A 10-Year Follow-Up of Different Intra-Radicular Retainers in Teeth Restored with Zirconia Crowns

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Abstract: Purpose To evaluate the survival rate in restored teeth with three different types of retainers prior to the fixing of crowns with zirconia through this retrospective clinical study. It is unclear how the type of post and core rehabilitation, and type of resin cement affect the longevity of teeth restored with crowns. Methods In a private clinic, a total of 101 retainers installed by the same professional between June 2008 and January 2018, with an average time of 58.2 months (4.8 years), were analyzed regarding the following factors: survival, cement and failure type. Three types of retainers were used according to the indications found in the literature: filling with Z250 light-cured composite resin, 22 elements; fiberglass post with Z250 light-cured composite resin, 45 elements; and cast metallic core in silver-tin alloy, 34 elements. The retainers were cemented with chemically cured cement, U100, U200, or Panavia F. Results Data were subjected to Kaplan-Meier analysis (p=0.495). Although the study presented several limitations, no significant differences were observed in the success rates between the types of intra-radicular retainers and the type of cement. The success rates were as follows: metal core, 97.1%; fiberglass post, 95.6%; and filling, 100%. On average, failures occurred at 48.4 months. Conclusion In view of the results, it is possible to conclude that the different retainers evaluated have similar survival rates.

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Survival of Metal-free Crowns With and Without Different Intra-Radicular Posts: Up To 10-Year Clinical Follow-Up

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Short title: Post-and-core and zirconia crown survival

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Abstract
**Purpose:** To evaluate the survival rate in teeth restored with full crowns onto zirconia copings with and without different types of post and cores through a retrospective clinical study.

**Material and Methods:** One hundred one (101) full crowns with copings in zirconia were placed by the same operator from June 2008 till January 2018, they were in function an average time of 58.2 months (4.8 years). They were analyzed regarding the following factors: survival, cement and failure type. Three types of intra-radicular post were used according to the indications found in the literature: restoration with Z250 light-cured composite resin, 22 elements; fiberglass posts with Z250 light-cured composite resin, 45 elements; and cast metallic cores made from silver-tin alloy, 34 elements. The post and core were cemented with chemically cured cement, U100, U200, or Panavia F.

**Results:** Data were subjected to Kaplan-Meier analysis (p=0.495). No significant differences were observed in the success rates between the types of intra-radicular post and core and the type of cement. The success rates were as follows: metal core, 97.1%; fiberglass post, 95.6%; and restoration, 100%. On average, failures occurred at 48.4 months.

**Conclusion:** According to the results of this study, with and without posts, survival of full crowns onto zirconia copings were similar after 10 years.

**Clinical Significance:** Different intra-radicular posts may present similar success rates under metal-free full crowns when properly indicated and prepared.

**Keywords** Endodontically treated teeth, Post-and-core technique, Ceramic crown.
Introduction

Caries, fractures, invasive endodontic access preparations, trauma, non-carious lesions, and extensive restorations can generate coronal loss of tooth structure. Teeth with severe damage may require restorations with intra-radicular post and core.\textsuperscript{1-7} In this cases, the remaining tooth structure is no longer sufficient, especially when the coronal destruction involves greater than 50\% of the structure.\textsuperscript{8}

Post and cores can be made of different materials: metal (prefabricated or cast), prefabricated fiberglass, or ceramic.\textsuperscript{9-11} Regardless of the material, post and core do not strengthen the tooth (teeth); it only confers retention for the restoration.\textsuperscript{2} Post and cores that have properties similar to those of dental structures can reduce stress generated around it\textsuperscript{12} and minimize the risk of root fracture.

