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Ferrari, M, Sorrentino, R, Juloski, J et al. (4 more authors) (2017) Post-Retained Single Crowns versus Fixed Dental Prostheses: A 7-Year Prospective Clinical Study. Journal of Dental Research, 96 (13). pp. 1490-1497. ISSN 0022-0345

https://doi.org/10.1177/0022034517724146

TITLE PAGE

Post-retained single crowns vs fixed dental prostheses: 7-years results

Marco Ferrari[1,2], Roberto Sorrentino[1,3], Jelena Juloski[4], Simone Grandini[5], Michele Carabba[1], Nicola Discepoli[6], Edoardo Ferrari Cagidiaco[7]

[1] Department of Medical Biotechnologies, Division of Fixed Prosthodontics, University of Siena, Siena, Italy; [2] Department of Restorative Dentistry, University of Leeds, UK.

[3] Department of Neurosciences, Reproductive and Odontostomatological Sciences, University Federico II, Naples, Italy.

[4]Department of Pedodontics, University of Belgrad, Serbia.

[5] Department of Medical Biotechnologies, Division of Restorative Dentistry and Endodontics, University of Siena, Siena, Italy.

[6] Department of Medical Biotechnologies, Division of Peridontics, University of Siena, Siena, Italy.

[7] Department of Medical Biotechnologies, Division of Peridodontics, Complutense University, Madrid , Spain.

Corresponding author:

Prof. Marco Ferrari, MD, DMD, Ph D

Department of Medical Biotechnologies, Division of Fixed Prosthodontics, University of Siena, Siena, Italy

Policlinico Le Scotte, vialeBracci, Siena 53100, Italy; phone: +39(0577)233131; fax: +39(0577)233117; e-mail: ferrarm@gmail.com

Abstract

The objective of this prospective clinical trial was to assess the influence of the type of prosthetic restoration as well as the degree of hard-tissue loss on 7-year clinical performance of endodontically treated teeth restored with fiber posts. Two groups (n=60) were defined depending on the type of prosthetic restoration needed: (1) single unit porcelain-fused to metal (PFM) crowns (SCs) and (2) 3-4 unit PFM fixed dental prostheses (FDPs). Within each group, samples were randomly divided into 2 subgroups (n=30) according to the amount of residual coronal tissues after abutment build-up and final preparation: (A) more than 50% of coronal residual structure, (B) equal to or less than 50% of coronal residual structure. The clinical outcome was assessed based on clinical and intra-oral radiographic examinations at the recalls after 6, 12, 24, 36, 48 and 84 months. Data were analyzed by Kaplan-Meier Log Rank test and Cox regression analysis ($p<0.05$). The overall 7-year survival rate of endodontically treated premolars restored with fiber post and either PFM SCs or FDPs was 69.2%. The highest 84-months survival rate was recorded in Group 1A (90%), whereas teeth in Group 2B exhibited the lowest performance (56.7% survival rate). The Log Rank test detected statistically significant differences in survival rates among the groups ($p=0.048$). Cox regression analysis revealed that the amount of residual coronal structure ($p=0.041$) and the interaction between the type of prosthetic restoration and the amount of residual coronal structure ($p=0.024$) were statistically significant factors for survival. (ClinicalTrials.gov number CT01532947)

Word count (abstract): 248

Total word count: 2822

Total number of tables/figures: 5

Number of references: 36

Keywords: endodontically treated teeth, post and core restoration, resin cement, tooth preparation, prospective clinical trial, survival rate, clinical performance, single crown, fixed dental prosthesis.

Introduction

The use of fiber-reinforced composite posts (i.e. fiber posts) for restoring endodontically treated teeth has been extensively investigated over the past 20 years (Peroz et al. 2005; Schwartz and Robbins 2004) and favorable physical properties and optimal biocompatibility were reported as their main advantages (Dietschi et al. 2008; Goracci and Ferrari 2011; Tay and Pashley 2007). However, as biomechanical integrity of endodontically treated teeth is compromised, making optimal treatment planning and choosing the most suitable techniques and adequate materials for restoring endodontically treated teeth may be difficult.

