

Retention of Provisional Intraradicular Retainers Using Fiberglass Pins

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ABSTRACT **Objectives:** The purpose of this study was to compare the retention properties between fiberglass pins with chemically activated acrylic resin and metallic intraradicular retainers often used for the purpose of temporary prosthetic retention. **Materials and Methods:** Two mechanical tests, pushout and traction, were performed on specimens distributed in three groups ($n = 10$) for each test; two metal pins G1: Metalpin Ângelus and G2: Provisional Pivot Jon in addition to one fiberglass pin G3: Whitepost DC-E, FGM. One-way analysis of variance (ANOVA) followed by Tukey's *post hoc* test was used at the level of significance $\alpha = 0.05$. **Results:** The fiberglass pins (G3) showed higher values in the traction test than the metal pins (G1 and G2) with a statistically significant difference ($P < 0.05$); however, they performed similarly to the metal pin groups in the pushout test ($P > 0.05$). They also presented a lower occurrence of failure in the relining acrylic resin. **Conclusion:** The study pointed out the use of fiberglass pins as suitable alternatives for provisional intracanal metallic retainers.

KEYWORDS: Fiberglass pins, intraradicular retainer, retention

INTRODUCTION

Restorative dentistry should follow the technological evolution in all stages of oral rehabilitation. The dental practice proves difficult in some respects; it is necessary to offer a solution ready, even temporary. Depending on the degree of coronary destruction, it is necessary in some cases to use provisional intraradicular retainers.^[1,2] The temporary restorations are important for the rehabilitation prosthetic treatment as they are necessary to promote pulp protection, masticatory function, and aesthetics.^[3,4] They are tools for diagnosis and planning in situations that demand the restoration of accurate vertical dimension, occlusal plane, adequacy of periodontal aesthetics, as well as defining the shape, color, and dimensions of the final restoration.^[5] This

temporary restoration should also provide adequate and efficient cleaning by the patient.^[6]

The use of fiberglass pins (FGPs) has been an alternative to improve the quality of temporary seals intracanal.^[1,2,7,8] Among its key features are aesthetic color, do not suffer from corrosion; not require laboratory steps; modulus of elasticity, compressive strength, flexural strength, and thermal expansion are similar to dentin; union chemistry the resin materials; and greater preservation of tooth structure.^[7-10]

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Similar clinical performance of glass fiber and cast metal posts has been reported. It is very important for dentists to know the best updated technique to rehabilitate endodontically treated teeth with no remaining coronal wall.^[11,12]

The pin and the resin material form homogeneous units, known as monoblock allowing the mechanical strength to be decreased within the root canal to reduce the damage to the tooth and surrounding tissues.^[13] This monoblock has great importance, as it provides less risk of fracture of the root remaining relative to metal seals.^[4,7] However, the green fluorescent protein (GFP) modulus of elasticity is approximately 20 GPa, whereas prefabricated metal pins have about 97 GPa and the dentin has a modulus of elasticity of about 18 GPa.^[9]

Therefore, the aim of this study was to compare the retention properties between FGPs with chemically activated acrylic resin and metallic intraradicular retainers often used for the purpose of temporary prosthetic retention.

MATERIALS AND METHODS

ETHICAL ASPECTS

This study was approved by the Research Ethics Committee of the Federal University of Juiz de Fora (FUJF) no. 2.219.071, together with the Declarations of Infrastructure and Agreement and Supply of Human Teeth by the Human Teeth Bank of the Faculty of Dentistry of FUJF.

EXPERIMENTAL DESIGN

Two mechanical tests (pushout and traction) were carried out to evaluate the performance of each material used for provisional intraradicular retainers with regard to retentivity using metallic (MP) or FGPs. For the pushout test, a sample of 30 pins was used, distributed in three groups ($n = 10$). G1 was represented by the trademark Metalpin Ângelus, Ind. Prod. Dental S/A, Lindóia, Brazil; the G2 by prefabricated temporary pins of the provisional Jon Prod. Dental, São Paulo, Brazil, and G3 for FGP of the provisional Whitepost DC-E n. 1, FGM Prod. Dental, Joinville, Brazil. The specimens were submitted to the shear extrusion test and the maximum pressure required for the displacement of the pin in relation to the repackaging acrylic resin was calculated in MPa and compared between the groups. Likewise, for the traction test, a sample of 30 pins was also used, distributed in three groups ($n = 10$) and in the same sequence [Figure 1]. A total of 30 human canine teeth were selected and prepared, to subsequently be submitted to the traction

