Influence of Clinical Baseline Findings on the Survival of 2 Post Systems: A Randomized Clinical Trial

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Purpose: The aim of this prospective randomized controlled trial was to evaluate the influence of clinical baseline characteristics on the survival of 2 post systems. ***Materials and Methods:*** One hundred patients needing a post were included. Half the patients received a glass fiber–reinforced post (FRP), and the other half received metal screw posts (MSP). The posts were assigned randomly. In addition to demographic data, the following parameters were recorded: type of tooth (incisor/canine versus molar/premolar), length of the post in relation to root length (percentage), extent of coronal tooth destruction (percentage), ferrule height (in millimeters), type of restoration (fixed or removable partial denture), and presence of antagonistic contacts (yes/no). After at least 1 year (mean: 13.84 months), the patients were recalled. Statistical analysis was performed using the log-rank test and Cox regression analysis. ***Results:*** The survival rate of FRPs was 93.5%. In the MSP group, the survival rate was significantly lower (75.6%; log-rank test, $P = .049$). Additionally, the metal posts were associated with more unfavorable complications, for example, root fracture. The type of the tooth and the degree of coronal tooth destruction influenced the survival of MSPs, whereas no influence of these variables could be seen for FRPs. ***Conclusion:*** FRPs are superior to MSPs with respect to short-term clinical performance. Especially for MSPs, clinical survival depends on several variables. *Int J Prosthodont 2007;20:173–178.*

Reconstruction of endodontically treated teeth is frequently required before definitive restoration can be accomplished, especially when the remaining coronal tooth structure is inadequate to provide retention and resistance form for the restoration. Selection of the most suitable post-and-core system is challenging for clinicians, and numerous in vitro studies have been conducted to evaluate the different aspects (fracture strength, retention, etc) of posts and cores. In recent years, nonmetallic posts (zirconium, carbon fiber, quartz fiber, glass fiber) have appeared on the dental market. Different aspects of post-and-core complexes were evaluated in a review that included in vitro and in vivo studies,[1] and it was found that the fracture strength of metal posts was slightly better. Another in vitro study[2] showed that the load to failure was greater for steel posts than for composite posts. Additionally, it was demonstrated in an in vitro study[3] that serrated metal posts are more retentive than other posts. Standlee et al investigated the retention of endodontic dowels in an in vitro study[4] and concluded that threaded, parallel-sided posts were the most retentive. King et al[5] found in their in vitro study that fiber-reinforced endodontic posts did not perform as well as conventional precious alloy posts; more failures occurred with the fiber-reinforced posts (FRPs). Additionally, many clinicians prefer metal posts because they are easier to set. However, in the aforementioned review[1] it was also reported that the mode

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of failure of fiber posts was more easily repaired than that seen for metal posts and that the distribution of stress in fiber posts led to fewer fractures. Thus, each post system has advantages and disadvantages.

Many of these results are based on in vitro studies and must, therefore, be accepted with caution because clinical conditions cannot be simulated satisfactorily under artificial conditions. Consequently, interpretation of in vitro results is difficult. Additionally, the results are often contradictory.

In recent years, several retrospective in vivo studies were performed analyzing the survival of different post systems.[6–8] These studies evaluated the effect of different clinical aspects, eg, occlusal contacts.[9] However, analysis of retrospective data implies a systematic bias, as there are no standardized baseline conditions. Only a few prospective studies have been published about the survival of FRPs. They have reported different failure rates,[5,10] and only 1 study is available evaluating the effect of baseline findings on the survival of glass FRPs.[11] There are also few clinical studies assessing the survival of serrated metal posts.[12,13] There are no studies evaluating the effect of baseline findings on the survival of these posts.

Consequently, the research hypothesis of the present prospective study was that, in teeth restored with fiber-reinforced posts versus teeth restored with metal screw posts, clinical baseline characteristics besides the post system may influence post survival.

Materials and Methods

Study Population

This prospective study was approved by the ethical approval board of the University of Heidelberg (approval number: L-072/2003). One hundred patients needing new crowns, fixed partial dentures (FPD), or removable partial dentures (RPD) were included in this study. The inclusion criteria were: the need for a new restoration of teeth that had been endodontically treated at least 3 months before placement of the post, the need for a post-and-core complex because of coronal tooth destruction (at least 40% of the crown was destroyed), at least 18 years of age, no periodontal disease, and no pregnancy or lactation. All patients provided written, informed consent. The patients were recruited during a 2-year period.