The selection of the post and core system to be used is a complex procedure, and the quantity and quality of remaining tooth structure, the occlusion of the patient, and the type of restoration to be performed should be taken into account.\textsuperscript{13} The cast metallic requires molding of the root cavity, which can be performed with acrylic resin or impression materials, a process that takes a longer time and makes the procedure more expensive. This procedure can be performed using several alloys, such as gold (Au), titanium (Ti), nickel-chromium (Ni-Cr), and others.\textsuperscript{14}

In contrast, prefabricated posts can be made usually in a single clinical visit (resin-reinforced fiberglass), and carbon, glass, quartz, or polyethylene fibers can be incorporated into a resin matrix.\textsuperscript{14}

The fiberglass posts are white or transparent and are therefore advantageous when the aesthetics of crowns in vitreous ceramics with high translucency are dependent on the color of the substrate.\textsuperscript{15} However, the lack of remnant structure challenges the use of this system, which is indicated when there is 1.5 to 2.0 mm of remnant coronary structure. \textsuperscript{16-17}

In addition to the coloration, the fiber post also has an elastic modulus that is more similar to that of the dentin.\textsuperscript{18,16} This mechanical property, closer to that of dentinal structures, generates a uniform distribution of stress at the root, reducing the risk of catastrophic failures.\textsuperscript{19-20} The very high elastic modulus can cause excessive stress concentrated around the apex,\textsuperscript{21} which can cause catastrophic failure.\textsuperscript{22-24} Catastrophic
failure generates loss of the dental element, while non-catastrophic failure allows repair or exchange of the retainer. The type of failure may be due to the different properties of each retainer. Nevertheless, other factors can also cause retainer failures: lack of marginal adaptation, failure in the adhesive technique, wedge effect of the cast metallic cores, and failure to indicate the retainer. In addition, oral fluids, bacterial toxins, and other chemical agents that penetrate the tooth-restoration interface may generate discoloration, secondary caries, and marginal microfracture, which may cause fractures or lead to loosening of the retainer.

Y-TZP zirconia is a crystalline ceramic that presents a high degree of opacity, which allows the restoration of different substrates and the neutralization of darkened ones, such as cast metallic cores or darkened tooth remnants.

The selection of the cementing agent used was based on the fact that it is important to optimize retention, prevent microleakage, and increase fracture resistance. The quality of intra-radicular adhesion is influenced by the density and orientation of the dentinal tubules in the different thirds of the root. In addition to this factor, chemically cured cement does not depend on light-curing.

The aim of this retrospective clinical study was to evaluate the influence of post and core system on the success rate in teeth restored with full crowns cemented onto zirconia copings over an average period of 58.2 months. The following factors were analyzed: survival, cement, and type of failure. The null hypothesis was that there would be no significant differences among the various restorative methods.

**Materials and Methods**

This study was approved by the Ethics and Research Committee (CAAE: 22942713.3.0000.0077) of São Paulo State University (Universidade Estadual Paulista – UNESP), São José dos Campos, São Paulo, Brazil. From a total of 1627 medical records of patients who received dental treatment by a single dentist between June 2008 and January 2018 in a private clinic, 53 medical records were selected, and a total of 101 teeth restored with post and cores and single crowns with zirconia copings, from 23 men and 30 women,
were analyzed. The inclusion criteria were the following: all restorations had to have opposing natural teeth present and in occlusion. Crowns had to be in function and followed for at least 2 years.

Before prosthetic treatment, if necessary, patients received periodontal treatment, caries control, endodontic treatment and occlusal adjustment. Teeth that received intra-radicular fiber posts or cast metallic cores retainers had whole roots, prior endodontic treatment with good quality filling, absence of signs or symptomatology. Also, old restorations, carious and contaminated tissue, unsupported enamel were removed. After the roots were unfilled, leaving 3 to 4 mm of apical sealing using Gates and Largo drills according to the root diameter.

The restored teeth had fiberglass posts, cast metallic cores or only composite resin restoration. The criteria for the selection of the system were based on the literature: the teeth receiving the composite resin as core should contain three or more intact walls; for fiberglass posts, the elements contained 1.5 to 2 mm of dental remnant; and for the teeth with no coronal tooth structure remaining or with darkening remnant due to the presence of metallic oxides, which would make adhesion difficult, cast metallic cores were used. 16-17 Thus, the systems were selected based on the remnants.

