THE JOURNAL OF PROSTHETIC DENTISTRY

RESEARCH AND EDUCATION

Retrospective analysis of survival rates of post-and-cores in a dental school setting

Nicole Martino, DMD, MS,[a] Caroline Truong, DMD, MS,[b] Arthur E. Clark, DMD, PhD,[c] Edgar O'Neill, DDS, MS,[d] Shu-Min Hsu, PhD,[e] Dan Neal, MS,[f] and Josephine F. Esquivel-Upshaw, DMD, MS, MS-CI[g]

ABSTRACT

Statement of problem. The clinical survival of different types of post-and-core systems requires assessment.

Purpose. The purpose of this retrospective clinical study was to evaluate the clinical survival rate (CSR) of custom-fabricated cast metal and prefabricated (both metal- and fiber-reinforced composite resin post) post-and-cores as a function of patient- and restoration-related variables.

Material and methods. A retrospective analysis was conducted on electronic charts indicating that these patients had received some type of post-and-core between January 2003 and January 2018. A total of 754 records were included in the analysis based on the inclusion criteria. Data were analyzed by using the Kaplan-Meier and Cox proportional hazards analysis.

Results. Kaplan-Meier analysis demonstrated the mean survival time for each group to be 12.0 years for fiber-reinforced composite resin posts, 11.8 years for cast metal post-and-cores, and 10.2 years for prefabricated metal posts. Although the mean survival time differed by 1.8 years among groups, with prefabricated metal posts having a slightly higher risk of failure, this effect was not statistically significant (P=.067). The effect of post type also failed to reach significance when controlling for patient demographics and post position in a Cox proportional hazards analysis (P=.106). However, the Cox model did show that survival was associated with tooth position (P=.003), cement (P=.021), and type of restoration (P<.001).

Conclusions. Analysis showed no evidence that post-and-core survival was significantly associated with 3 types of post-and-cores (custom-fabricated metal, prefabricated metal, and prefabricated fiber-reinforced composite resin). The percentage of root in the bone, tooth position, cement, and type of restoration, however, were significantly associated with survival. (J Prosthet Dent 2020;123:434-41)

Root canal therapy is indicated when there is extensive loss or destruction of tooth structure or irreversible pulpitis. The therapy is performed either to remove the source of infection, provide a means for reconstruction of the coronal component of the tooth, or both.[1,2] Depending on the amount of remaining coronal tooth structure, a post may be necessary to allow the tooth crown to withstand the intraoral forces during normal function.[3] In the decision process of whether to restore a tooth with a post prior to definitive restoration, the extent of hard-tissue destruction and the number of remaining axial cavity walls plays a critical role.[1,4] However, laboratory and clinical studies have failed to provide evidence that a post may strengthen endodontically treated teeth or enhance their survival.[2,5] Thus, the primary purpose of post placement is to retain the core material.[3]

Whether to use a custom-cast post-and-core or a prefabricated post is controversial among clinicians. A cast post-and-core can be made using gold alloy, silver-palladium alloy, or a base metal alloy such as

Supported by NIH-NIDCR grant R01 DE025001 and the University of Florida Graduate Prosthodontics Program.
[a]Graduate Prosthodontic resident, Graduate Prosthodontics Program, Restorative Dental Sciences, University of Florida College of Dentistry, Gainesville, Fla.
[b]Graduate Prosthodontic resident, Graduate Prosthodontics Program, Restorative Dental Sciences, University of Florida College of Dentistry, Gainesville, Fla.
[c]Professor, Restorative Dental Sciences, Division of Prosthodontics, University of Florida College of Dentistry, Gainesville, Fla.
[d]Clinical Associate Professor, Restorative Dental Sciences, Graduate Prosthodontics Program, University of Florida College of Dentistry, Gainesville, Fla.
[e]Research Associate, Restorative Dental Sciences, Division of Prosthodontics, University of Florida College of Dentistry, Gainesville, Fla.
[f]Senior Statistician, Department of Neurosurgery, University of Florida College of Medicine, Gainesville, Fla.
[g]Associate Professor, Restorative Dental Sciences, University of Florida College of Dentistry, Division of Prosthodontics, Gainesville, Fla.

Clinical Implications

The survival of post-and-cores is not associated with post-and-core type. For higher predictability, clinicians should focus more on the proper design and treatment plan for their post-and-cores.

nickel-chromium (Ni-Cr). A cast post-and-core is not indicated in teeth that cannot accommodate additional root preparation resulting from inadequate root dimensions or unsuitable internal morphology such as mandibular incisors.[2] In situations where the angle of the core must be altered in relation to the root, a cast post-and-core is the optimal choice.[2] Despite a long history of success with cast post-and-cores, clinicians are using prefabricated posts more because of their ease of use, reduced chair time, decreased cost, and improved esthetics.[6-10] Prefabricated posts are presently available in a variety of materials, ranging from metallic (stainless steel and titanium alloys) to nonmetallic (zirconia and fiber-reinforced composite resin).