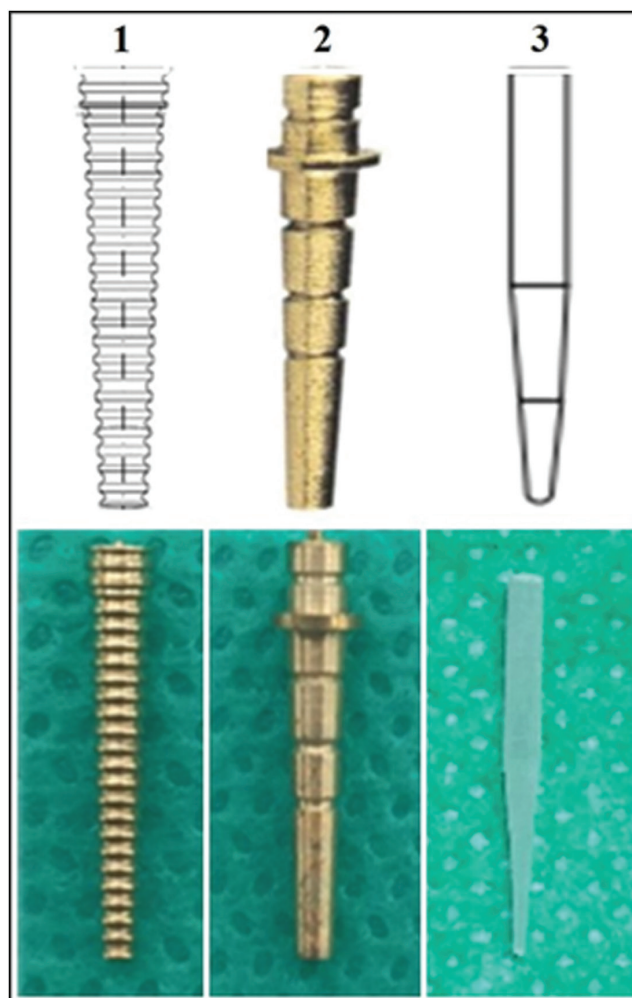


Figure 1: Macroeometry of the pins: (1) Metalpin Ângelus, (2) Provisional Pivot Jon, (3) Whitepost DC-E FGM

test of the intraradicular retainers, previously cemented with temporary calcium hydroxide cement (Hydro C, Dentsply Ind. Com, Petrópolis, RJ, Brazil). The tests were carried out on the universal testing machine (Emic DL-2000 Equip. Cientif. Ltd. São José dos Pinhais, PR, Brazil) at the UFJF Research Laboratory.

PUSHOUT SHEAR TEST

Thirty samples using teflon molds (Impaktto, São Paulo, Brazil) were made, which were formed and cut using the software (GibbsCAM 2014) on a Sinumerik CNC (Siemens AG Ind., Nurnemerg, Alemanha) milling machine as required by the test. Each mold was 7 mm in diameter and 6 mm height and had a central hole of 3 mm in diameter compatible with the pin's 3 mm apex. In each mold, the pins were positioned and guided vertically through the central hole and then the CAAR, color 69 (Duralay) was manipulated in a silicone Dappen bowl (Maquira Ind. Prod. Dental S/A, Maringá, PR, Brazil), according to the proportions

indicated by the manufacturer, and poured in stages, using a plaster vibrator (Vibramaxx Gold Line - Essence Dental VH, Araraquara, SP, Brazil) to avoid the formation of bubbles and overheating during its polymerization reaction, being filled to the upper limit of the mold.

Subsequently, after filling the molds, two cross-sections were made using the Labcut cutting equipment (Isomet 1000, Springfield, Virginia), obtaining specimens with 3mm thickness, extracted from the middle portion of the pins, being this portion corresponding to the middle third of the pins in the cervical apex direction. This resulted in circular specimens of 7 mm in diameter and 3 mm in height [Figure 2].