The amount of remaining sound coronal tissues is considered very important for clinical performance of fiber post-restored teeth. In particular, preservation of at least a circumferential 2-mm ferrule may contribute to improve tooth mechanical resistance and is considered one of the key factors affecting tooth longevity (Jotkowitz and Samet 2010; Juloski et al. 2014a; Juloski et al. 2012; Stankiewicz and Wilson 2002). Several clinical studies have been conducted specifically aiming at revealing the influence of the degree of hard tissue loss on the survival of endodontically treated and fiber post-restored teeth (Ferrari et al. 2012a; Juloski et al. 2014b; Mancebo et al. 2010; Signore et al. 2011). Although the results showed low percentages of failure rates and satisfactory overall survival rates, higher occurrence of failures were recorded in teeth with higher degree of tissue loss (Ferrari et al. 2012a; Juloski et al. 2014b; Mancebo et al. 2010; Signore et al. 2011).

Moreover, in all abovementioned clinical studies, teeth were restored with fiber posts and full porcelain-fused-to-metal (PFM) or all-ceramic crowns. However, the influence of the type of the final prosthetic restoration on the clinical performance must be considered. Also, care should be taken to make optimal treatment planning, in terms of occlusal loads and parafunctional stresses the restored tooth might be exposed to. Unfortunately, data about these issues are scarce in the current scientific literature. It has been reported that position of teeth (Naumann et al. 2005b; Schmitter et al. 2011; Schmitter et al. 2007) and presence of adjacent elements (Naumann et al. 2005b; Naumann et al. 2008) were significant predictors of failure. Conversely, another study did not reveal any difference in clinical behavior among incisors, canines, premolars and molars (Mancebo et al. 2010). Regarding the type of final restoration, an observational prospective clinical study reported that the type of final restoration represents a significant predictor for failure in fiber-post retained restorations (Naumann et al. 2005b). Nevertheless, a recently published review on randomized controlled clinical studies (RCTs) (Sorrentino et al. 2016) confirmed that a univocal correlation between failure rates of fiber post-restored teeth and the type of prosthetic restoration (SC or FDP) cannot be found.

Therefore, the aim of this prospective clinical study was to assess the 7-year clinical performance of endodontically treated teeth restored with fiber posts and either single unit crowns (SCs) or fixed dental prostheses (FDPs) and to investigate whether the degree of hard-tissue loss affected the clinical outcome.

The null hypothesis tested was that neither the type of prosthetic restoration nor the amount of coronal tissues remaining after abutment preparation had a significant effect on the 7-year survival of endodontically treated teeth restored with fiber posts.

Material and methods

The protocol for this prospective clinical study was approved by the Institutional Review Board of the University of Siena, Italy (ClinicalTrials.gov number CT01532947). In total, 120 patients who consecutively presented at a private dental office for receiving endodontic treatment on teeth in posterior areas that were subsequently prepared as abutments for SCs or 3- to 4-unit FDPs participated in the study. Each FDP had no more than 1 endodontically treated and fiber post-restored abutment.

After receiving clear information about the purpose of the trial, according to a preliminarily approved protocol, all patients provided written, informed consent before entering the study. The study population consisted of 53 males and 67 females (age ranged between 18-76 years, with a mean of 49 years). Between January 2008 and December 2009, endodontic treatment was performed and fiber posts were placed by a single experienced operator with expertise in the fields of endodontics and prosthodontics. Baseline radiographs of the endodontically treated teeth included in the study did not show any signs of periapical lesions.

Two experimental groups (n = 60) were defined as follows, according to the type of prosthetic restoration needed by each single patient:

Group 1 - Single unit PFM SCs;

Group 2 - 3- to 4-unit PFM FDPs.