Direct core materials used in conjunction with prefabricated posts include amalgam, composite resin, and glass ionomer-based materials. According to Subash et al,[11] the use of resin-modified glass ionomers as a core build-up material should be limited to nonstress-bearing areas. Composite resin is the preferred core build-up material to use with direct posts because of high fracture resistance and bonding to tooth structure.[1,11]

The materials used to cement posts into the canal have changed over time. Metal posts may be cemented with zinc phosphate or with an adhesive resin system. Adhesive cementation is the preferred method because this results in lower microleakage, increased retention,[12,13] and greater fracture resistance compared with zinc phosphate.[14,15] Naumann et al[4] demonstrated in a randomized clinical trial that adhesively luted glass fiber and titanium posts used to restore endodontically treated teeth had a mean survival up to at least 100 months, regardless of the post material and rigidity.

The amount of remaining ferrule and tooth structure is essential in determining an appropriate treatment plan. A direct relationship has been shown between the amount of remaining coronal tooth structure and the ability of the tooth to resist occlusal forces.[16-18] As more tooth structure is removed, the ability to resist occlusal forces is reduced, and the possibility of fracture is increased.[3] The addition of a post often results in further reduction of the remaining tooth structure and a weakened ability to resist masticatory forces. This is compounded by the fact that post-and-core restorations are influenced by the mechanical properties of the post material (such as Young modulus). Consequently, the material and design selection of the post can influence the pattern of stress distribution throughout the tooth.[19] Based on a study using a finite element analysis (FEA) of weakened roots restored with various post materials, Coelho et al[19] concluded that stress was distributed differently between metallic and nonmetallic posts. Glass and carbon fiber posts presented a more homogenous stress distribution, which was close to that produced by an intact tooth, resulting in decreased risk of biomechanical failure in endodontically treated teeth. A Young modulus closer to dentin is thought to result in favorable stress distribution and is frequently recommended.[19,20] Biomechanical considerations also suggest different behavior of anterior teeth, premolars, and molars because of different force directions.[4] The maxillary region is considered to be a high-risk area for technical failures because of greater horizontal forces.[20-22] Therefore, not only is the material selection a factor to be considered in selection but also the location of the tooth.

Other characteristics that have been reported to influence post survival include post length, diameter, and design.[23] Different studies have supported one post type over another,[24-32] but other studies have reported no difference among post types.[1,33-36] The authors are unaware that a consensus has been reached as to which post type provides a better survival rate for endodontically treated teeth. Systematic reviews comparing different post materials have reported conflicting results.[37-43] A meta-analysis compiled from a systematic review of in vitro and in vivo studies reported no significant differences between cast and direct post-and-core systems that would justify recommending the use of one over the other.[44]

The purpose of this retrospective clinical study was to evaluate the clinical survival rate (CSR) of custom-fabricated cast metal post-and-cores and prefabricated post-and-cores (both metal and fiber) while controlling for the age and sex of the population, type of post material, length of post, amount of alveolar bone tissue supporting the roots, location of the tooth in the dental arch, type of cement used, effect of opposing dentition, and type of definitive prosthetic treatment received. The objective of this study was to test the hypothesis that there is no difference in survival rate of post-and-cores as a function of material type.

MATERIAL AND METHODS

After institutional review board (IRB) approval was granted, a list of patients who had a completed treatment code on file for a prefabricated (D2954) or custom-cast post (D2952)-and-core was derived from the electronic database (axiUm; Exan) and compiled on a spreadsheet (Excel; Microsoft Corp). Inclusion criteria included patient files with enough available information on the electronic

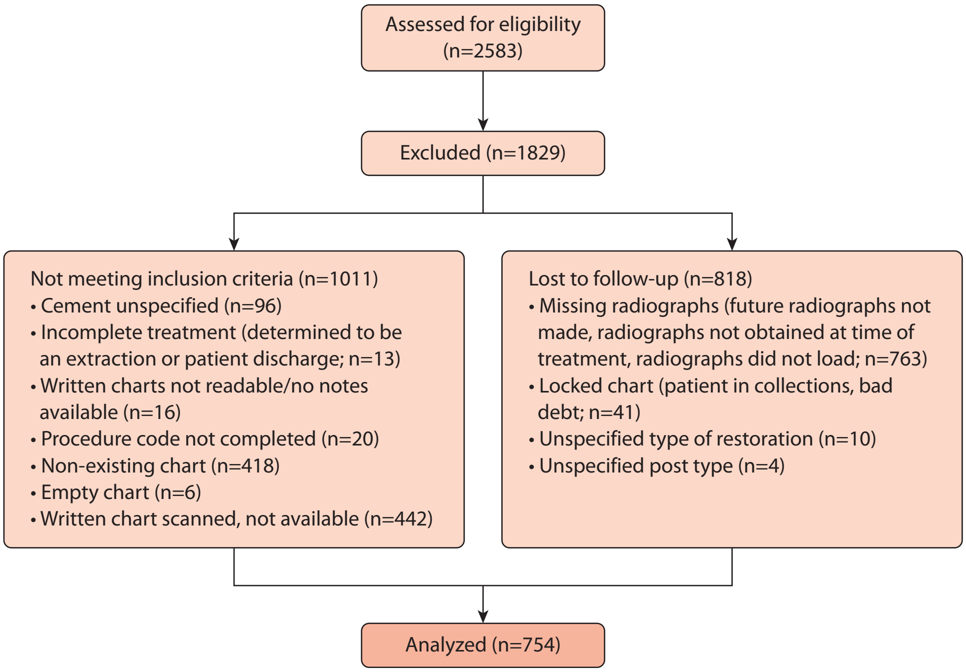

Figure 1. Flowchart illustrating distribution of patient records not included in analysis.

