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Research Article

Influence of Different Root Canal–Filling Materials on the Mechanical Properties of Filled Roots: an *in vitro* study

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Abstract

The aim of this study was to analyze two filling materials (Resilon and Thermafil) and to evaluate their contribution to fracture resistance of endodontically treated teeth. Thirty-two single rooted teeth stored in saline solution at 4ºC were used on this study. The teeth were randomly assigned into four groups: Group 1 (n=10), obturation with Thermafil; Group 2 (n= 8), obturation with RealSeal 1™; Group 3 (n= 7), instrumented but not filled (positive control); Group 4 (n=7), specimens not instrumented and not obturated (negative control). The teeth were embedded in self-curing acrylic resin using a robot and the resistance to fracture was evaluated using a universal testing machine (Autograph). Statistical analysis was performed to determine significance differences (α = 0.05).

Results: The present study showed that none of the rooth canal filling material could increase to fracture resistance of endodontically treated teeth. According to a Kruskal-Wallis test, there were statistically significant differences (α= 0.05), regarding the type of fracture (p= 0.031). There were more oblique fractures in the negative control group and more vertical fractures in the positive control group.

Regarding the direction of the fracture, there are no statistically significant differences between the groups (p= 0,125, Kruskall-Wallis).

Within the limitations of an *in vitro* study, it might be concluded that neither Thermafil® nor Real Seal-1® enhanced the resistance to root fracture of endodontically treated teeth.

Keywords: Endodontics; Filling materials; Root fracture; Resilon; Thermafil

Introduction

The first step of endodontic treatment is focused on microbial control, followed by root filling [1]. The purpose of obturation is to prevent microbial leakage within the root canal, which leads to a nutrient environment available to microorganisms. Furthermore, root canal filling confines remaining microorganisms and inhibits coronal leakage of microorganisms from the oral cavity [2].

Root canal treatment often leads to serious complications, since endodontically treated teeth become more likely to fracture [3-6]. Therefore, the probability of endontontically treated teeth to fracture increases with the amount of dentin removal [7-11].

According to Tang et al. [7], dental and filling material fractures could result from regular functional stresses or increased functional and parafunctional stress. Ordinary functional stress could lead to coronary and root fracture of endodontically treated teeth, when mechanical properties are diminished. Repeated stress overload may cause dental fracture [7].

Endodontic sealers play a primary role, by filling the void spaces between the obturation material and root dentin. Sealer adhesion is also important, since it potentially prevents leakage and according some authors contributes to the root reinforcement [12-16].

According to Grossman, mechanical tests evaluating dentin bond strength are relevant because in a static situation, any void allowing fluid leakage between the filling material and root canal dentin should be eliminated and, in a dynamic condition, adhesion is a key to create resistance to dislodgement of the filling material during its manipulation [17]. Therefore, filling materials could enhance the resistance to fracture of endodontically treated teeth [18].

The in vitro study presented in this paper was to test the mechanical behavior of two filling materials Thermafil (Dentsply Maillefer, Ballaigues, Switzerland) and RealSeal 1™ Bonded Obturator (SybronEndo, Orange, CA), in strengthening the structure of filled root teeth

Thermafil® consists of a thermoplastic obturation technique, in which the central carrier is pre-coated with thermoplasticised gutta-percha [19]. The RealSeal 1™ is a polysulfone core that is precision coated with Resilon material using high-tolerance injection molding. Resilon a thermoplastic filled polymer composite, was introduced that could challenge the use of gutta-percha as an obturation material.

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Resilon is composed of a parent polymer, polycaprolactone or Tone (P787, Union Carbide, Dansbury, CT), which is a biodegradable aliphatic polyester, with filler particles consisting of bioactive glass, bismuth oxychloride, and barium sulfate. One of the claimed advantages of Resilon is the creation of a "monoblock", referring to a situation where any void space in the root canal system would be completely filled creating a single cohesive unit comprising the core material, the endodontic sealer and the root dentin. Some claimed benefits include the simultaneous sealing and fracture resistance improvement [20]. Gutta-percha does not bond to dentin and its modulus of elasticity is about 79 MPa, which is quite lower than the modulus of elasticity of dentin (approximately, 17400 MPa) [21,22]. Despite the ability of Resilon to bond to root dentin, both its bond strength (0,5 MPa) [23] and its modulus of elasticity (around 87 MPa) are quite low [21]. Therefore, it is still controversial whether Resilon has the ability to reinforce root dentin [23,24]. To sum up, there are two key factors regarding the ability of filling materials to enhance the resistance to fracture of endodontically treated teeth: stable bonding to the root canal walls and modulus of elasticity similar to dentin [7].