The specimens were distributed in three groups according to the provisional intraradicular retainer used. The G1 pins (Metalpin Ângelus) and G2 (Pivot provisório Jon) are made of Copper-Zinc (Cu-Zn) alloy and the pins of G3 (Whitepost DC-E FGM) are made of fiberglass/epoxy resin. The purpose of this test was to evaluate the union between the retainer and the self-curing acrylic resin color 69 (Duralay) in which it was involved.

To perform the test, a metal rod with an active tip of 1.2mm in diameter, fixed through a 6mm thread on the top of the universal testing machine (Emic DL-2000) with a 50 Kg load cell. At the bottom of the universal testing machine, the specimen was fixed to a base stabilized by screws and lathes. The specimen was disposed such that the active tip attached to the top of the machine and positioned over the center of the retainer, which was subjected to extrusion test.

To start the test, the machine was activated with a constant speed of 0.5mm/minute, applying a force on the center of the retainer, until its displacement of the CAAR body occurred. The resistance to pin displacement in relation to CAAR (bond strength or adhesion force) was obtained in MPa, dividing the force required for the pin displacement (N) by the area

of the pin/CAAR interface (mm^2). The surface area of the pin was calculated individually in each cut using the following formulas:

$$g = (h^2 + (R_2 - R_1)^2)^{1/2} \quad (1)$$

where g = taper of the pin, h = slice thickness, R_1 = radius of the pin at the apical end, and R_2 = radius of the pin at the cervical end.

$$A = \pi \cdot g \cdot (R_2 - R_1)$$

where A = adhesive area, $\pi = 3.14$, g = taper of the pin, R_1 = radius of the pin at the apical end, and R_2 = radius of the pin at the cervical end.

The thickness of the slices (h) and the measures (R_1) radius of the apical end of the pin and (R_2) radius of the cervical end of the pin were measured with a digital caliper with 0.03 mm precision.

TRACTION TEST

In the CNC Sinumerik milling machine, 30 samples using teflon molds (Impaktto) were made, which were formed and cut using the software (GibbsCAM). Each mold was 25.4mm in diameter, 10mm height and a central hole in the bottom of the mold was 1.5mm in diameter and 2mm height. This hole was used to centralize the root apex. This second test also followed the criterion of distribution of three groups ($n = 10$), as the pushout test.

A total of 30 human canine teeth with healthy roots had the following exclusion criteria: roots with sharp curvatures; cracks, perforations, and/or some root destruction; teeth with previous endodontic treatment; teeth with previous intraradicular retainer. After selecting the teeth, cleaning was performed with Gracey 5/6 periodontal curettes (Hu-Friedy, Rio de Janeiro, RJ, Brazil) and bicarbonate jet (Jet-Sonic, Gnatus, Ribeirão Preto, SP, Brazil), sectioned transversely below the cementum/enamel junction using a carborundum disc (SS White Company, Philadelphia, EUA). Then they were mounted on bench micromotor handpiece

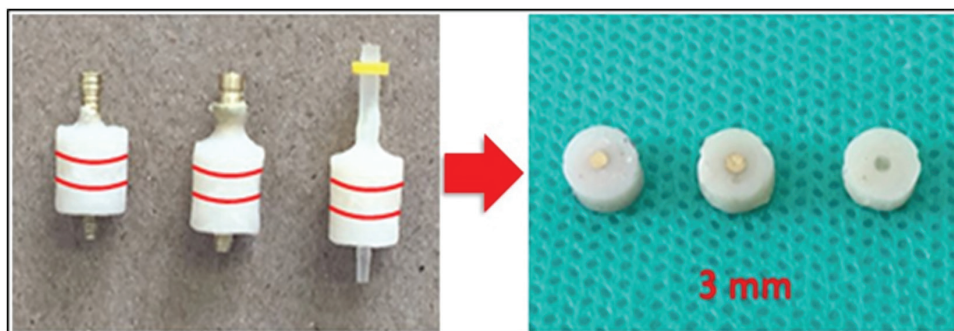


Figure 2: Specimens removed from the teflon matrix and then sectioned 3 mm thick in the middle third of the pins

(Marathon, SMT – Saeyang Microtech, Daegu, Coréia do Sul) with a speed of 20,000 rpm and cooled in distilled water resulting in the separation of the root portion and the coronary portion. A reference of 15 mm from the root apex was considered to standardize the length of the specimen. Then, the teeth were placed in plastic containers, submerged in saline, and stored in an oven at 37°C and 100% relative humidity, for a period of 72 h.