file or scanned attached documents regarding the procedure performed and radiographic and clinical confirmation of post placement and post survival or failure. Failure refers to when the original post-and-core or the tooth was no longer in the mouth. Patients were treated with either a prefabricated fiber-reinforced composite resin post (ParaPost Taper Lux; Coltène or DT Light Post; Bisco Dental), a prefabricated metal post (ParaPost XH Titanium; Coltène), or a custom-cast (Argenco type III gold alloy; Argen) metal post-and-core at the University of Florida College of Dentistry between January 2003 and January 2018.

After reviewing a total of 2583 patient files, 754 records were selected based on the inclusion criteria (Fig. 1). Data were gathered mainly from the provider's treatment notes and from examining patients' dental radiographs in their charts. Grading codes were specified and applied for each parameter (Table 1): age, sex, post type, post length, percentage of root in bone, type of restoration, type of cement, tooth position, opposing dentition, failure, and duration (not lifetime duration, but rather the duration as derived from chart information).

Data were analyzed using the R statistical software package (V.3.0.2; R Foundation for Statistical Computing). The Fisher exact test and Kruskal-Wallis test were used to assess differences in patient and procedure factors among the 3 post-and-core types. The Kaplan-Meier analysis and the log-rank test were used to compare survival time among the 3 post groups, and a Cox proportional hazards model was used to assess the effect of post-and-core type when controlling for age, sex, post type, post length, percentage of root in bone, type of restoration, type of cement, tooth position, and opposing dentition.

RESULTS

The patient- and restoration-related variables and their breakdown and significance are analyzed in Table 2. Age ($P<.001$), type of restoration ($P<.0001$), cement used ($P<.0001$), opposing dentition ($P<.0001$), and duration of service ($P<.001$) were significantly associated with post type, while other factors showed no significance ($P>.05$).

The Kaplan-Meier analysis showed that the mean survival time for each group was as follows: 12.0 years for fiber-reinforced composite resin posts, 11.8 years for cast metal posts, and 10.2 years for prefabricated metal posts. However, these differences were not significant (log-rank $P=.067$). Figure 2 shows little difference in survival among the 3 post types until year 10 when survival dropped off sharply in the prefabricated metal group.

In addition to the Kaplan-Meier analysis, the Cox proportional hazards model assessed the effect of post type while controlling for other factors. This model showed no significant effect of post type ($P=.106$) across the 3 post types and no pairwise differences (fiber versus prefabricated metal $P=.171$, cast metal versus prefabricated metal $P=.246$, cast metal versus fiber $P=.883$) (Fig. 3). The Cox analysis did find significant effects of other factors. Type of restoration was associated with survival (overall $P<.001$) (Fig. 4), with metal-ceramic,

Table 1. Parameters examined and the grading criteria involved in chart analysis

Parameter	Age	Sex	Post Type	Post Length	Root in Bone (%)	Type of Restoration	Type of Cement	Tooth Position	Opposing Dentition	Failure	Duration
Grading Scale	Years	Female = 0; male = 1	Prefabricated metal (PM) = 0; prefabricated fiber (PF) = 1; custom cast metal (CM) = 2	<2/3 of the root = 0; >2/3 of the root = 1	<75% = 0; >75% = 1	Build up, filling, or provisional restoration = 0; porcelain fused to metal crown (PFM)= 1; complete gold crown (CGC) = 2; ceramic crown (CC) = 3	Zinc phosphate (ZP) = 0; resin = 1; glass ionomer (G) = 2	Anterior = 0; posterior = 1	Natural dentition (ND) = 0; fixed dental prosthesis = 1; removable prosthesis = 2	Yes = 0; no = 1	Years

Table 2. Patient and material characteristics that were examined to determine factors affecting survival of post-and-core restorations