Two experimental subgroups (n = 30) were defined as follows, according to the amount of tissues left at the coronal level after endodontic treatment and abutment preparation:

Group A - More than 50% of residual coronal structure. at least 2 sound walls and a 1.5-mm ferrule effect of the endodontically treated and fiber post-restored abutment;

Group B- Equal to or less than 50% of residual coronal structure, at least 1 sound wall and a 1.5-mm ferrule effect of the endodontically treated and fiber post-restored abutment.

A ‘wall’ was defined as a residual coronal structure of at least 3 mm in height. In the teeth with more than 1 root, only 1 post was placed.

Clinical Procedures

The procedures followed for the endodontic treatment, post space preparation and fiber post cementation are described in detail in Table 1. The crown preparation varied from a full chamfer with interproximal and lingual bevels to a feather-egde finish line, depending on the height and thickness of the remaining structure. PFM SCs or FDPs were fabricated and luted with a glass-ionomer cement (Fuji Cem, GC Corp.).

Evaluation Parameters

The clinical outcome was assessed based on clinical and intra-oral radiographic examinations at the recalls after 6, 12, 24, 36, 48 and 84 months. Periapical radiographs were taken with the modified parallel technique and Ultra-Speed films (Eastman Kodak Company, Rochester, NY, USA) and examined at 5x magnification.

Two blinded, well-trained examiners, other than the operator who had carried out the restorative treatment, performed evaluation of the outcome independently. To obtain the maximum unbiased comparison, observers were calibrated. The following events were recorded as failures: (1) post debonding, (2) post fracture, (3) vertical or horizontal root fracture and (4) periapical lesions requiring endodontic retreatment. The criterion for survival was no signs of any kind of clinical failure.

Statistical Analysis

Survival rates were calculated by the non-parametric Kaplan Meier survival analysis. The fiber-post retained restorations were defined as either surviving or not surviving according to the following criteria: survival was a positive, censored event, whereas non-survival was defined as the negative, uncensored event (JELENA PUOI CONTROLLARE? NON DOVREBBE ESSERE IL CONTRARIO TRA CENSORED E UNCENSORED?). The cementation of the final restorations (SCs or FDPs) was considered as the analysis baseline. Time until failure or censoring was recorded in months. The end of observation for a failed restoration was when the failed restoration was detected during the follow-up appointment. The null hypothesis that there is no difference among the groups in the probability of failure was tested by means of the Log Rank test.

Additionally, the Cox regression analysis was used to assess the influence of the type of prosthetic restoration (SC vs FDP), the amount of residual coronal tooth structure (more than 50% vs equal to or less than 50% of residual coronal structure), as well as the interaction between the 2 variables on the survival rate.

The level of significance was set at $p < 0.05$ and statistical calculations were handled with IBM SPSS Statistics software version 21 for Mac (SPSS Inc., Chicago, IL, USA).

Results

Data were not affected by any loss at follow-up. The overall 7-year survival rate of endodontically treated restored with fiber post and either PFM SCs of FDPs was 69.2%. Teeth with more than 50% of coronal structure restored with SCs (Group 1, Subgroup A) had the highest 84-months survival rate (90%). Conversely, the least satisfactory clinical performance was recorded for fiber-post restored teeth with equal to or less than 50% of coronal residual structure prepared as 1 of the abutments for FDPs (Group 2, Subgroup B, survival rate 56.7%). Table 2 reports survival rates after 7-year observation period in the experimental groups.

The results of the Kaplan-Meier analysis of cumulative survival rate for the 4 experimental groups are presented in Figure 1a. The Log Rank test determined that there were significant differences among the 4 groups (p=0.048). The Kaplan Meier plot is presented in Figure 1.

The Cox regression analysis revealed that the type of prosthetic restoration did not have a significant influence on the restoration failure risk (p=0.120; Hazard ratio, HR=1.695; 95% Confidence Interval, CI, for HR=0.872-3.295). Conversely, the amount of coronal residual structure significantly influenced the restoration failure risk (p=0.041; HR=2.026; 95% CI for HR=1.031-3.982). However, the interaction between the 2 variables was also found to have a significant influence on the survival of fiber-post restored teeth (p=0.024; HR 1.372; 95% CI for HR 1.042-1.806).