In addition to demographic information, other data recorded were: tooth location (anterior/posterior), presence of antagonistic contacts (yes/no), length of post in relation to root length (percentage), extent of coronal tooth destruction (percentage), ferrule height (in millimeters), and type of restoration (FPD or RPD). Measurement of coronal tooth destruction was performed according to the following scheme: each side of the tooth (occlusal, mesial, distal, buccal, lingual) was divided into 4 parts. Each quarter represented 5% of the coronal tooth surface and, consequently, each side represented 20%. If, for example, the mesial and buccal parts of the coronal tooth were destroyed, the extent of destruction would be 50% (mesial 20% + buccal 20% + occlusal 10%) as, automatically, parts of the occlusal area were destroyed also.

Post Assignment and Cementation

Two post designs were used in this study: fiber-reinforced posts (FRPs) (ER-dentin post, Brasseler) and parallel-sided titanium screw posts (metal screw posts, or MSPs) (BKS, Brasseler). If a patient fulfilled the inclusion criteria, a post was assigned randomly (computerized randomization). If a patient received 2 or more posts, only 1 post, chosen randomly, was included in the study. The randomization list was managed by a study nurse who was not involved in the study. If a tooth had more than 1 root canal, the preferable canal was selected (eg, the straighter canal). Each tooth received 1 post only.

All posts were placed by students between 6 months and 1 year before their graduation, so the level of experience of all students was similar. Both MSPs and FRPs were placed according to the manufacturer's instructions.

To place the metal screw posts (MSP), the root canals were extended to ISO 80 and tapped using the appropriate tapper (Brasseler). The thread extended to at least 50% of the length of the root canal. Radiographs were then acquired to determine whether the MSP was positioned correctly; the position was adjusted if necessary (for example, if the MSP did not extend for 50% of the root canal length). The root canal was then rinsed with alcohol and dried with paper tips.

MSPs were cemented using zinc phosphate (Harvard Dental) in accordance with the manufacturer's guidelines. The cement was placed in the root canal by use of a lentulo. The MSP was set using the appropriate setter (Brasseler). Excess cement was removed.

To place the FRPs, the appropriate FRP was selected and the root canal was extended. The FRP was replaced with a metal duplicate for acquisition of radiographs. The correct position of the post was then verified on the radiographs and adjusted, if necessary. The FRP was defatted using alcohol. The root canal was pretreated by roughening (diamond-surfaced hand instrument, Brasseler), etching (37% phosphoric acid, Excite-DSC soft-touch single dose, Ivoclar Vivadent), rinsing, and drying. The FRPs were then luted using a composite cement (Variolink II, Ivoclar Vivadent) in accordance with the manufacturer's guidelines.

Table 1 Data for the Post Groups

	Glass fiber–reinforced posts	Metal screw posts
Sex	34.9% male 65.1% female	55.9% male 44.1% female
Time between setting and recall (mo)	13.6 ± 3.3	14.1 ± 5.6
Tooth	20% anterior teeth 80% posterior teeth	40% anterior teeth 60% posterior teeth
Antagonistic contact	72% yes 28% no	84% yes 16% no
Length of post in root vs root length	65.12% ± 9.85%	63.53% ± 10.4%
Percentage of tooth destruction	86% ± 10%	87% ± 9%
Ferrule height (mm)	3.4 ± 1.04	3.03 ± 0.95
Kind of restoration	41.9% single crown 23.3% FPD 34.8% RPD	44.1% single crown 23.5% FPD 32.4% RPD

To standardize core buildups, a self-curing flowable adhesive core buildup system on a composite base (Rebilda SC, Voco) in combination with a dentin adhesive system (Solobond, Voco) was used to reconstruct the coronal tooth structure. The core was applied using rubber dam. In 4 cases, the patients refused rubber dam.

The cores were then prepared to produce artificial crowns, FPDs, or crowns integrated into a RPD. The impressions were made using Impregum (3M ESPE) or Optosil and Xantopren (Heraeus Kulzer).

Follow-up

All patients were instructed to consult only the Department of Prosthodontics if they experienced problems. After at least 1 year, patients were recalled to check the current status of the posts. If a failure occurred before the first recall, the patient had to visit the Department of Prosthodontics.