Factor	All Posts (N=754) N (%) or mean (SD); median [IQR] (range)	Prefab Metal Post (N=144)	Fiber-Reinforced Composite Resin Post (N=448)	Cast Metal Post-and-Core (N=162)	P Value (Fisher Exact or Kruskal-Wallis Test)
Sex					
Male	440 (52.9)	64 (44.4)	246 (54.9)	83 (51.2)	.091
Female	361 (47.9)	80 (55.6)	202 (45.1)	79 (48.8)	
Age (y)	65.0 (15.4); 68 [57, 76] (19, 96)	67.6 (14.1); 70 [60, 76] (24, 93)	62.5 (16.0); 65 [54, 74] (19, 96)	69.8 (13.4); 71 [62, 80] (29, 96)	<.001*
Post length					
1/2 root	468 (62.1)	95 (66.0)	277 (61.8)	96 (59.3)	.476
2/3 root	286 (37.9)	49 (34.0)	171 (38.2)	66 (40.7)	
% Root in bone					
<50%	5 (0.7)	0 (9)	5 (1.1)	0 (0)	.280
50-75%	195 (25.9)	32 (22.2)	114 (25.4)	49 (30.2)	
>75%	554 (73.5)	112 (77.8)	329 (73.4)	113 (69.8)	
Type of restoration					
PFM	484 (64.3)	102 (70.8)	254 (56.7)	128 (79.0)	<.0001*
CGC	60 (8.0)	12 (8.3)	25 (5.6)	23 (14.2)	
CC	88 (11.7)	12 (8.3)	69 (15.4)	7 (4.3)	
Other	122 (16.2)	18 (12.5)	100 (22.3)	4 (2.5)	
Cement					
Zinc phosphate	57 (7.6)	7 (4.9)	2 (0.4)	48 (29.6)	<.0001*
Resin	542 (71.8)	73 (50.7)	406 (90.6)	63 (38.9)	
GI	155 (20.6)	64 (44.4)	40 (8.9)	51 (31.5)	
Tooth position					
Anterior	316 (41.9)	55 (38.2)	193 (43.1)	68 (42.0)	.594
Posterior	438 (58.1)	89 (61.8)	255 (56.9)	94 (58.0)	
Opposing dentition					
Natural	525 (69.6)	109 (75.7)	326 (72.8)	90 (55.6)	<.0001*
FPD	189 (25.1)	28 (19.4)	95 (21.2)	66 (40.7)	
RPD or CD	40 (5.3)	7 (4.9)	27 (6.0)	6 (3.7)	
Duration (y)	4.3 (3.3); 3.5 [1.75, 6] (0.25, 14.5)	4.7 (3.1); 4 [2, 6.5] (0.25, 14)	3.6 (2.9); 2.8 [1.2, 5] (0.5, 14.5)	6.0 (3.7); 5.3 [3, 8.4] (0.5, 14.5)	<.001*

*Statistically significant.

complete metal, and complete ceramic all showing significantly lower risk of failure than other types (HR=0.25, 95% CI=0.149, 0.418, P<.001; HR=0.38, 95% CI=0.158, 0.891, P=.026; HR=0.33, 95% CI=0.156, 0.717, P=.005, respectively). Pairwise comparisons among metal-ceramic, complete metal, and complete ceramic showed no significant differences in survival. Type of cement was significantly associated with survival overall (P=.021) (Fig. 5), with zinc phosphate and other cement types showing significantly lower risk of failure than glass ionomer (HR=0.35, 95% CI=0.132, 0.912, P=.032 and HR=0.37, 95% CI=0.187, 0.713, P=.003, respectively). Posts with posterior tooth position had significantly better survival than anterior posts (HR=0.50, 95% CI=0.324, 0.758, P=.003; Fig. 6). Finally, patients with >75% root in bone had a significantly lower hazard of failure (HR=0.66, 95% CI=0.435, 1.01, P=.009; Fig. 7).

DISCUSSION

The data suggest that the null hypothesis stating that there is no difference in survival rate of post-and-cores as

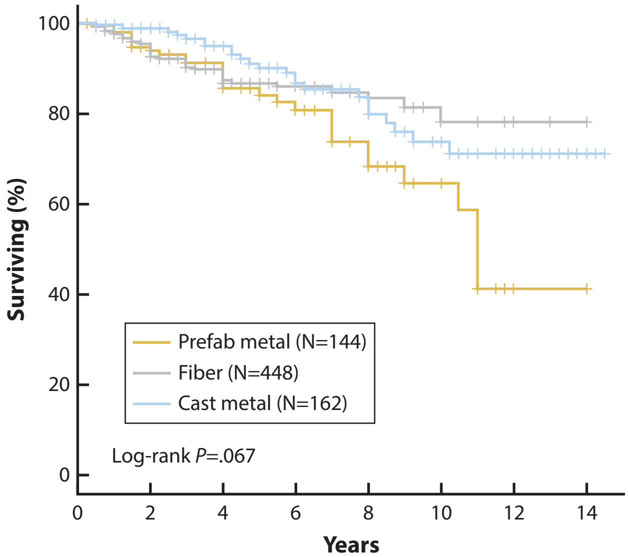

Figure 2. Kaplan-Meier plots representing cumulative survival probability for each post type. No statistically significant differences found among post types. Prefabricated metal posts presented with more failures than prefabricated fiber and cast metal posts.

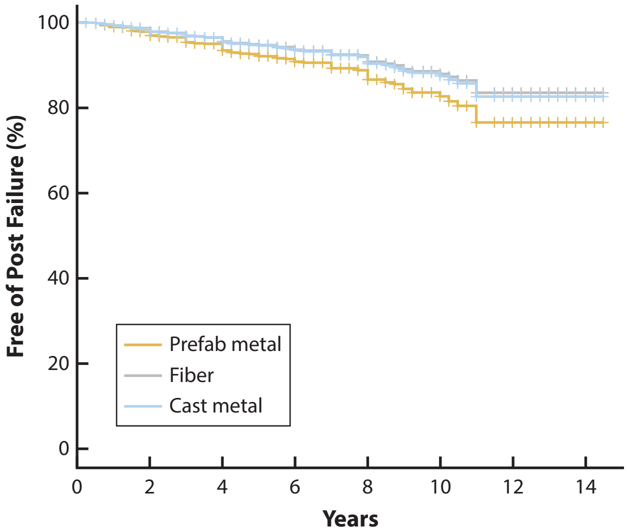

Figure 3. Cox proportional hazards analysis for post survival with respect to post type adjusted for age, sex, post length, post type, percentage of root in bone, cement type, tooth position, and opposing dentition. No statistically significant difference found among post type with regard to survival, although prefabricated metal posts had marginally increased risk of failure.