The distribution of failure modes over 7-year evaluation period among the groups is presented in Table 3.

Discussion

The results of the present study indicated that the risk of failure in endodontically treated and fiber post-restored teeth was significantly influenced by the amount of coronal residual structure during 7 years of clinical service. The interaction terms of the 2 investigated variables (i.e. the type of prosthetic restoration and the amount of coronal residual structure) were also statistically significant factors for survival. Additionally, the Kaplan Meier survival analysis showed statistically significant differences among the groups. Therefore, the null hypothesis was rejected.

The present study revealed the satisfactory overall 7-year survival rate of endodontically treated posterior teeth restored with fiber post and either PFM SCs or FDPs (69.2%, regardless of the type of prosthetic restoration and the amount of hard-tissue loss). This findings are in agreement with a substantial number of previously published studies (Ferrari et al. 2012a; Guldener et al. 2017; Juloski et al. 2014b; Sterzenbach et al. 2012) and reviews (Cagidiaco et al. 2008b; Ploumaki et al. 2013) on the clinical performances of fiber-post restored teeth.

To the best of our knowledge, this study is the first RCT study to report results on long-term performance of endodontically treated teeth restored with fiber posts and FDPs compared to SCs. The Log Rank test determined that there were significant differences in the survival rates among the 4 groups ($p=0.048$). The highest survival rate was found in teeth with >50% of tooth structure restored with SC (90.0%) while the lowest survival rate was recorded in teeth with <50% of remaining tooth structure restored with FDPs (56.7%). Teeth from the remaining 2 groups exhibited similar survival rates (SC and <50% of tooth structure 63.3%, FDP with >50% of tooth structure 66.7%).

Regardless of the type of prosthetic restoration (SC or FDP), the survival of teeth with >50% of residual coronal structure and at least 2 sound walls was 78.3% and survival of teeth with equal to or less than 50% of residual coronal structure and at least 1 sound wall was 60% over 7 years. The Cox regression analysis revealed that the degree of hard tissue loss was a significant risk factor associated with survival (p=0.041). This finding is in accordance with the majority of laboratory (Akkayan 2004; da Silva et al. 2010; Lima et al. 2009) and clinical studies (Cagidiaco et al. 2008a; Creugers et al. 2005; Ferrari et al. 2007b; Ferrari et al. 2012b; Juloski et al. 2014b) agreeing on the fact that more coronal structure positively affects the prognosis of endodontically treated teeth. However, the present study revealed another important information: when endodontically treated teeth that suffered considerable loss of the tooth structure are restored, the type of the final restoration becomes an important issue. The interaction between the 2 variables (type of restoration*amount of remaining tooth structure) was statistically significant (p=0.024), indicating that less predictable outcome could be expected when structurally compromised teeth are restored with a FDPs than with SCs. In other words, the amount of remaining tooth structure becomes even more important when fiber-post restored teeth are planned to be abutments for FDPs than for SCs. However, in the present study only 1 of the abutments of 3- to 4-unit FDPs was endodontically treated and fiber post-restored and therefore different results could be expected if the clinical situation was different and if more than 1 abutment needed endodontic treatment and fiber post placement.

Moreover, only 1 previous study (Juloski et al. 2014b), in addition to the present one, evaluated the amount of coronal tooth structure after the abutment preparation. All clinical studies published over the last years (Ferrari et al. 2007a; Ferrari et al. 2007b; Ferrari et al. 2012a; Mannocci et al. 2002; Monticelli et al. 2003; Naumann et al. 2005b; Schmitter et al. 2011; Zicari et al. 2011) assessed the residual tooth structure before the abutment preparation, which may have led to overestimation of the amount of tissues actually remaining at the coronal level, as preparation of finish margins and axial walls leads to the additional loss of tooth structure and reduction of the number of residual walls. In one study, the teeth were categorized according to the expected dentin height after tooth preparation, which in fact represented a prediction made by the operator (Creugers et al. 2005). Therefore, in order to obtain more dependable facts on the importance of the amount of coronal dentin and ferrule effect on clinical performance of endodontically treated teeth, it would be advisable to perform the calculation of the remaining tooth structure after the abutment preparation in future clinical studies.