The teeth were then treated endodontically and subsequently cleared and prepared to receive the retainers, with Largo drills (Mani, Wilcos of the Brazil Ind. Com, Petrópolis, RJ, Brazil), reaching 10 mm in depth and using drills with increasing diameters from numbering I to VI, thus standardizing the useful length of the pin. After unblocking the ducts, the roots were positioned in the center of the matrix using the central hole for positioning the apex. The canals were prepared as vertically as possible and positioned with the aid of a parallelometer and utility wax, to avoid oblique loads on the canals walls at the time of the tensile test. Once the roots were positioned, a colorless, self-curing acrylic resin was poured into the matrix to fix them.

The provisional intraradicular retainers were personalized to the respective root canal, by repackaging the prefabricated FGP and MP, with acrylic resin Duralay, color 69. The root canals were isolated with water-soluble lubricant (Ky-Gel Johnson and Johnson of the Brazil Ind. Com. Prod. For Health Ltd., Brazil), so that there is no retention of acrylic resin to the root canal at the time of relining. After customizing the pins with self-curing acrylic resin, the root canals were washed with a jet of distilled water, cleaned, and dried. Next, the pins were cemented to the root canal with temporary calcium hydroxide cement (Hydro C, Dentsply). Then, the pin/CAAR monobloc was cemented inside the conduits with the same provisional cement for later tensile testing. As in the previous test, this test also aimed to assess the union between the retainer and the self-curing acrylic resin in which it was involved. However, the specimens were prepared in such a way that a simulation occurred as close as possible to a clinical situation.

A traction force was applied to remove the retainer/CAAR monobloc from the root canal. The prepared specimens were arranged as follows: a CAAR body with a central hole perpendicular to the retainer was fixed to the more coronal end of the relined pin. Through this hole, a 0.9 mm thick steel cable was transfixed, which was also attached to the upper part of the universal testing machine so that the retaining monoblock/CAAR would be pulled out. This flexible

steel cable was intended to make the pulling force as vertical as possible, to minimize unwanted lateral forces on the root canal walls.

At the bottom of the universal testing machine, the specimen containing the root in a colorless, self-curing acrylic resin base was stabilized by screws and lathes so that there was no movement during the test. To start the test, the machine was activated with a speed of 0.5 mm/minute, making a traction force through the steel cable, removing the monobloc from inside the root canal [Figure 3]. The resistance to displacement of the unit in MPa was obtained by dividing the force required for the displacement pin (N) area by cementing interface pin (mm^2). The pin surface area was calculated individually for each specimen, following the same formulas as the previous test.

STATISTICAL ANALYSIS

One-way analysis of variance (ANOVA) followed by Tukey's *post hoc* test at the level of significance of $\alpha = 0.05$ was used.

RESULTS

PUSHOUT SHEAR TEST

After calculating the cone trunk area corresponding to the middle third of each pin, 3 mm high, the adhesion force between the pin and the relining resin was measured in MPa. Descriptive data samples selected for testing are allocated in Table 1. One-way ANOVA indicated that the three groups behaved in a similar way ($P = 0.683$), so there is no statistically evidence to reject the hypothesis that, at least one of the three groups, behaves differently from the others [Table 2].

Figure 4 shows a failure in the specimen of the MP Metalpin Ângelus (G1) during the pushout test on the universal testing machine.