The 101 elements analyzed were distributed as follows: 22 restored with composite resin, 34 with cast metal cores, and 45 with fiberglass posts and composite resin. Among the 34 restored with cast metallic core, four were cemented with U100 (U100; 3M ESPE), 23 with U200 (U200; 3M ESPE), and seven with Panavia F (Panavia F; Kuraray). Of the 45 teeth restored with fiber posts associated with composite resin, nine were cemented with U100 (U100; 3M ESPE), 17 with U200 (U200; 3M ESPE), and 19 elements with Panavia F (Panavia F; Kuraray).

After removal of caries and old restorations, the following procedures were performed: coronal preparation, decontamination with 2% chlorhexidine (antiseptic Riohex 2%, Rioquímica), and selective conditioning with 37% phosphoric acid (Ultra-etch; Ultradent) for 30 seconds in enamel, followed by washing for 1 minute with water/air spray, drying of the cavity with absorbent paper and application of the adhesive (Clearfil SE; Kuraray) according to the manufacturer’s protocol, and primer application by smear for 20 seconds, followed
by a light jet of air and smear bond application for 30 seconds, again followed by a light jet of air and polymerization for 20 seconds. Then, filling with light-curing composite resin (Z250; 3M ESPE) was performed according to the increment method. All post indications except for metal post had presented ferrule.

Fiberglass post associated with composite resin filling

The fiber posts (Whitepost; FGM) used were selected based on the diameter of the root, with the post diameter being one-third of the root diameter, using a ruler for selection of the manufacturer’s posts. Unfilling was performed with Gates and Largo drills, and the final preparation of the canal was performed using the system’s milling cutter.

For U100 and U200 (3M ESPE), the element preparation consisted of decontamination with 0.5% sodium hypochlorite (Dakin’s solution; Asfer) and drying with an absorbent paper cone. Post preparation was performed by decontamination with 37% phosphoric acid (Ultra-etch; Ultradent), water/air spray washing, drying, and application of silane (Dentsply, Chicago, IL, USA) for 3 minutes. The insertion of the cement into the canal was performed with a Centrix syringe (Precision; Maquira), followed by light-cure at a 400- to 480-nm wavelength (Radii-Cal; SDI).

For the Panavia F cement (Panavia F; Kuraray), the element was decontaminated with 2% chlorhexidine (Antiseptic Riohex 2%, Rioquímica) and 37% phosphoric acid (Ultra-etch; Ultradent) applied for 30 seconds, followed by washing with water/air spray for 1 minute. After drying with an absorbent paper cone, the system adhesive was applied to the canal and to the coronal part of the element, following the manufacturer’s protocol. The preparation of the post consisted of decontamination with 37% phosphoric acid (Ultra-etch; Ultradent), washing with water/air spray, drying, and application of silane (Silane; Dentsply) for 3 minutes. The cement insertion in the canal was performed using a Centrix syringe (Maquira, Paraná, Brazil), followed by light-cure at a 400- to 480-nm wavelength (Radii-Cal; SDI).

After post cementation, composite resin filling was initiated by conditioning the enamel with 37% phosphoric acid (Ultra-etch; Ultradent), followed by washing for 1 minute with water/air spray and cavity drying with
absorbent paper. The adhesive (ClearFil SE; Kuraray) was applied according to the manufacturer’s instructions, followed by primer application by smear for 20 seconds, followed by a light air jet and bond application by smear for 30 seconds, light air jet again, and light-curing for 20 seconds at 400-480 nm (Radii-Cal; SDI). The restoration with Z250 light-curing composite resin (Z250; 3M ESPE) was then performed using the increment technique.

Cast metallic cores

The cast metallic cores were prepared using the modeling technique. After preparation of the canal, it was isolated with solid petroleum jelly (Biochemistry, São José do Rio Preto, Brazil) and red acrylic resin (Pattern Resin LS; CG), and modeling was performed using a modeling post (Pinjet; Angelus). Then, the mold was sent to the dental laboratory for casting in metal alloy (Silver-Tin; Primalloy) using the lost-wax technique. The metallic cores were decontaminated with 70% alcohol and blasted (Microjato Plus, Bio Art) with 50-micrometer aluminum oxide (Aluminum Oxide, Bio Art) for 20 seconds at a pressure of 2 bar.