In methacrylate-based resin sealers, as used in Resilon, low bond strength values can be explained by the high C factor (cavity configuration factor) in long and narrow root canals. This leads to the inability of stress relief from polymerization. It is likely that the bond between sealer and root dentin is not strong enough to resist those polymerization stresses, thus resulting in void formation [25].

The purpose of this study was to evaluate the resistance to fracture of teeth obturated with Thermafil® and RealSeal1™, after a twelve month period of saline solution storage.

Materials and Methods

Thirty-two single rooted teeth caries free with one root canal and closed apices were used on this study. The samples were stored in saline solution at 4ºC. For standardization purposes, the teeth were sectioned with a high-speed bur with cooling system, leaving all the roots 15mm long.

The working length was determined by leveling a size 15 K-file (Dentsply/Maillefer, Ballaigues, Switzerland) with the apical foramen and then subtracting 1mm. Twenty-five teeth were instrumented with Profile® (Dentsply-Maillefer, Ballaigues, Switzerland)). Irrigation was performed with 1ml sodium hypochlorite (2,5%) between each file. The apical third was instrumented with hand K-files until a 35 master apical file was achieved. After completion of instrumentation, the foramen permeability was confirmed by viewing a size 15 K-file at the foramen. All specimens were finally irrigated with 3ml EDTA 17% (30 seconds), followed by 3ml sodium hypochlorite 2.5% and 3ml saline solution.

The teeth were randomly assigned into four groups: two experimental groups (n=18) and two control groups (n=14). The following procedures were performed in each group:

- **Group 1** - 10 specimens obturated with Thermafil® (Dentsply/Maillefer, Ballaigues, Switzerland) and AH Plus sealer (Dentsply, Maillefer, Ballaigues, Switzerland);
- **Group 2** – 8 specimens obturated with RealSeal 1™ Bonded Obturator (SybronEndo, Orange, CA),RealSeal primer and sealer (SybronEndo, Orange, CA);
- **Group 3** – 7 specimens instrumented but not filled (positive control);
- **Group 4** – 7 specimens not instrumented (negative control).

The obturation quality was confirmed by radiographic means and the specimens were stored in saline solution for 12 months. The buccolingual and mesiodistal diameters were measured.

The teeth were embedded in self-curing acrylic resin (Orthocryl, Dentaurum, Germany) using a robot (Industrial manipulator ABB - IRB2400 with the S4Cplus controller), which stabilized each specimen during the setting of the acrylic resin (approximately 20 minutes at 26ºC). The purpose of the robot was to minimize the instrumental variability, since the specimens were always embedded on the same position and by the same "operator". This approach minimized the posterior adjustments on the universal testing machine, and ensured a vertical position for all the specimens.

PVC rings were used to contain the teeth embedded in the acrylic resin and were sectioned with 2cm high. A circle (with the same diameter of the PVC rings) and its center were drawn in a transparent acrylic plate, which was attached to the arm of the robot.

The specimens were glued by their coronary portion, so that the long axis of the root was perpendicular to the acrylic plate and parallel to the walls of the PVC rings. Both the acrylic plate and the super glue were transparent, in order to align the root canal with the center of the circle drawn on the plate. This enabled all the specimens to be placed in the same position with high precision

The robot took each specimen glued to the acrylic plate to the correct position of alignment with the PVC ring, which was filled with recently mixed acrylic and placed on a holding platform. From that position, the robot lowered until the root was embedded 6mm deep in the acrylic, leaving 9mm without being embedded. This position was hold during the acrylic polymerization.

A universal testing machine (Autograph, AG-I Shimadzu, 5kN, Chiyoda-ku, Tokyo 101-8448, Japan) was used to evaluate the resistance to fracture. A diamond bur was used to shape the root canal access to accept the loading fixture. Each PVC ring containing a root specimen was mounted on the machine platform and a vertical load (parallel to the long axis of the root) was applied at 1mm/min until fracture of the specimen, defined by sound and visible sign of fracture. At this point, the test was terminated.