Furthermore, a resin cement with high-filler-content (Gradia Core), suitable for core build-up as well as for fiber post luting, was used in the present study, as the use of such material could simplify the clinical procedures and results in more mechanically homogeneous restorations (Boschian Pest et al. 2002). Also, the results of a recent clinical study (Juloski et al. 2014b) encouraged the use of material for simultaneous post luting and core build-up for restoration of endodontically treated teeth with fiber posts.

Regarding the type of failure, root fractures leading to tooth extraction did not occur only in Group 1A. In the other groups, root fractures were observed for the first time after 3 years of clinical service, with a higher rate in the last few years that can be due to the deterioration of the adhesive interface or cumulative mechanical stress. Previous studies investigating survival of endodontically treated premolars (Cagidiaco et al. 2008a; Creugers et al. 2005; Ferrari et al. 2007b; Ferrari et al. 2012b) confirmed that higher occurrences of failures were recorded as the observation time increased. Throughout 7 years of clinical service, 4 teeth (13.3%) were extracted in Group 1B, 5 teeth (16.7%) in Group 2A and 7 teeth (23.3%) in Group 2B. Among the other failure modes, the most common type of failure was periapical lesion that occurred in 15 teeth (12.5%), which may be attributed to inadequate endodontic treatment, followed by post debonding occurring in 13 teeth (10.83%). These results confirm previous findings (Cagidiaco et al. 2008b; Ploumaki et al. 2013; Sorrentino et al. 2016). Post fractures were noticed only in 1 tooth (3.3%) from group 1A and in 1 tooth from group 1B. In contrast to this findings, fiber post fracture has been reported as a frequent type of failure (Naumann et al. 2005a). The distribution of failure modes among the groups observed after 84 months are reported in Table 3. However, all other failures beside the root fracture were considered favorable and restorable. In all those cases, the teeth could be restored in the same manner as described previously and they remained in clinical service.

To a certain extent, the results of the present study are in disagreement with previously reported higher failure rates for SCs and combined fixed-removable dental prostheses compared to failure rates of FDPs (Naumann et al. 2005b). However, those are the results of a prospective cohort study performed on different types of teeth and different types of post on a relatively small sample size and small number of failures. In addition, the same study reported that anterior teeth had 3 times higher failure rate than posterior teeth. All prosthetic restorations evaluated in this study were placed in posterior regions. It cannot be extrapolated that the results recorded in this study can be similar in anterior teeth, since anterior teeth are exposed to higher horizontal forces causing tension stress during lateral and protrusive movements compared to more perpendicular compressive forces acting on posterior teeth. Therefore, as the maxillary anterior regions could be considered to be high-risk areas for failures (Naumann et al. 2005b; Naumann et al. 2008; Schmitter et al. 2011; Torbjorner and Fransson 2004), further similar clinical studies evaluating the performance of endodontically treated and fiber-post restored anterior teeth are desirable.

In conclusion, over a 7-year observation period, the clinical performance of endodontically treated and fiber post-restored teeth with SCs and FDPs was significantly affected by the degree of hard-tissue loss. Higher degree of hard-tissue loss increased the risk of failure. Less predictable clinical outcome could be expected when teeth with insufficient coronal structure are restored with FDPs than with a SCs.

Acknowledgments

The authors report no conflict of interest.

FIGURES AND TABLES

Figure 1. Kaplan-Meier survival curves for 4 experimental groups (significant differences among the groups, Log Rank test, p=0.048).