For U100 and U200 (3M ESPE), the element was decontaminated with 0.5% sodium hypochlorite (Dakin’s solution; Asfer) and drying with an absorbent paper cone. The insertion of the cement into the canal was performed with a Centrix syringe (Precision; Maquira), followed by light-curing at 400-480 nm (Radii-Cal; SDI).

For the Panavia F (Kuraray) cement, the element was decontaminated with 2% chlorhexidine (antiseptic Riohex 2%, Rioquímica). Then, 37% phosphoric acid (Ultra-etch; Ultradent) was applied for 30 seconds, followed by washing with water/air spray for 1 minute. After drying with an absorbent paper cone, the system adhesive was applied to the canal and to the coronal part of the element. The insertion of the cement into the canal was performed with a Centrix syringe (Precision; Maquira), followed by light-curing at 400-480 nm (Radii-Cal; SDI).

After fixing the retainer, all elements were restored with fixed single prosthesis with zirconia coping. Regardless of the retainer, all of the preparations were performed with chamfer finish, drill number 4138 (KG Sorensen), and the finishing of the preparations was performed with a 30-blade multilayer drill bit (Komet).
against a 1:5 multiplier angle (T3 Line E 200; Sirona). Between the consultations, temporary crowns in acrylic resin were cemented with temporary cement with calcium hydroxide (Provicol; Voco).

The molds were obtained with the addition of silicone (Futura AD, DFL), using gingival retraction with the retraction cord (Ultrapak; Ultradent) according to the indication of the gingival biotype, using the simultaneous technique.

All crowns were cemented with chemically cured resin cement according to the manufacturer’s recommendations. Before cementation, the adaptation was verified with an exploratory probe, and radiography and the adjustment of the occlusion and proximal region was performed. The crown/cement distribution was performed as follows: 14/U100 (3M ESPE); 54/U200 (3M ESPE); 33/Panavia F (Kuraray).

The survival rate was assessed according to the absence of complications. The complications included loosening of the retainer, fracture of any region of the dental element, fracture of the retainer, secondary caries, pain, need for endodontic treatment after fixing the prosthesis, and patient dissatisfaction. Retention longevity was measured from the month of cementation until January 2018 for the elements that did not fail and until the month of complication for those that failed. Kaplan-Meier survival analysis was used to compare the success rates of the different variables under study as a function of time, using $\alpha=0.05$. The statistical program SPSS 21 (IBM, USA, Chicago, IL) was used.

Results

One-hundred one cases of teeth with retainers were analyzed for a mean time of 58.24 months, with a standard deviation of 25.72 months; the minimum observed time was 26 months, and the maximum was 115 months. The types of intra-radicular retainer used in the sample were as follows: 33.7% (34 teeth) with cast metallic core, 44.6% (45 teeth) with fiberglass post, and 21.8% (22 teeth) with filling, totaling 101 teeth. The distribution of the elements in the arch and in the retainers was represented in the demographic table (Table 1). The distribution of the retainers according to cement was as follows: for the cast metallic cores,
four were cemented with U100, 23 with U200, and seven with Panavia F. For the fiberglass posts, nine were cemented with U100, 17 with U200, and 19 with Panavia F, as shown in Table 2.

As shown in Table 3, of the failure cases, one (33.3%) had a cast metallic core, and two (66.7%) were of fiberglass; no failures were observed in the teeth that used filling as the intra-radicular retainer material. The failures found included fiberglass post fracture in an element that was cemented with Panavia F, which was restored with a cast metallic core; root fracture in an element that was restored with fiberglass post cemented with Panavia F, which was extracted, and an implant was fixed in the region; and root fracture in a tooth that was cemented with a metallic core bonded with Panavia F, which was also extracted, and an implant was fixed in the region. The three failures presented in the study were in different periods, but all occurred in the same patient.

No significant difference was observed between the intra-radicular retainers analyzed (p=0.495). The survival rates as a function of time for the types of retainers are shown in Graph 1. The metallic core survival rate was 97.1%, that of the fiberglass post was 95.6%, and that of the filling was 100%, as shown in Kaplan-Meier Graph 1 (Figure 1).