All the tested teeth were photographed and observed to classify the type of fracture that occurred. This classification was based on two parameters: the orientation and the direction of the fracture; the 'orientation of the fracture' seeks to measure the main direction of the fracture in the vertical plane defining three possible options: vertical, oblique and vertical more oblique. On the other hand, the direction of the fracture classifies the main angle of the fracture in the occlusal plane by defining the directions mesiodistal, buccolingual and mesiodistal more buccolingual.

Statistical analysis of the results was conducted to explore significant differences between Thermafil and RealSeal 1 (ANOVA, Kruskal-Wallis, Mann-Whitney and Spearman). The significant level was fixed to 5% (α = 0.05).

Results

The fracture load (N) was recorded by the universal testing machine software for each root. Mean, standard deviation, maximum and minimum were determined (Table 1).

To assess statistical meaning an ANOVA test was performed, using SPSS (version 19). It was concluded that there were no statistically significant differences between the 4 groups (ANOVA, p=0.655).

The fracture load of the roots was apparently related to the surface area where the vertical load was applied. It was performed a correlation test and Spearman coefficient to explore this association. Although, the correlation was statistically significant (p=0.009), the correlation strength was only moderate (Spearman correlation coefficient = 0.469).

Photographs of each group were taken to analyze the type of fracture. The orientation of the fracture of each root (vertical/ oblique and buccolingual/ mesiodistal) was recorded. According to a Kruskal-Wallis test, there were statistically significant differences (α= 0.05), regarding the type of fracture (p= 0.031) (Table 2). There were more oblique fractures in the negative control group and more vertical fractures in the positive control group.

Applying the Mann-Whitney test (Table 3) was possible to verify which groups showed statistically significant differences (signed with*).

Regarding the direction of the fracture, there are no statistically significant differences between the groups (p= 0,125, Kruskall-Wallis) (Table 4).

Table 1: Fracture load (N) for each root.

Group	Thermafil	Resilon	Nevative control	Positive control
Mean	780,99 N	1003,133 N	945,93 N	754,24 N
Standard deviation	442,48 N	887,77 N	207,24 N	135,07 N
Masimum	1880,78 N	1635,50 N	1520,00 N	1270,00 N
Munimum	339,53 N	352,00 N	242,00 N	254,00 N

Table 2: Descriptive statistics of fracture direction on the groups.

Fracture ofientation *vs* Group					
Fracture ofientation	**Thermafil**	**Resilon**	**Control (-)**	**Control (+)**	**Total**
Vartical	7	7	1	5	20
Oblique	0	0	3	1	4
Vartical+Oblique	2	0	1	0	3
Total	9	7	5	6	27

Table 3: Statistically significant differences between the groups *(Mann-Witney test, p=0.05).

	1	2	3	4
1	--	0,197	0,135	0,673
2		--	0,006*	0,280
3			--	0,041*
4				--

Table 4: Direction of fracture obtained in each group.

Fracture direction *vs* Group					
Fracture direction	**Thermafil**	**Resilon**	**Control (-)**	**Control (+)**	**Total**
Mesiodistal	3	1	0	3	7
Buccolingual	3	3	1	2	9
Mesiodistal+Buccolingual	3	3	4	1	11
Total	9	7	5	6	27

Discussion

The results obtained in this in vitro study indicate that neither the root canal instrumentation nor its filling were relevant to the mechanical strength of endodontically treated teeth. This is in accordance with previous studies [13,25-37].

However, it is important to emphasize that the relative variation in each group is quite high (approximately 50%), which contributes to the lack of statistically significant differences between the four groups. Since there was extreme caution to reduce any error introduction related to the experimental protocol, it is legitimate to assume that the observed variability is mainly biological. Thus, it would be advantageous to increase the number of specimens, in order to enhance the statistical relevance.

It was possible to establish an association between the fracture load and the surface area where the vertical load was applied. Nevertheless, one should consider that the application of a compressive load on a thermoplastic material can lead to erroneous results, due to its tendency to deform during mechanical testing. Uncertain results can also derive from non instrumented areas in oval shaped root canals [38].

Extracted teeth experience significant changes in their chemical and physical properties, depending on time and storage solution, which affect dentin bond strength. The twelve month storage in saline solution could have created a qualitative variation in dental structure due to dehydration, becoming more susceptible to fracture [39,40].