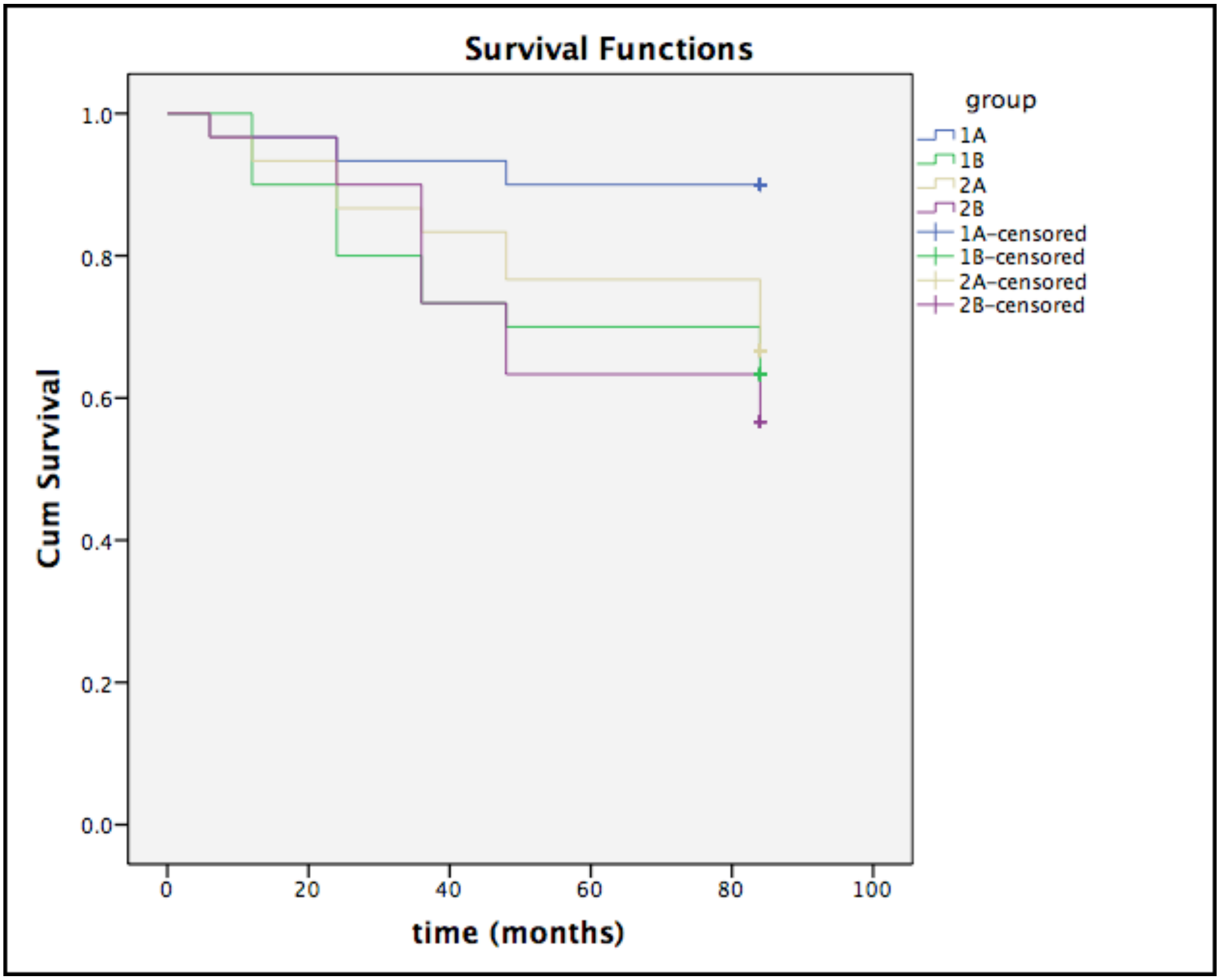

Figure 2. Consort flow diagram.