Of the cases that presented failures, the mean was 48.4 months, with a standard deviation of 16.38 months. In addition to the failures with the retainers, the present study presented two other failures related to the crowns, with one cementation failure in a crown cemented with U100 on a cast metallic core, which was re-cemented with U200, and the other a fracture of the chipping recoating ceramics in a cemented crown on a fiberglass post with Panavia F, which was restored. All failures were summarized in Table 4 as a function of time.

Discussion
The goal of this study was to clinically evaluate the survival rates of three types of fixed prosthesis retainers: composite resin filling, fiberglass post, and cast metallic core. In view of the results, the null hypothesis that
there would be no significant difference between them was accepted. This hypothesis was demonstrated based on the indications for each retainer found in the literature.

All elements of this study were restored with bilayer zirconia crowns, i.e., zirconia infrastructure with the application of aesthetic coating ceramics. Zirconia, besides having a flexural strength of 800 MPa at 1200 MPa and a fracture resistance of 6 MPa · m¹/² at 8 MPa · m¹/², has a high degree of opacity because it is a polycrystalline ceramic, which indicates its use on a darkened substrate restoration, as a cast metallic core; thus, it presents versatility over different retainers and ensures the final aesthetics of the restoration. The use of chemically cured cements is possible with different types of retainers, as the cements do not depend on light for their polymerization. Thus, the difficult access of light in the apical third of the root is not a negative factor because different densities and orientations of the dentinal tubules already exist in the different thirds of the root, and the resin cements present higher retention than zinc phosphate cement.

Several biological, mechanical, and aesthetic factors are involved in the survival rate of the restoration, and the selection of the retainer must satisfy and optimize these factors. The selection of the type of retainer in this study was determined from the coronal remnant of the element to be restored with the fixed prosthesis. The indication for a fiber post was the presence of dentinal remnant with a minimum of 1.5 to 2.0 mm height, with no metallic oxides present; thus, cast metallic cores were performed in elements that had remnants smaller than 1.5 to 2.0 mm; in the cases where filling was performed, the dental element had at least three walls, as indicated in the literature. The lack of coronal remnant is cited as one of the challenges for the use of fiberglass posts; another study also recommended the criterion of 1.5 to 2 mm of remnant coronal structure.

In the present study, three types of retainers for fixed prosthesis were used: an intra-radicular retainer with a fiberglass post, a cast metallic core intra-radicular retainer, and a resin filling retainer and/or dental remnant only. There were no significant differences in the survival rates between them. Another clinical study with a 12-month follow-up also stated that different retainers, including fiberglass posts and cast metallic core systems, have high success rates. Although there was no significant difference between fiberglass and
metal retainers, another study\textsuperscript{36}, with a sample of 40 elements, in a 6-month follow-up, divided into two groups, fiberglass post and metallic core, concluded that fiberglass posts have better clinical performance than metallic cores. In another study\textsuperscript{37}, with a sample of 203 elements, which compared prefabricated and individualized fiber posts, metallic cores, and filling with no retainer in 1-, 3-, and 5-year follow-up periods, despite the 12.8\% of failures after the last follow-up consultation, showed no significant differences between the groups, allowing the conclusion that all systems used in total restorations of ceramics present similar good clinical performance.

The results of the present study revealed three cases of failure: one with a cast metallic core where root fracture occurred 33 months after crown cementation; and two with fiberglass, one with a fracture of the post 66 months after cementation, and the other with root fracture at the fiber post after 55 months. No cases of failure were observed in teeth that used filling as the intra-radicular retainer material. In spite of the absolute numbers, the statistical tests did not show significant differences between the groups, and the literature review\textsuperscript{34} indicated that fiberglass posts have presented similar performance to cast metallic posts. In addition to survival, the literature reviews described possible types of failure and their prevalence in each system: in cast metallic cores, fracture of the retainer, loss of retention of the retainer, and/or crown and root fracture occur, while in fiberglass posts, the most common failure is loss of retention.\textsuperscript{38} Thus, metallic retainer failures are mostly catastrophic, unlike with fiberglass posts.\textsuperscript{34}