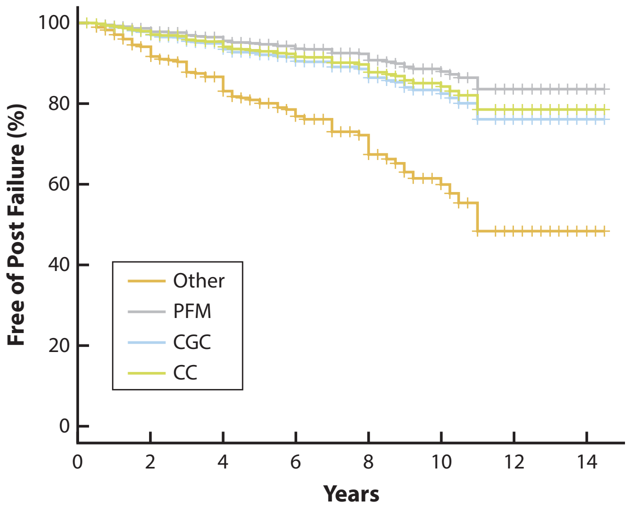

Figure 4. Cox proportional hazards analysis for post survival with respect to type of restoration. Other includes composite resin foundation and interim restorations, which showed significantly higher risk of failure ($P \leq .001$) compared with complete crown restorations. No significant difference in post survival among restorations with a complete metal crown, complete ceramic crown, or metal-ceramic crown.

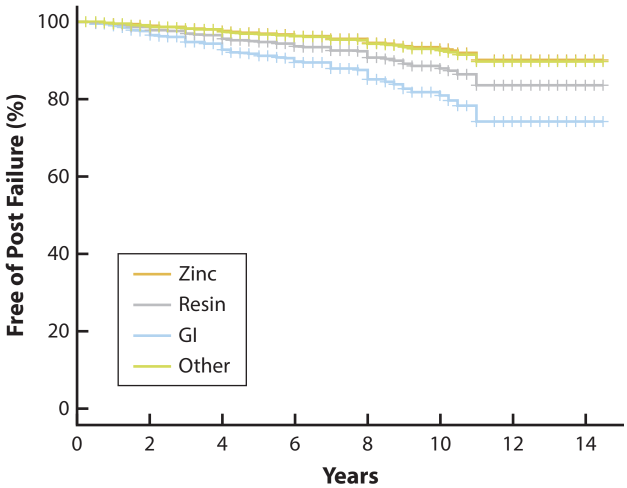

Figure 5. Cox proportional hazards analysis for post survival with respect to type of cement used. Overall, cement type played significant role (P=.021) in post survival. However, similar trend in decline found over time with respect to type of cement used.

a function of type of material should be accepted. The results of this study agree with those of a randomized controlled trial which compared glass fiber-reinforced composite resin posts with cast metal post-and-cores in teeth with no remaining coronal wall and demonstrated that post type did not significantly influence the survival of restorations.[21] The survival rates of post-and-core restorations in this study did not differ according to post type. However, Sarkis-Onofre et al[21] noted that survival rate did not differ according to tooth position. Those results do not agree with the results of this study, in which anterior teeth were shown to have a higher incidence of failure. These findings agree instead with studies by Torbjorner and Fransson[20] and Torbjorner et al.[22] A possible rationale for anterior teeth having a higher failure rate is the angulation of the teeth, which makes the teeth susceptible to shear forces and eccentric loading.

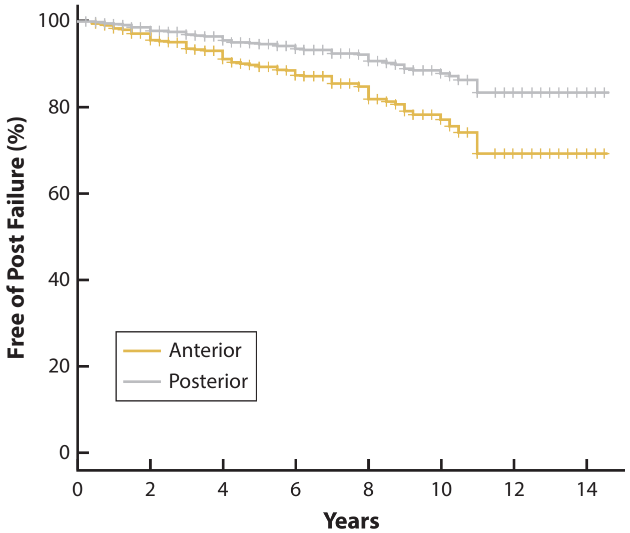

Figure 6. Cox proportional hazards analysis for post survival with respect to tooth position (anterior versus posterior). Statistically significant difference (*P*=.003) found when post placed in anterior versus posterior tooth, with anterior restorations more likely to fail.