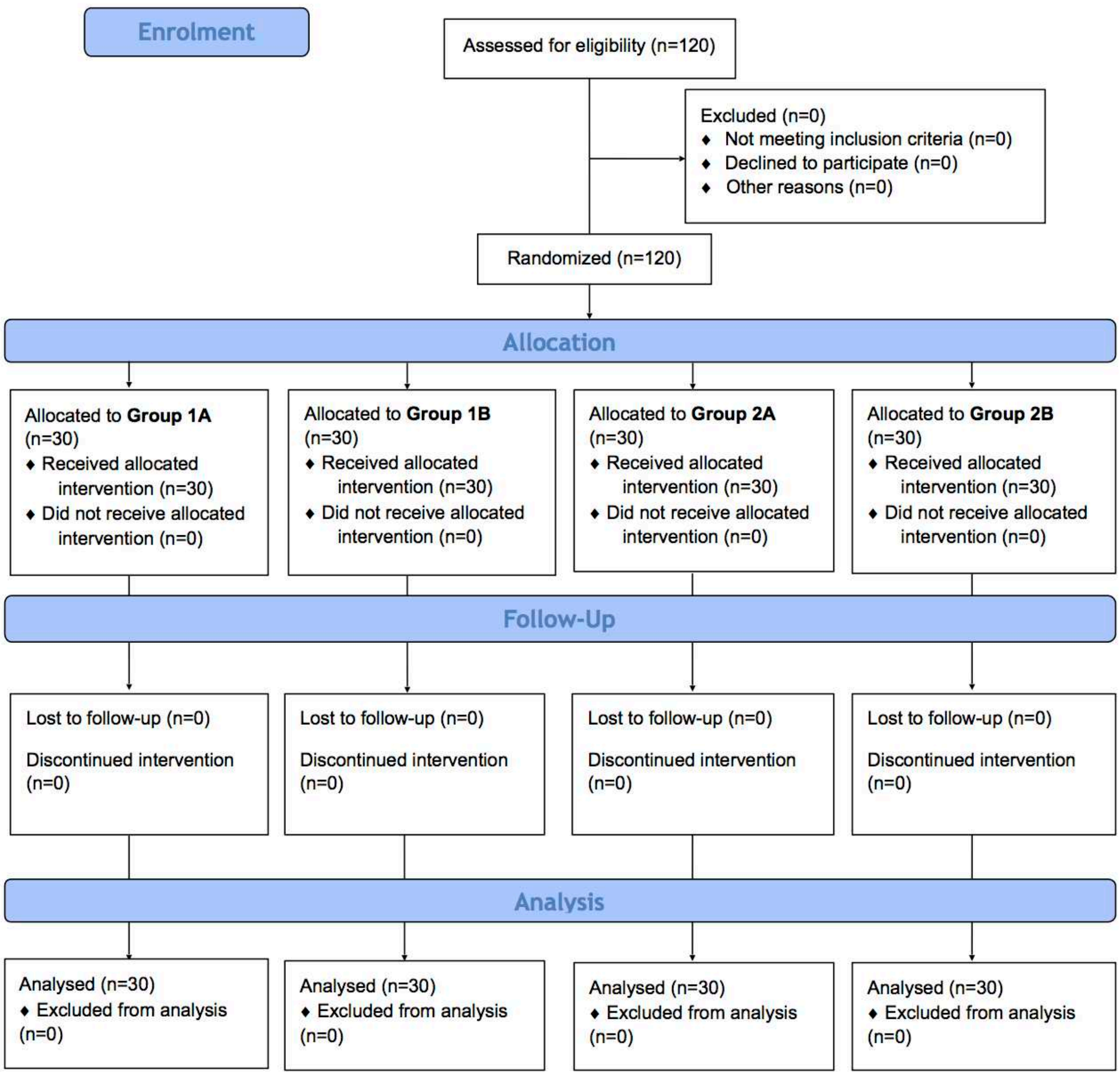

Table 1. Detail description of clinical procedures followed in endodontic treatment and post space preparation and cementation.

