05	7.85
Direct post	5.21	0.79	3.67	6.75
Post and Core with a single root post	7.34	0.20	6.95	7.73
Sectional post and core with two root posts	5.13	1.05	3.07	7.19

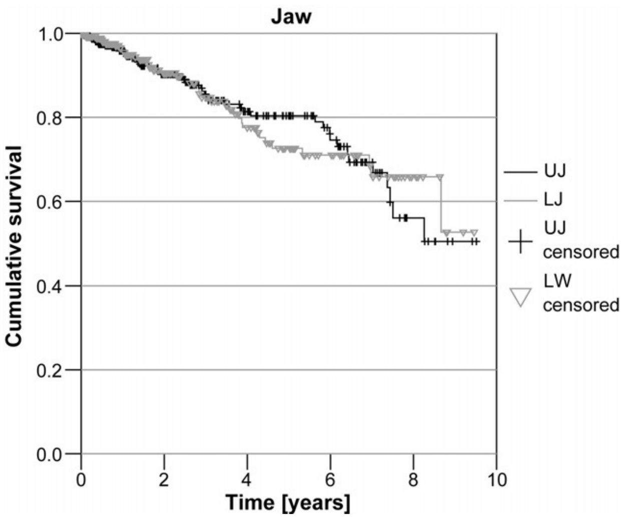

Fig. 4 – Kaplan–Meyer survival-curves for the post and cores, subdivided according to the jaw. UJ: upper jaw; LJ: lower jaw.

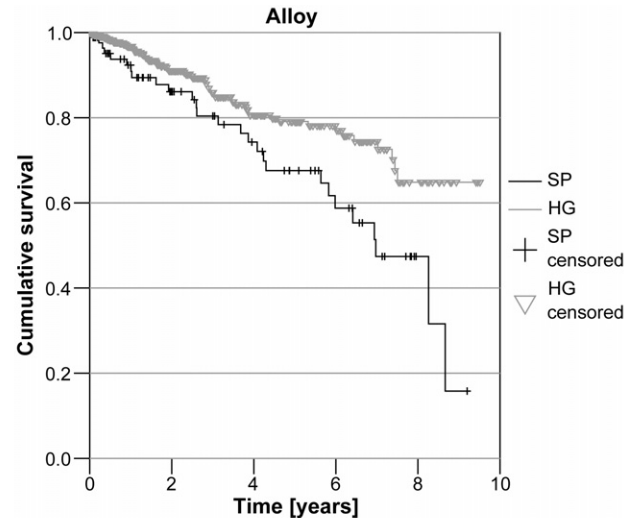

Fig. 6 – Kaplan–Meyer survival-curves subdivided according to the alloy used for the post and core. HG: high-gold-content alloy; SP: semi-precious alloy.

excluded in each case was the covariate reference variable. Post and cores under crowns and bridges did not differ significantly with regard to the risk of failure. On the other hand, post and cores fitted as abutments under telescopic crown retained RPDs exhibited a failure risk 1.9 times higher than with crowns. In the case of post and cores with low friction at the try-in stage, which had been inserted using glass ionomer cement, the risk of failure was increased by 2.4 times.

All other covariates did not increase the risk of failure significantly ($p > 0.05$). As the results of the Cox regression for the sub-groups, ''alloy'' and ''type of post fabrication (direct versus indirect)'' contradicted the results of the log rank test, both these sub-groups were subjected to further analysis. There were no statistically significant differences in the two sub-groups of fixed restorations (crowns and bridges) with regard to survival probability, so they were pooled together. The new group was then subjected to a Kaplan–Meyer analysis separate from the telescope dentures. In the fixed restoration group, high-gold-content posts tended to have a higher survival probability, though it was not significant ($p > 0.05$). In contrast, in the telescope denture group posts fabricated using a high-gold content alloy had a significantly lower survival expectancy (log rank test: $p < 0.05$).