The statement that methacrylate-based resin sealers are better alternatives to conventional non adhesive root canal filling materials is yet to be confirmed by scientific studies. Furthermore, there are few studies using control groups. The scarce evidence-based information available relatively to these recent materials suggests a pondered approach is required when choosing dental filling materials [41].

Conclusion

Within the confines of an in vitro study, it might be concluded that neither Thermafil® nor RealSeal-1® enhanced the resistance to root fracture of endodontically treated teeth. It is important to emphasize that the bond strength is only one parameter regarding to the evaluation of obturation quality. Further investigation is necessary on other material properties and different obturation techniques on anatomical variations.

References

1. Schilder H. Filling root canals in three dimensions. Dent Clin North Am 1967; 11: 723-744.
2. Sundqvist G, Figdor D. Endodontic treatment of apical periodontitis. In: Ørstavik D, Pitt Ford TR (ed.) *Essential endodontology*. 5th ed. Oxford: Blackwell 2003: 242-268.

3. Trope M, Ray Jr HL. Resistance to fracture of endodontically treated roots. Oral Surgery Oral Medicine Oral Pathology 1992; 73: 99-102.

4. Sirimai S, Riis DN, Morgano SM. An *in vitro* study of the fracture resistance and the incidence of vertical root racture of pulpless teeth restored with six post and core systems. Journal of Prosthetic Dentistry 1999; 81: 262-269.

5. Sagsen B, Er O, Kahraman Y, Akdogan G. Resistance to fracture of roots filled with three different techniques. International Endodontic Journal 2007; 40: 31-35.

6. Apicella MJ, Loushine RJ, West LA, Runyan DA. A comparison of root fracture resistance using two root canal sealers. International Endodontic Journal 1999; 32: 376-380.

7. Tang W, Wu Y, Smales R. Identifying and Reducing Risks for Potential Fractures in Endodontically Treated Teeth. J Endod 2010; 36: 609-617.

8. Gutmann JL. The dentin root complex: anatomic and biologic considerations in restoring endodontically treated teeth. J Prosthet Dent 1992; 67: 458-467.

9. Tait C, Ricketts D, Higgins A. Restoration of the root-filled tooth: preoperative assessment. Br Dent J 2005; 198: 395-404.

10. Trabert KC, Caput AA, Abou-Rass M. Root fracture: a comparison of endodontic and restorative treatments. J Endod 1978; 4: 341-345.

11. Kishen A. Mechanisms and risk factors for fracture predilection in endodontically treated teeth. Endod Topics 2006; 13: 57-83.

12. Branstetter J, von Fraunhofer JA. The physical properties and sealing action of endodontic sealer cements: a review of the literature. J Endod 1982; 8: 312-316.

13. Grande NM, Plotino G, Lavorgna L, et al. Influence of different root canal filling materials on the mechanical properties of root canal dentin. J Endod 2007; 33: 859-863.

14. Shipper G, Ørstavik D, Teixeira FB, Trope M. An evaluation of microbial leakage in roots filled with thermoplastic synthetic polymer-based root canal filling material (Resilon). J Endod 2004; 30: 342-347.

15. Shipper G, Trope M. *In vitro* microbial leakage of endodontically treated teeth using new and standard obturation techniques. J Endod 2004; 30: 154-158.

16. Bouillaguet S, Bertossa B, Krejci I, Wataha JC, Tay FR, et al. Alternative adhesive strategies to optimize bonding to radicular dentin. J Endod 2007; 33: 1227-1230.

17. Grossman LI. Physical properties of root canal cements. J Endod 1976; 2: 166-175.

18. Tay FR, Hirashi N, Pashley DH, Loushine RJ, Weller N, et al. Bondability of Resilon to a methacrylate-based root canal sealer. Journal of Endodontics 2006; 32: 133-137.

19. Goodman A, Schilder H, Aldrich W. The thermomechanical properties of gutta-percha: II. The history and molecular chemistry of gutta-percha. Oral Surgery, Oral Medicine, Oral Pathology 1974; 37: 954-961.

20. Schäfer E, Zandbiglari T, Schäfer J. Influence of resin-based adhesive root canal fillings on the resistance to fracture of endodontically treated roots: an *in vitro* preliminary study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007; 103: 274-279.