Neither the patients nor the examiners knew which post had been placed. The recalls were performed by 3 experienced clinicians (at least 5 years of professional experience and at least 3 years in the Department of Prosthodontics) who were not the operators. After radiographs were made, the examiners were no longer blinded.

The criteria for survival were: no complications with respect to the post (eg, tooth or post fracture, loss of retention), restoration remaining intact on the tooth, and no pain (on palpation or percussion).

Statistical Analysis

The statistical analysis was performed by use of SPSS 13.0 software (SPSS). For descriptive purposes, percentages of the baseline findings were calculated. Additionally, Kaplan-Meier analysis was used to construct survival plots. If a failure occurred before the 12-month recall, the patient was required to visit the Department of Prosthodontics. Thus, the survival plots might include failures before the established recall time.

The log-rank test was used to compare the survival of both types of posts. To isolate risk factors for the failure of the post-core-crown complex, a Cox regression was performed for both types of posts. The hazard ratios and the 95% confidence intervals (CI) were derived from the Cox regression analysis.

Results

During recruitment, 41 patients did not agree to participate in the study. These patients were 58.38 ± 11.22 years old (42.5% male and 57.5% female).

The study population consisted of 45 male (56.33 ± 12.95 years) and 55 female (54.56 ± 12.88 years) patients. Nine patients (4 men and 5 women) did not attend the recall appointment (dropout: 9%). Thus, 45 patients with MSPs (dropout: 10%) and 46 patients with FRPs (dropout: 8%) attended the recall. Data for the 2 groups are listed in Table 1.

Results for the FRPs

In the FRP group, 3 failures were observed: 1 post-core-crown complex had to be recemented, 1 tooth had to receive a new crown because the crown cracked, and 1 tooth had to be observed because of an apical alteration. Thus, the survival rate of FRPs was 93.5% (43/46), including the fracture of 1 crown. If this failure is excluded, the survival rate was 95.7%. Figure 1 shows the flow of participants and posts.

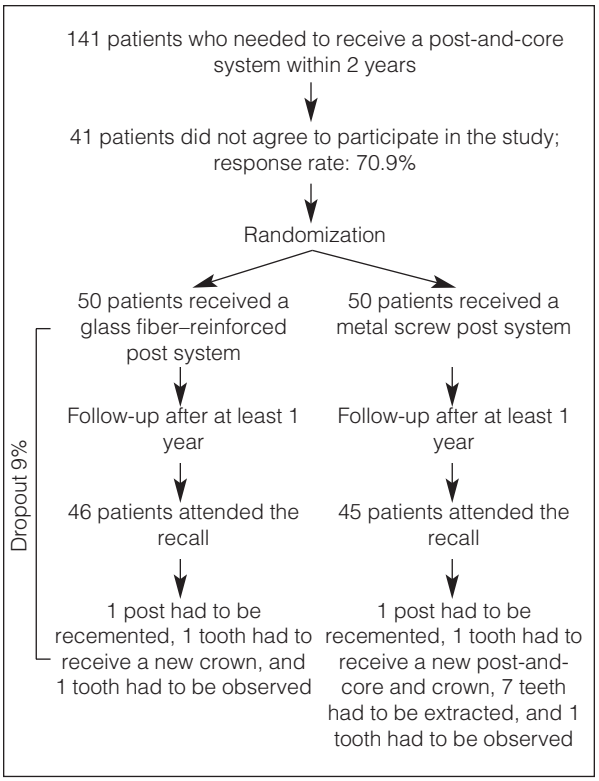

Fig 1 Flow of participants and posts after at least 12 months.

To isolate other relevant risk factors for failure of the FRPs, a Cox regression analysis (backward elimination, *P* in: .05, *P* out: .1) was performed using the variables: tooth location, degree of coronal tooth destruction, ferrule height, length of post in relation to root length, kind of restoration, and antagonistic contacts. However, no additional risk factors could be found (Table 2).

Results for the MSPs

In the MSP group, 11 failures were observed. One post and 1 crown had to be recemented. One tooth had to receive a new post and core and crown, because the post-core-crown complex had loosened. Seven teeth had to be extracted—4 with root fractures at the apical end of the post, 2 with perforations in the buccolingual direction, and 1 with a post fracture—and 1 tooth had to be observed because of an apical alteration. Thus the survival rate was 75.6%, including the failure of 1 crown. If this failure is excluded, the survival rate was 77.8%.