TRACTION TEST

The measurements in MPa were obtained after calculating the external area of the post after its

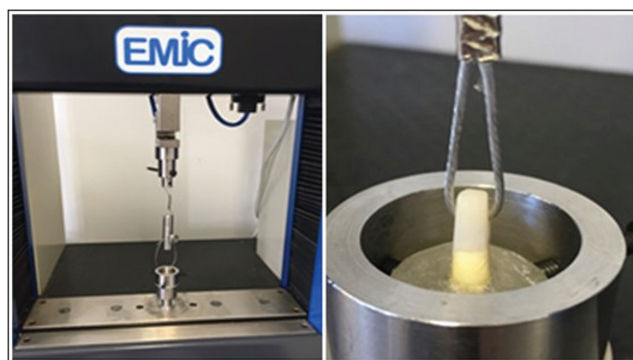


Figure 3: Specimens finalized and positioned on the universal testing machine for mechanical traction testing

relining. Table 1 shows the descriptive measurements of the samples selected for the test. At the 5% level, One-Way ANOVA showed that there was statistically significant difference in the tensile test ($P = 0.006$) [Table 3]. Tukey's *post hoc* test showed that FGP Whitepost DC-E FGM (G3) presented higher values than Metalpin Ângelus and provisional Pivot Jon (G1 and G2) and this was statistically significant ($P < 0.05$) [Table 4].

Figure 5 shows failures in the traction test in G1 specimens (Metalpin Ângelus) and G2 (Provisional Pivot Jon). The G3 (Whitepost DC-E FGM) specimens did not present any failures in the repackaging.

DISCUSSION

The restoration of endodontically treated teeth has evolved from a totally empirical level to the application of new biomechanical concepts that serve as guidance for the decision-making process. The preservation of dental tissue is one of the first steps to be followed for the long-term success of the restorative procedure.^[13-16] This study evaluated and compared the different forms used in the retention of temporary prostheses with the use of intraradicular pins.

Temporary restorations have shown increasingly satisfactory survival rates over relatively long follow-up periods. The clinical effectiveness of such restorations has been attributed mainly to their biomechanical behavior.^[9] The mechanical properties of provisional restorative resins could be improved by the use of fiber

reinforcement. This reinforcement with fibers enhances the flexural strength and the modulus of elasticity of the restoration.^[17] In this study, the two metal pin groups (Metalpin Ângelus; Provisional Pivot Jon) were selected using the materials available on the market for the purpose of provisional intraradicular retainers. The test group was composed of FGP (Whitepost DC-E FGM) indicated as definitive retainers, however, they were used as temporary pins, as the existence of FGP for temporary purposes is unknown. The three groups were compared after being subjected to two mechanical tests, pushout and traction, in which the forces necessary for the displacement of the retainers were measured and the integrity of their relining was evaluated. The pushout and pull tests, the universal testing machine were used as the "gold standard" for mechanical tests.^[18-21]

Specifically, when used, FGPs are less rigid than metallic ones, root fractures are more rare, restorative failures are less frequent, and displacements are less likely to occur.^[9,13,15] These studies corroborate the results found in the traction test, in which the group represented by the FGP obtained more favorable results, as the maximum traction force required for the displacement of the pin/CAAR monoblock was statistically superior. Endodontically treated teeth are susceptible to root fracture due to loss of crown structure, dehydration, and changes in the physical condition of devitalized teeth.^[9,15,19] For this reason, they need to be precisely restored so that they can resist root fracture.^[15,19] These teeth generally have a loss of more than half of the

Table 1: Mean (SD) in MPa of the mechanical tests with P value

Groups	Type of retainer	Pushout	Traction
G1	Metalpin Ângelus	15.71 ± 5.27	5.20 ± 2.33 A
G2	Pivot provisório Jon	17.21 ± 5.77	6.27 ± 3.21 A
G3	Whitepost DC-E FGM	17.32 ± 3.39	9.11 ± 1.98 B
Sig		0.683	0.006*

* Significant difference by ANOVA at $P < 0.05$

Different letters indicate statistical difference in the same column (Tukey's *post hoc* test)

Table 2: Measures (MPa) when comparing groups by ANOVA in the pushout test

Comparison	Sum of squares	DF	Mean square	Z	Sig
Between groups	16.24	2	8.12	0.39	0.683
In the group	567.22	27	21.00		
Total	583.46	29			

Table 3: Measures (MPa) when comparing groups by ANOVA in the traction test

Comparison	Sum of squares	DF	Mean square	Z	Sig
Between groups	81.66	2	40.83	6.23	0.006*
In the group	177.01	27	6.56		
Total	258.67	29			

*Significant difference by ANOVA at $P < 0.05$

coronal structures. Thus, the pins provide strength and retention for the core material, whereas the core provides stability to the portion coronorradicular.^[22,23]