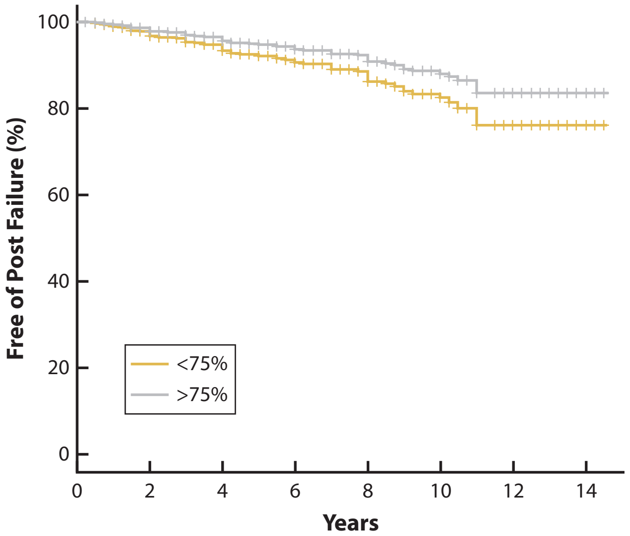

Figure 7. Cox proportional hazards analysis for post survival with respect to percentage of root surrounded by bone. Statistically significant difference (*P*=.009) found when post placed in tooth with root surrounded by greater than 75% of bone compared with tooth with root surrounded by less than 75% of bone. Posts in teeth with >75% of root in bone have marginally lower risk of failure.

The age distribution, which favored placement of fiber-reinforced composite resin posts in a younger population, can be explained by the fact that younger people demand a more esthetic result and prefer not to have metallic restorations. Another reason is that cast metal post-and-cores could have been requested by the older population, especially if they had had this type of restoration previously.

This study demonstrated that metal-ceramic crowns were placed as definitive restorations in a higher percentage of teeth that received metal posts compared with fiber-reinforced composite resin posts. The frequency of restoration with a composite resin foundation or complete ceramic crown was 37.7% for fiber-reinforced composite resin posts, 20.8% for prefabricated metal posts, and 6.8% for cast metal post-and-cores This trend is likely attributable to the fact that metal posts tend to show a grayish hue through the ceramic crowns or at best decrease the depth of translucency, thus requiring extensive masking of the post with a metal framework to maintain esthetics.[6-10] Since fiber-reinforced composite resin posts are much more esthetic, there might be a tendency to place them in the anterior region, where the functional load is not as high and complete ceramic crowns are more acceptable. However, the data do not support this as more of these fiber-reinforced composite resin posts were placed in the posterior region.

The survival analysis did confirm that when the root of a tooth is surrounded by greater than 75% of bone, a post-and-core restoration has a greater chance of survival (*P*=.009). Additionally, post-and-core restorations placed in posterior teeth are significantly more likely to survive compared with those placed in the anterior region. Posts cemented with resin or zinc phosphate cement were significantly more likely to survive compared with those cemented with glass ionomer cement. Finally, the placement of a complete coverage crown will increase the survival rate compared with a composite resin foundation or interim restoration. Placement of a complete coverage crown predicts survival rate in the following order from highest to lowest: metal-ceramic, complete ceramic, complete metal.

With respect to the considerable number of variables, several limitations were associated with this study. Because this study was retrospective in nature, the protocol for post preparation and cementation and the materials used was not standardized nor was the same clinician used. Treatment protocol most likely varied between providers, which could impact the survival rate. The post material was not always specified in the chart, and the post material had to be determined based on the radiographs. The radiographs reviewed were a mix between conventional film radiographs scanned into the electronic chart or digital radiographs. All radiographs were made with the aid of a film holder and beam alignment device, per the college's protocol. Although prefabricated metal and fiber-reinforced composite resin posts have characteristic appearances in radiographs, some posts may have been misidentified. Additionally, some of the parameters studied are difficult to quantify (such as percentage of root surrounded by bone), which introduces a certain amount of investigator bias regarding the subjectivity of the parameters. There was no documentation of post space width during preparation, which eliminated the ability to compare posts based on narrow versus flared anatomy. Hygiene, caries risk, and bone loss over time were not reported. For example, if the caries risk is relatively higher in one patient, failure due to secondary caries would be more likely than in a patient with a low caries risk. Moreover, the uncertainty of the amount of ferrule remaining and the number of dentinal walls maintained, which are indicative factors for restorative failure, were not reported.

Studies with better controlled parameters should be conducted to address this same question. According to Peroz et al,[1] prospective clinical studies with well-documented inclusion criteria for endodontically treated teeth, remaining coronal hard tissue, and flaring are lacking. A prospective or randomized controlled trial would provide more beneficial data that could be directly correlated with dental practice. Additionally, including more types of fiber-reinforced composite resin posts (resin fiber, quartz fiber, carbon fiber, woven polyethylene fiber) and different post designs (active versus passive, parallel versus tapered) would be ideal. Finally, longer observation periods with appropriate follow-up examination would enhance the results of further studies.

CONCLUSIONS

Based on the findings of this retrospective clinical study of post-and-core restorations, the following conclusions were drawn:

1. Survival is significantly more likely if the tooth root is surrounded by greater than 75% of bone tissue.
2. Survival is significantly more likely if the tooth is located in the posterior region.
3. Survival is significantly more likely if resin cement is used.
4. Survival is significantly more likely if a complete coverage restoration is provided.