Endodontic treatment	
-	Canal instrumentation with K-files (#8-10-15, Dentsply Maillefer, Ballaigues, Switzerland) and Flexmaster rotary instruments (#15-20-25-30-35-40; VDW, Munich, Germany) mounted on the endodontic motor (Endo IT professional, Aseptico Inc., Woodinville, WA, USA) to a working length of 0.5 mm from the apex;
-	Irrigation with 5.25% sodium hypochlorite using a long 27-gauge needle at each change of instrument;
-	Final rinse with deionized water and patency of the canal maintained with a #10 K-file;
-	Drying the canals with multiple paper points;
-	Obturation with gutta-percha using the continuous wave technique up to 4-5mm from the apex with a System B heat source (SybronEndo, Orange, CA, USA);
-	Backfilling of the canals using termoplastic gutta-percha from Obtura II Unit (Obtura Corp., Fenton, MO, USA);
-	Sealing the canal access with glass-ionomer cement (Fuji IX, GC Corp., Tokyo, Japan).
Post space preparation	
-	Removing the temporary coronal seal at least 24 hours after endodontic treatment;
-	Preparation of post spaces 7-8 mm in depth with pre-calibrated drills provided by the manufacturer (GC Corp.); at least 4 mm of intact apical seal left;
-	Choosing post size to fit best the diameter of the canal (diameter of the post 1.2mm, 1.4mm or 1.6mm);
-	Trying-in the post and shortening with a diamond bur to an adequate length;
-	Pre-treating the post with a silane coupling agent (GC Ceramic Primer, GC Corp.).
Fiber post cementation	
-	Application of Self-Etching Bond (GC Corp.) by dispensing of one drop of Bond Liquid A and B into the dispensing dish, mixed thoroughly for 5 sec by means of the micro-tip applicator;
-	Application of the mixture inside the post space and on the residual coronal structure, left undisturbed for 30 sec, gently air-dried, and light-cured for 10 sec with a visible light- curing unit (GC Light, GC Corp.);
-	Gradia Core (GC Corp.) was dispensed into the prepared root canal through an Automix Endo tip;
-	Insertion of the post (GC Fiber Post, GC Corp.) and light-curing (5 sec) to fix its position temporarily;
-	The paste was dispensed around the post to form the core, light-curing from the vestibular and lingual sides (10 sec each side) for final setting.

Table 2. Cumulative survival rates recorded in experimental groups over 84-months observation period.

Type prosthetic of restoration	Amount of residual coronal dentin		Baseline	6 months	12 months	24 months	36 months	48 months	84 months
1. Single-unit PFM crown	A. >50%	Cumulative survival	30/30 (100%)	29/30 (96.6%)	29/30 (96.6%)	28/30 (93.3%)	28/30 (93.3%)	27/30 (90%)	**27/30 (90%)**
	B. <50%		30/30 (100%)	30/30 (100%)	27/30 (90%)	24/30 (80%)	22/30 (73.3%)	21/30 (70%)	**19/30 (63,3%)**
2. 3-4 Unit PFM FDP	A. >50%		30/30 (100%)	29/30 (96.6%)	28/30 (93.3%)	26/30 (86,6%)	25/30 (83.3%)	23/30 (76.6%)	**20/30 (66,7%)**
	B. <50%		30/30 (100%)	29/30 (96.6%)	29/30 (96.6%)	27/30 (90%)	22/30 (73.3%)	19/30 (63.3%)	**17/30 (56,7%)**

Table 3. Distribution of failure modes among the groups observed after 84 months of clinical service. PAL= periapical lesion; PoDe = post debonding; PoFr = post fracture; RoFr = root fracture.

Type prosthetic of restoration	Amount of residual coronal dentin		Type of failure			
			PAL	PoDe	PoFr	RoFr
1. Single-unit PFM crown	A. >50%	Number (%) of teeth failed	2 (6.6%)	0 (0%)	1 (3.3%)	0 (0%)
	B. <50%		4 (13.3%)	4 (13.3%)	1 (3.3%)	4 (13.3%)
2. 3-4 Unit PFM FDP	A. >50%		4 (13.3%)	4 (13.3%)	0 (0%)	5 (16.6%)
	B. <50%		5 (16.6%)	5 (16.6%)	0 (0%)	7 (23.3%)
		Total number (%) of teeth failed	15 (12.5%)	13 (10.83%)	2 (1.6%)	16 (13.3%)

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