To isolate other relevant risk factors for the failure of the MSPs, a Cox regression analysis (backward elimination, *P* in: .05, *P* out: .1) was performed using the same variables as in the FRP group. Two variables were found to have an influence on the survival of teeth restored with MSPs: degree of coronal tooth destruction ($P = .033$, hazard ratio = 12.937, 95% CI = 1.227 to 136.359) and tooth location ($P = .015$, hazard ratio = 0.052, 95% CI = 0.005 to 0.556). Teeth with more decay were at higher risk of failure. Additionally, the risk of failure was higher in anterior teeth (see Table 2).

Comparison of MSP and FRP Survival

The log-rank test was used to assess differences in failures in the 2 post systems, and these differences were found to be significant ($P = .049$). Kaplan-Meier analysis was performed (Fig 2). The details of survival for both groups are given in Table 3.

Discussion

Glass FRPs have become popular in recent years. The major advantage of FRPs is the fact that their Young's modulus is closer to that of dentin. Consequently, glass FRPs induce less stress.[14,15] However, metal posts are easier to apply and are used in dental practice frequently.

This present randomized and blinded study was conducted to assess variables that might influence the survival of 2 different post systems. Additionally, the failure rates and failure modes of the 2 post systems were assessed.

In this study the dropout rate was 9%, which seems acceptable compared with other studies.[16] The survival rate of FRPs was 93.5% (43/46), including 1 crown that fractured. If this failure is excluded, the survival rate was 95.7%. This result is comparable with the findings of another investigation,[17] which found a survival rate of 93.8%. Another study[6] observed 3.2% failure after 1 to 6 years in service. The follow-up period in the present study was between 12 and 29 months (mean: 13.84 months). Thus, the number of failures might increase in the following months in both groups. Additionally, this study did not assess other factors influencing survival.

In the MSP group in this study, the number of failures was higher than in the FRP group (75.6%, 34/45), including the failure of 1 crown. If this failure is excluded, survival was 77.8%. This result is confirmed by another retrospective clinical study[18] that compared the performance of FRPs and cast posts and found that the clinical success rate was higher for the FRPs (95%) than for the cast posts (84%). In another study the success of threaded posts was 60%,[19] which is lower than in the present study. This demonstrates that there is a large variation in success rates described in the literature. However, Fox et al[12] concluded in their study that the post design that fractured most commonly was a serrated and parallel design. This might explain the rel-

Table 2 Results of Multivariate Cox Regression Analysis

			95% CI	
	P	Hazard ratio	Lower	Upper
Tooth location (anterior/posterior)				
MSP	.015*	0.052	0.005	0.556
FRP	.408	0.330	0.024	4.575
Degree of tooth destruction (%)				
MSP	.033*	12.937	1.227	136.359
FRP	.525	0.622	0.144	2.692
Ferrule height (mm)				
MSP	.411	0.724	0.336	1.563
FRP	.906	0.914	0.205	4.070
Length of post in root vs root length				
MSP	.053	1.102	0.999	1.216
FRP	.388	0.938	0.811	1.085
Kind of restoration				
MSP	.748	1.264	0.303	5.264
FRP	.870	1.282	0.065	25.360
Antagonist				
MSP	.565	0.749	0.280	2.004
FRP	.290	1.772	0.614	5.113

*Significant ($P < .05$).

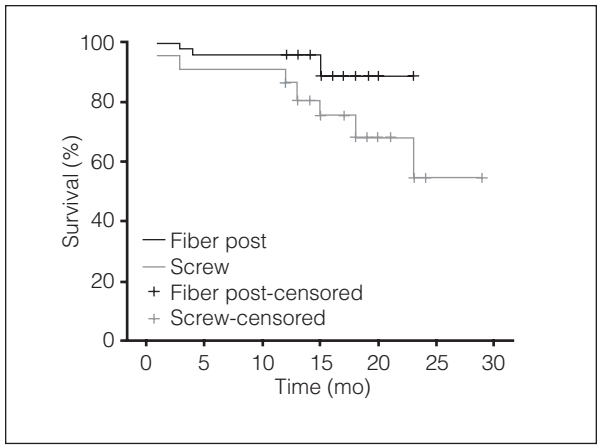

Fig 2 Kaplan-Meier survival analysis.

atively low survival of the MSPs in the present study. The failure characteristics in the FRP group were comparable with those seen in other studies[20]: root fractures were rarely observed in teeth restored with fiber posts. More often, the tooth/post-core interface failed. This meant that the clinician could repair the affected teeth. The metal posts in the present study suffered less favorable complications, such as root fracture. This result is confirmed by another in vitro study[21] in which fiber posts provided an advantage over conventional posts, which showed a higher number of irretrievable posts and unrestorable root fractures. A retrospective study[16] supported these results; after 24 months, 12.8% of glass FRPs failed, but only 1 tooth could not be restored after the failure. It can be concluded that the results of the present study with respect to failure characteristics and failure rate are comparable with those of other studies.