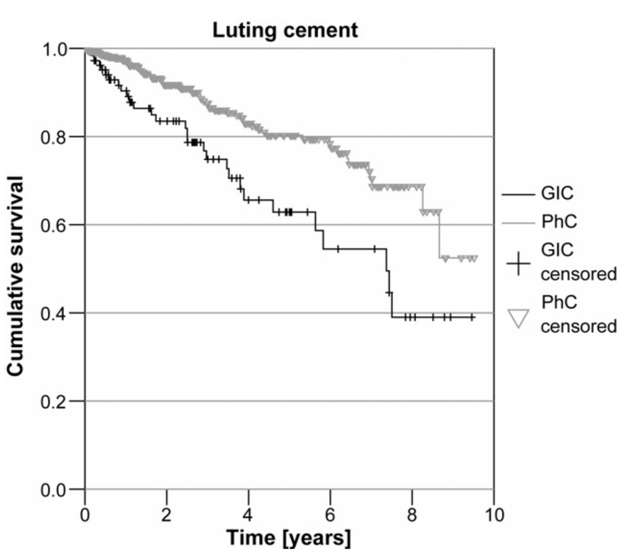

Fig. 5 – Kaplan–Meyer survival-curves for the post and cores, subdivided according to the luting material used. PhC: phosphate cement; GIC: glass ionomer cement.

4. Discussion

4.1. *Method*

The data of the study were acquired using a retrospective, longitudinal study design. A typical problem with retrospective studies is the availability of analysable, consistent data. This did not, however, pose a problem with this retrospective study, as the clinical findings had been recorded in the Department of Dental Prosthetics since the beginning of 1995 according to a standardised procedure. It can therefore be assumed that the recorded data are representative and comparable. It would have been more practical, if the average observation period had been much longer than 2 years. This could have been achieved either by disregarding data for shorter observation periods (e.g. 1 year) or by referring to patient files prior to 1995. Excluding shorter observation periods, however, would have negatively influenced a time-related analysis of failures. Patient files prior to 1995 were not analysed, as there was no standardised documentation of treatment before that time.

4.2. *Results*

Prosthetic restorations following post insertion included single crowns, telescopic crown retained RPDs and bridges.

Table 6 – Result of the Cox regression analysis

Predictor variables	B	p-value	Exp (B)	95% Confidence interval of Exp (B)	
				Upper	Lower
Lower jaw	−0.03	0.90	0.97	0.62	1.52
Premolars	0.04	0.89	1.04	0.62	1.74
Molars	−0.35	0.40	0.71	0.31	1.60
Bridges	0.04	0.90	1.04	0.54	2.00
Telescopic crown retained RPDs	0.64	0.03[a]	1.90	1.08	3.34
Glass ionomer cement	0.86	0.00[a]	2.37	1.52	3.72
Semi-precious alloy	0.38	0.14	1.46	0.89	2.42
Direct posts	−0.65	0.06	0.52	0.27	1.02
Sectional post and cores with two root posts	0.92	0.22	2.51	0.59	10.74

B = coefficient; Exp (B) = hazard. Reference for the hazard is the respective missing category.
[a] Significant influence.

If the type of prosthetic restoration is not taken into consideration, the average survival time of post and cores was 7.3 years.

Only limited comparison of the survival times (or rather survival probabilities) can be made with the results of other studies, as the calculation of the survival times was based on different statistical methods, definitions of a failure were not the same or different types of post and core techniques were used. This problem had been highlighted by Creugers et al. in 1993.[15]

The cumulative failure rate was 11.2% and was therefore below the range of 13–30% defined as ‘‘acceptable’’ [25] with a recall interval of 6–8 years.[17] A prospective study by Ellner et al. indicated a survival rate of 100% for cast, custom-fabricated post and cores after 10 years [20]. The reason that the results differed from those of this study was presumably because Ellner et al. examined a comparatively small patient collective, the inclusion criteria were very strict and the post and cores were always fitted with single crowns.