Dentistry used PM for some time as the main option for the rehabilitation of endodontically treated teeth. Yet, it was not considered aesthetically satisfactory. Added to this, due to the high metal elastic modulus compared to root dentin, the core transfers a large part of

incoming masticatory forces directly to the root, which can result in fractures.^[13,15] In this way, prefabricated FGPs have an elasticity module similar to that of root dentin and relining resin, enabling the formation of a mechanically uniform unit that distributes masticatory loads and protects the remaining tooth.^[19,24] The properties of FGP depend on the nature of the fibers, strength, and pin geometry. In FGP and the composite core system, the modulus of elasticity is similar to dentin, thus improving the stress distribution between the pin and dentin, resulting in better flexibility when the load is applied. This property reduces the risk of root fracture.^[25-27] The new post systems such as fiberglass have offered the excellent features including biocompatibility, less fatigue, and corrosion resistance, having mechanical properties similar to dentin.^[23,26,27]

Among other advantages, mention should be made of the final aesthetics obtained, as well as less wear on the dental remnant.^[19,28] FGP is added through applications of resins, phenols, silicones, among others.^[24,26,27] In the first test, which was measured maximum force required for extrusion shear pin relative to acrylic resin in which it was involved, the results at the 5% level were statistically similar, showing that even the FGP having its smooth macrogeometria, it obtained results similar to the MP of the metal pin groups, which have provided their macrogeometria of mechanical retentions for CAAR. It was also observed, during the pushout test, that in these groups (Metalpin Ângelus; Provisional Pivot Jon), there was a fracture in the resin body surrounding the pin, which did not occur in the fiberglass group (Whitepost DC-E FGM). Such findings might indicate that the mechanical retention of the MP may have no axial forces generated during the extrusion pin, may have favored the CAAR these fractures. This fact shows that the chemical adhesion can be obtained in the FGP, making it similar mechanical adhesion retention. This suggests that, in future studies, FGP provided with mechanical present holds on your macrogeometria can present even more satisfactory results in relation to the MP on the market with temporary purposes. This is evidenced in this study, as even the displacement force of the tensile testing being superior in the test group.

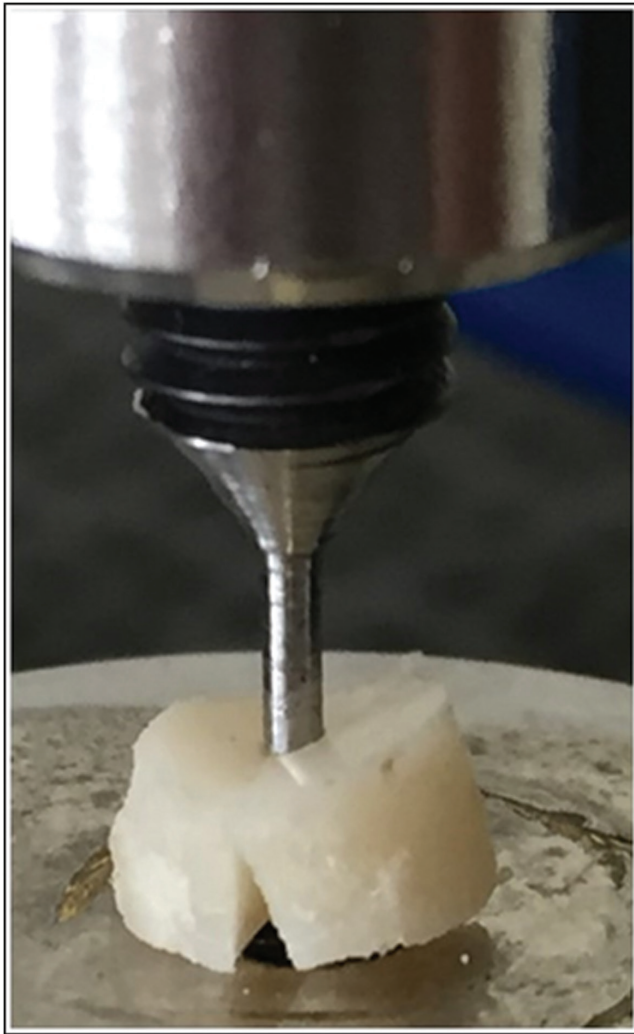


Figure 4: Failure of a specimen of the Metalpin Ângelus pin during the pushout test on the universal testing machine