REFERENCES

1. Peroz I, Blankenstein F, Lange KP, Naumann M. Restoring endodontically treated teeth with posts and cores–a review. Quintessence Int 2005;36:737-46.
2. Baba NZ. Contemporary restoration of endodontically treated teeth: evidence-based diagnosis and treatment planning. 1st ed. Chicago: Quintessence Int; 2013. p. 19-22, 61-72.
3. Assif D, Gorfil C. Biomechanical considerations in restoring endodontically treated teeth. J Prosthet Dent 1994;71:565-7.
4. Naumann M, Sterzenbach G, Dietrich T, Bitter K, Frankenberger R, von Stein-Lausnitz M. Dentin-like versus rigid endodontic post: 11-year randomized controlled pilot trial on no-wall to 2-wall defects. J Endod 2017;43:1770-5.
5. Sorensen JA, Martinoff JT. Endodontically treated teeth as abutments. J Prosthet Dent 1985;53:631-6.
6. Siebert C, Thiel N. Spinell/Luminary porcelain: Natural light optics for anterior crowns. Quintessence Dent Technol 1996;19:43-9.
7. Vichi A, Ferrari M, Davidson CL. Influence of ceramic and cement thickness on the masking of various types of opaque posts. J Prosthet Dent 2000;83:412-7.
8. Rinaldi P. Esthetic correction of PFM restoration: a case report. Pract Periodontics Aesthet Dent 1996;8:34-6.
9. Mutobe Y, Maruyama T, Kataoka S. In harmony with nature: Esthetic restoration of a nonvital tooth with IPS-Empress all-ceramc material. Quintessence Dent Technol 1997;20:83-106.
10. Frejilich S, Goodrace CJ. Eliminating coronal discoloration when cementing all-ceramic restorations over metal posts and cores. J Prosthet Dent 1992;67:576-7.
11. Subash D, Shoba K, Aman S, Bharkavi SKI, Nimmi V, Abhilash R. Fracture resistance of endodontically treated teeth restored with biodentine, resin modified GIC and hybrid composite resin as a core material. J Clin Diagn Res 2017;11:ZC68-70.
12. Bachicha WS, DiFiore PM, Miller DA, Lautenschlager EP, Pashley DH. Microleakage of endodontically treated teeth restored with posts. J Endod 1998;24:703-8.
13. Tjan AH, Sun JC. Retention of Luminex post system. Oral Health 1997;87:31-5.
14. Mendoza DB, Eakle WS, Kahl EA, Ho R. Root reinforcement with a resin-bonded preformed post. J Prosthet Dent 1997;78:10-4.
15. Utter JD, Wong BH, Miller BH. The effect of cementing procedures on retention of prefabricated metal posts. J Am Dent Assoc 1997;128:1123-7.
16. Vale WA. Cavity preparation. Irish Dent Rev 1956;2:33-41.
17. Larson TD, Douglas WH, Geistfeld RE. Effect of prepared cavities on the strength of teeth. Oper Dent 1981;6:2-5.
18. Mondelli J, Steagall L, Ishikiriama A, de Lima Navarro MF, Soares FB. Fracture strength of human teeth with cavity preparations. J Prosthet Dent 1980;43:419-22.
19. Coelho CS, Biffi JC, Silva GR, Abrahão A, Campos RE, Soares CJ. Finite element analysis of weakened roots restored with composite resin and posts. Dent Mater J 2009;28:671-8.
20. Torbjörner A, Fransson B. Biomechanical aspects of prosthetic treatment of structurally compromised teeth. Int J Prosthodont 2004;17:135-41.
21. Sarkis-Onofre R, Jacinto RC, Boscato N, Cenci MS, Pereira-Cenci T. Cast metal vs. glass fibre posts: a randomized controlled trial with up to 3 years of follow up. J Dent 2014;42:582-7.
22. Torbjörner A, Karlsson S, Odman PA. Survival rate and failure characteristics for two post designs. J Prosthet Dent 1995;73:439-44.
23. Stockton LW. Factors affecting retention of post systems: a literature review. J Prosthet Dent 1999;81:380-5.
24. Bergman B, Lundquist P, Sjögren U, Sundquist G. Restorative and endodontic results after treatment with cast posts and cores. J Prosthet Dent 1989;61:10-5.
25. Creugers NH, Mentink AG, Käyser AF. An analysis of durability data on post and core restorations. J Dent 1993;21:281-4.
26. Maroulakos G, Nagy WW, Kontogiorgos ED. Fracture resistance of compromised endodontically treated teeth restored with bonded post and cores: an in vitro study. J Prosthet Dent 2015;114:390-7.
27. Ellner S, Bergendal T, Bergman B. Four post-and-core combinations as abutments for fixed single crowns: a prospective up to 10-year study. Int J Prosthodont 2003;16:249-54.
28. Raedel M, Fiedler C, Jacoby S, Boening KW. Survival of teeth treated with cast post and cores: A retrospective analysis over an observation period of up to 19.5 years. J Prosthet Dent 2015;114:40-5.
29. Dikbas I, Tanalp J. An overview of clinical studies on fiber post systems. ScientificWorldJournal 2013;2013:171380-7.
30. Zhou L, Wang Q. Comparison of fracture resistance between cast posts and fiber posts: a meta-analysis of literature. J Endod 2013;39:11-5.
31. Dietschi D, Duc O, Krejci I, Sadan A. Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature, Part II (Evaluation of fatigue behavior, interfaces, and in vivo studies). Quintessence Int 2008;39:117-29.
32. Martínez-Insua A, da Silva L, Rilo B, Santana U. Comparison of the fracture resistances of pulpless teeth restored with a cast post and core or carbon-fiber post with a composite core. J Prosthet Dent 1998;80:527-32.
33. Cloet E, Debels E, Naert I. Controlled clinical trial on the outcome of glass fiber composite cores versus wrought posts and cast cores for the restoration of endodontically treated teeth: a 5-year follow-up study. Int J Prosthodont 2017;30:71-9.
34. Fokkinga WA, Kreulen CM, Vallittu PK, Creugers NH. A structured analysis of in vitro failure loads and failure modes of fiber, metal, and ceramic post-and-core systems. Int J Prosthodont 2004;17:476-82.
35. McDonald AV, King PA, Setchell DJ. In vitro study to compare impact fracture resistance of intact root-treated teeth. Int Endod J 1990;23:304-12.
36. Assif D, Bitenski A, Pilo R, Oren E. Effect of post design on resistance to fracture of endodontically treated teeth with complete crowns. J Prosthet Dent 1993;69:36-40.
37. Marchionatti AME, Wandscher VF, Rippe MP, Kaizer OB, Valandro LF. Clinical performance and failure modes of pulpless teeth restored with posts: a systematic review. Braz Oral Res 2017;31:1-14.