The most common cause of failure in this study was loss of retention of the post. This should be regarded as a relative failure, as in all cases the problem was solved by recementing the post. The least common complication was post fracture. These results concur with those of other studies.[1,2,12,17,24,25,35,36] In contrast, Valderhaug et al. recorded only a very small proportion of complications involving loss of retention.[21]

The Cox regression analysis indicated a significantly lower risk of failure if the post and cores were fitted with crowns or bridges, with no significant difference between these two groups. Bergmann et al. [14] also obtained the same results. The risk of failure of post and cores under telescope dentures was 1.9 times higher than with single crowns. This result concurs with those of other studies,[17,19,36] which also recorded a higher failure rate with RPDs compared with single crowns.

It should be noted in making this comparison that no specific information had been provided regarding the type of the RPDs. The authors assume that the reason for the increased risk of failure of post and cores under telescopic crown retained RPDs was, that the load equilibration between tooth and support of the saddle on the edentulous alveolar ridge was intermittent or had been lost (i.e. that the denture saddles did not fit the edentulous jaw areas uniformly when the secondary units were in situ), which led to increased extra-axial loading of the telescope abutment teeth. Tensile forces during removal of the denture and extra-axial loading if the denture was removed or inserted incorrectly could also have an effect, as the lever arm at the denture saddle can be very long. Other authors assume the cause to be that the teeth have to be prepared more to create a common path of insertion with telescopic crown retained RPDs and consequently the proportion of stabilising tooth structure is greatly reduced.[36] On the other hand, some authors regard the cause to be reduced proprioception of root-filled teeth, which could reduce protective reflexes. They therefore do not recommend root-filled teeth in combination with fixed/removable restorations.[30] Due to the very high survival probability of post and cores under telescopic crown retained RPDs, the authors would not regard a tooth fitted with a post and core as a contraindication for incorporating it into a telescope restoration.

Neither the type of tooth (anterior, premolar, molar) nor the jaw (upper, lower) had an effect on the survival probability of a post and core. Other studies also produced this result.[14,37] On the other hand, a few studies recorded a prevalence of failures in the upper jaw, generally in the anterior region.[12,17]

The type of luting material selected had a significant effect on the survival probability. Post and cores inserted with phosphate cement exhibited the highest survival probability, while the post and cores inserted with glass ionomer cement had a higher risk of failure. It is important to bear in mind that selection of the cement was not randomised but based on the operator's assessment of the friction of the root post.

For this reason, it should not be concluded, that glass ionomer cements are basically unsuitable for inserting post and cores. It can, however, be concluded that glass ionomer cement cannot be used to compensate for a post with low friction at the try-in stage.

Posts fabricated from a high-gold-content alloy had a significantly higher survival probability than posts fabricated from a semi-precious alloy. As there was, however, a large number of failures of high-gold-content root posts under telescopic crown retained RPDs, the Cox regression analysis did not record a significant reduction of the risk of failure. These results cannot be easily explained and will have to be investigated by further clinical studies.

Directly fabricated posts had a higher risk of failure compared with indirectly fabricated posts. In the Cox regression this parameter was not significant. The overlapping effects of covariates are possibly relevant in the Cox regression analysis. The reason for the lower survival probability of direct post and cores could be that there is a problem building up a post and core intraorally to the same precision as with indirect fabrication on a model. This does not mean that the direct fabrication technique is basically impractical. It does, however, clearly indicate that direct fabrication of posts requires a greater degree of skill on the part of the operator. Indirect fabrication of post and cores in the dental laboratory is always a more reliable means of ensuring long-term success. The group sizes with sectional posts were too small to give a reliable indication of the survival probability or risk of failure and have therefore not been included.

5. Conclusions

- Post and cores custom-fabricated using a standardised fabrication technique have a good long-term prognosis with an average survival probability of 7.3 years.
- The type of restoration fitted has a significant influence on the survival probability. Post and cores under single crowns and bridges have the highest survival probability.
- The survival probability did not depend on the location of the tooth in the dental arch (anterior, premolar, molar) or the jaw (upper, lower).
- The most common cause of failure is loss of retention of the post and cores.
- The durability of posts with low friction at the try-in stage could not be compensated for by using glass ionomer cement as the luting material.
- With regard to survival probability it seems practical to recommend the indirect fabrication technique for post and cores.

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