Table 4: Multiple comparison of Tukey (MPa) between groups in the traction test

Retainer type		Mean difference	Sig	Interv. confidence	
				Lim. inf.	Lim. sup.
Metalpin Ângelus	Whitepost DC-E FGM	-1.07	6.23	-3.91	1.77
	Pivot provisório Jon	-3.91	0.06	-6.75	-1.07
Pivot provisório Jon	Metalpin Ângelus	1.07	6.23	-1.77	3.91
	Whitepost DC-E FGM	-2.84	0.50	-5.68	-0.00
Whitepost DC-E FGM	Metalpin Ângelus	1.14	0.06	1.07	6.75
	Pivot provisório Jon	1.14	0.50	0.00	5.68

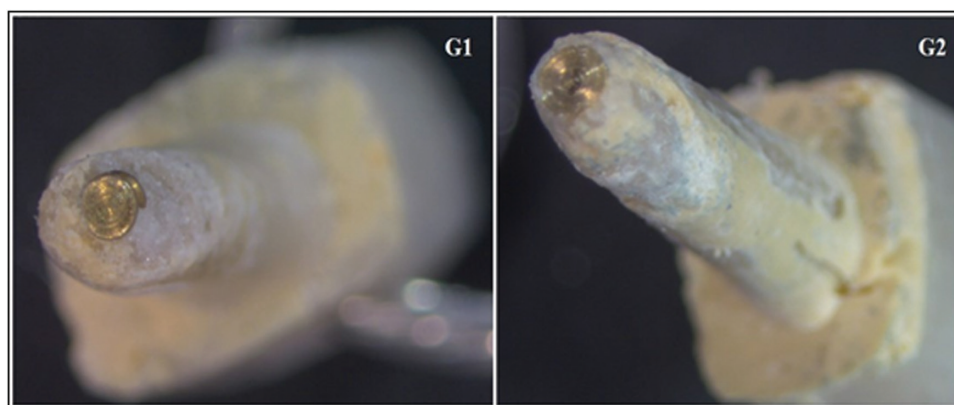


Figure 5: Failures that occurred after tensile testing in specimens of groups G1 (Metalpin Ângelus) and G2 (Provisional Pivot Jon)

Whitepost DC-E FGM showed less failure reline when analyzed under a microscope. After completion of the tensile test samples were taken under an optical microscope and evaluated for the integrity or pins resin reline fracture. The test group (Whitepost DC-E FGM) showed less failure in relocking (20%), whereas fragments of acrylic resin moved from the monoblock during the test more frequently in the groups Provisional Pivot Jon (70%) and Metalpin Ângelus (50%). It was found therefore that the detachment CAAR fragments were more common in metal pin groups. Thus, the findings show a better performance of FGP (Whitepost DC-E FGM) with regard to the anatomical integrity of the pin/CAAR monobloc. This result could possibly be attributed to chemical bonding of the epoxy matrix resin with the resin-curing acrylic reline. This did not occur between the CAAR and Cu-Zn alloys of the provisional pins used in the control groups.^[26-28]

CONCLUSION

A conclusion could be drawn that the use of FGPs can be suitable alternatives for provisional intracanal metallic retainers. The use of fiberglass for provisionals has been based on the search for esthetic properties.

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Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHORS CONTRIBUTION

Otávio Alberto da Costa Fartes:

Literature search, manuscript preparation, and data acquisition.

Leandro Marques de Resende:

Data acquisition and manuscript review.

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Data acquisition, manuscript editing, and review.

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*Kusai Baroudi:

Manuscript preparation, editing, and review.

José Roberto Cortelli:

Planning the research project. Manuscript editing and review.

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

The study was carried out after the approval of the Research Ethics Committee of the Federal University of Juiz de Fora (FUJF) no. 2.219.071, Juiz de Fora, Minas Gerais, Brazil.

PATIENT DECLARATION OF CONSENT

Not applicable.

DATA AVAILABILITY STATEMENT

Not applicable.

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