The present study found that the risk of failure of MSPs was higher in anterior teeth than in posterior teeth. In their prospective study, Naumann et al[11] assessed several factors that might influence the survival of glass fiber–reinforced endodontic posts and found that the risk of failure was higher in anterior teeth. The present study confirmed this result for MSPs. Thus, the influence of tooth location might be independent of the type of post system used. The reason for the higher failure rate in anterior teeth might be differences in the occlusal load (especially the horizontal ratio of the applied load) of incisors versus molars/premolars. However, for FRPs this result could not be confirmed. In this context it must be considered that the failure rate of these posts was lower than that seen for MSPs; consequently the results of the survival analysis must be interpreted

Table 3 Enrollment and Survival Data for Both Groups

Type of post	No. of patients	Dropouts	Censored	Failures
MSP	50	10%	34	11
FRP	50	8%	43	3

with care. The study of Naumann et al[11] found 2 more risk factors: number of proximal contacts and type of definitive restorations. In the present study, the number of proximal contacts was not recorded. However, the type of restoration (FPD versus RPD) was not identified as a risk factor in the present study for either MSPs or for FRPs. One reason for this discrepancy might be the different follow-up periods; the present study assessed survival after only 1 year. This fact and the low number of failures in the FRP group limit comparison with the aforementioned study. Additionally, the mean ferrule height in the present study was > 3.0 mm (see Table 1) in both groups. Consequently, the forces acting on abutment teeth might be absorbed mostly by the tooth. In the aforementioned study, the proportion of teeth with circumferential ferrules of at least 2 mm was low. Because the combination of ferrule preparation and endodontic post seems to influence load resistance,[22] the different findings become explainable. Despite this difference with respect to the ferrule height, the failure rate of FRPs in the present study (6.5%) was comparable to the results of Naumann et al[11] (6.7%). Other studies found lower failure rates.[18,23,24] Because of inhomogeneous study populations, inclusion criteria, and other factors, direct comparison of different studies is difficult.

In the present study, the degree of coronal tooth destruction proved to be a risk factor for the failure of MSP restorations. Naumann et al[11] distinguished between 1 or 2 and more than 2 surfaces for adhesion and could not confirm this result. It has to be considered that the degree of tooth destruction was defined in the present study as a percentage. This might explain the different findings. Additionally, an influence of the degree of tooth destruction was found for metal posts only. Again, the lower failure rate in FRPs may have affected the statistical analysis.

The present study was performed in a preselected population (Department of Prosthodontics, University of Heidelberg), and the treatment was performed by moderately experienced dental students with comparable experience under standardized conditions. Additionally, the follow-up time was limited (mean: 13.84 months). To simulate clinical conditions, both MSPs and FRPs were placed according to the manufacturer's instructions. However, as the research hypothesis of the present study was that, in teeth restored with fiber-reinforced posts on the one hand and in teeth restored with metal screw cemented posts on the other, different clinical baseline characteristics aside from the post system may influence the survival, it was necessary to accept some statistical uncertainty with respect to different cementation methods. Another factor that must be mentioned is the randomization. In the present study, post assignment was randomized with respect to the patient but not with respect to tooth location. Thus, a slight mismatch between the analyzed factors (tooth location, antagonist contact, ferrule height) might have resulted. However, in spite of randomization, there was a difference in gender between the groups. Because gender does not influence the survival of posts, this bias seems to be acceptable. Nevertheless, these limitations have to be considered when interpreting the results.

Conclusion

The short-term clinical performance of the examined FRPs was superior to that of the examined MSPs; the number of complications was lower and the types of failure were less severe. Furthermore, other variables (tooth location and amount of coronal tooth destruction) were identified that influenced the survival of metal post-and-core systems.

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