Like the literature reviews, laboratory and finite element studies have also cited the differences between failures in retainer systems and have shown that the greatest numbers of non-catastrophic failures are in fiberglass posts when compared with cast metallic cores, justifying the results where minor stresses are generated at the root when the fiberglass post is used, reducing the chance of the occurrence of root fracture, different from the higher fracture rates with cast metallic cores.\textsuperscript{39-41} These results of lower catastrophic failure rates for the fiberglass post are associated with the lower elastic modulus, as the fiberglass posts are more similar to dental structures than are metal retainers.\textsuperscript{40} This elastic modulus, which is similar to that of dentin, generates a better load distribution throughout the system;
therefore, the fracture resistance is smaller than in metallic cores, and the fiberglass post shows a more favorable biomechanical behavior.

Although the three groups of retainers showed no significant differences and the fiberglass post showed an elastic modulus that was more similar to that of dentin structures than the cast metallic core, the group in which a composite resin filling core was used was the only one that did not show any failures. In another 5-year clinical follow-up study comparing metallic core, fiberglass post, and filling core, there were also no differences among the groups. Another study compared composite resin filling core and fiberglass post, showing that the insertion of the intra-radicular retainer does not reduce the risk of failure of the filling core.

Considering that the filling core was the only type that did not show failures and still maintained the largest amount of tooth structure, and because it is a less complex procedure, whenever possible, it is more appropriate to perform this procedure, depending on the quantity and the quality of the remnant. The prosthesis will present an equal or better clinical performance.

In the present study, despite no significant differences identified, all failures occurred in the same patient: two root fractures, one with a fiberglass post, element 12, and one with a cast metallic core, element 22, and a fracture of the intra-radicular retainer, fiberglass post, element 15. All of them had been cemented with Panavia F. During the onset of failures, the patient reported having started using the psychotropic fluoxetine, which may induce parafunctional activity.

The results of this study showed that there were no differences among the retainers in a clinical follow-up with a mean time of 58.2 months (4.8 years), where time, cement, and type of failure were evaluated. These results provide the dental surgeon with the possibility of system selection, including resin filling in vital and non-vital teeth, fiberglass post, or cast metallic core, according to the indications and following the clinical protocol of each system.

Conclusions

From this study, the following could be concluded:
The different intraradicular post types evaluated and no post at all have similar survival rates under zirconia crowns, with excellent clinical performance when indicated accordingly.

**Conflict of interest**

The authors did not have any commercial interest in any of the materials used in this study.
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Captions to tables and legends:

Tables:

Table 1. Demographic table.

Table 2. Division of retainers according to the cement used.

Table 3. Summary of case processing.

Table 4. Time, in months, and cause of the failures that occurred.

Figures:

Figure 1 Graph – survival functions.
*FP: Fiberglass post; CM: Cast metallic core; FC: Filling core.

Table 1. Demographic table.

| Region    | Anterior | Posterior | Anterior | Posterior |
|-----------|----------|-----------|----------|-----------|
| Total     | 4        | 16        | 46       | 35        |

| Retainer | FP | CM | NP | FP | CM | NP |
|----------|----|----|----|----|----|----|
| Total    | 4  | 0  | 0  | 7  | 6  | 3  |

Table 2. Division of retainers according to the cement used.

| Post group | Total No. | No. of events | Censored No. | Percentage |
|------------|-----------|---------------|--------------|------------|
| Metallic Core | 34       | 1             | 33           | 97.1%      |
| Fiberglass | 45       | 2             | 43           | 95.6%      |
| Filling    | 22       | 0             | 22           | 100.0%     |
### Table 3. Summary of case processing.

| Failure cause | Failure time (months) |
|---------------|-----------------------|
| Cementation   | 29                    |
| Post          | 56                    |
| Post          | 66                    |
| Post          | 33                    |
| Crown         | 58                    |

Failure mean (SD) 48.40 (16.38)

### Table 4. Time, in months, and cause of the failures that occurred.
Figures:

Figure 1. Graph – survival functions.

**Figure 1** Graph – survival functions.