38. Sarkis-Onofre R, Fergusson D, Cenci MS, Moher D, Pereira-Cenci T. Performance of post-retained single crowns: a systematic review of related risk factors. J Endod 2017;43:175-83.
39. Al-Thobity AM. Clinical outcomes of zirconium-oxide posts: up-to-date systematic review. Compend Contin Educ Dent 2016;37:e17-20.
40. Barfeie A, Thomas MB, Watts A, Rees J. Failure mechanisms of fibre posts: a literature review. Eur J Prosthodont Restor Dent 2015;23:115-27.
41. Figueiredo FE, Martins-Filho PR, Faria-E-Silva AL. Do metal post-retained restorations result in more root fractures than fiber post-retained restorations? A systematic review and meta-analysis. J Endod 2015;41:309-16.
42. Schmitter M, Sterzenbach G, Faggion CM, Krastl G. A flood tide of systematic reviews on endodontic posts: methodological assessment using of R-AMSTAR. Clin Oral Investig 2013;17:1287-94.
43. Theodosopoulou JN, Chochlidakis KM. A systematic review of dowel (post) and core materials and systems. J Prosthodont 2009;18:464-72.
44. Heydecke G, Peters MC. The restoration of endodontically treated, single-rooted teeth with cast or direct posts and cores: a systematic review. J Prosthet Dent 2002;87:380-6.

Corresponding author:
Dr Josephine F. Esquivel-Upshaw
University of Florida College of Dentistry
1395 Center Drive, Room D9-6
Gainesville, FL 32610
Email: jesquivel@dental.ufl.edu

https://doi.org/10.1016/j.prosdent.2019.05.003

Noteworthy Abstracts of the Current Literature

Assessing the accuracy of casting and additive manufacturing techniques for fabrication of a complete palatal coverage metal framework

Forrester K, Sheridan R, Phoenix RD

J Prosthodont 2019 Aug;28:811-17

Purpose. To provide information regarding the accuracy of additive manufacturing in comparison to conventional casting, specifically for fabrication of complete palatal coverage metal frameworks.

Material and Methods. Three additive manufacturing techniques were tested: selective laser melting (SLM), electron beam melting (EBM), and computer-aided design/cast (CADcast), with conventional casting as the control. Both the SLM and EBM groups were tested pre- and post-finishing, for a total of six test groups (n=10/group). A digital master design was used as the standard to which all frameworks were digitally compared by best-fit analysis, which generated root mean square values using proprietary software. A one-way ANOVA was conducted to test for statistical differences among materials, followed by a post-hoc multiple comparison test (Tukey's test HSD). Surface roughness for one framework arbitrarily selected from each group was analyzed using a profilometer.

Results. There was a significant difference in accuracy among the materials ($F=99.79$, $P<0.0001$). A post-hoc Tukey test indicated that CADcast differed significantly from the other five materials (i.e., most accurate, $P< 0.01$). EBM prefinished and EBM finished were both significantly different from the other materials (i.e., least accurate). Color mapping images help visualize the differences between each framework compared to the master design. The surface roughness values ranged from 22 to 63.5 μm, with CADcast being the smoothest, and EBM prefinished the roughest.

Conclusions. CADcast and SLM techniques were as or more accurate than the conventional technique for producing an uncomplicated framework design. Further investigation is recommended regarding the surface roughness of additive manufacturing products and potential biological complications.

Reprinted with permission of The American College of Prosthodontists.