21. Williams C, Loushine RJ, Weller RN, Pashley DH, Tay FR. A comparison of cohesive strength and stiffness of Resilon and gutta-percha. J Endod 2006; 32: 553-555.

22. Yasuda G1, Inage H, Kawamoto R, Shimamura Y, Takubo C, et al. Changes in elastic modulus of adhesive and adhesive-infiltrated dentin during storage in water. J Oral Sci 2008; 50: 481-486.

23. Skidmore LJ, Berzins DW, Bahcall JK. An *in vitro* comparison of the intraradicular dentin bond strength of Resilon and gutta-percha. J Endod 2006; 32: 963-966.

24. Shrestha D, Wei X, Wu W, Ling J. Resilon: a methacrylate resin-based obturation system. J Dent Sci 2010; 5: 47-52.

25. Fisher M, Bahcall J. An *in vitro* comparison of bond strength of various obturation materials to root canal dentin using a push-out test design. J Endod 2007; 33: 856-858.

26. Jainaen A, Palamara JE, Messer HH. Effect of dentinal tubules and resin-based endodontic sealers on fracture properties of root dentin. Dent Mater 2009; 25: e73-81.

27. Sly MM, Moore BK, Platt JA, Brown CE. Push-out bond strength of a new endodontic obturation system (Resilon/Epiphany). J Endod 2007; 33: 160-162.

28. Ungor M, Onay EO, Orucoglu H. Push-out bond strengths: the Epiphany-Resilon endodontic obturation system compared with different pairings of Epiphany, Resilon, AH Plus and gutta-percha. Int Endod J 2006; 39: 643-647.

29. Ureyen B, Kececi AD, Orhan H, Belli S. Micropush out bond strengths of gutta-percha versus thermoplastic synthetic polymer-based systems – an study. Int Endod J 2008; 41: 211-218.

30. Gesi A, Raffaelli O, Goracci C, Pashley DH, Tay FR, et al. Interfacial strength of Resilon and gutta-percha to intraradicular dentin. J Endod 2005; 31: 809-813.

31. De-Deus G, Di Giorgi K, Fidel S, Fidel RAS, Paciornik S. Push-out Bond Strength of Resilon/Epiphany and Resilon/Epiphany Self-Etch to Root Dentin. J Endod 2009; 35: 1048-1050.

32. Wilkinson KL, Beeson TJ, Kirkpatrick TC. Fracture resistance of simulated immature teeth filled with Resilon, gutta-percha, or composite. J Endod 2007; 33: 480-483.

33. Stuart CH, Schwartz SA, Beeson TJ. Reinforcement of immature roots with a new resin filling material. J Endod 2006; 32: 350-353.

34. Ribeiro FC, Souza-Gabriel AE, Marchesan MA, Alfredo E, Silva-Sousa YT, et al. Influence of different endodontic filling materials on root fracture susceptibility. J Dent 2008; 36: 69-73.

35. Hemalatha H, Sandeep M, Kulkarni S, Yakub SS. Evaluation of fracture resistance in simulated immature teeth using Resilon and Ribbond as root reinforcements: an *in vitro* study. Dent Traumatol 2009; 25: 433-438.

36. Karapinar M, Sunay H, Tanalp J, Bayirli G. Fracture resistance of roots using different canal filling systems. Int Endod J 2009; 42: 705-710.

37. Ulusoy OI, Genc O, Arslan S, Alacam T, Gorgul G. Fracture resistance of roots obturated with three different materials. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007; 104: 705-708.

38. Babb BR, Loushine RJ, Bryan TE, Ames JM, Causey MS, et al. Bonding of self-adhesive (self-etching) root canal sealers to radicular dentin. J Endod 2009; 35: 578-582.

39. Monteiro J, Ataide I, Chalakkal P, Chandra P. *In vitro* Resistance to Fracture of Roots Obturated with Resilon or Gutta-percha J Endod 2011; 37: 828-831.

40. Leloup G, D'Hoore W, Bouter D, Degrange M, Vreven J. Meta-analytical review of factors involved in dentin adherence. J Dent Res 2001; 80: 1605-1614.

41. Kim Y, Grandini S, Ames J, Gu L, Kim S, et al. Critical Review on Methacrylate Resin–based Root Canal Sealers. J Endod 2010; 36: 383-399.

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