Sealing Ability of Resilon versus Thermo-plasticized Gutta-Percha as Root End Filling Materials

Research project, submitted to
Faculty of Dentistry, Ain Shams University

In partial fulfillment of the requirements of Master Degree in
Conservative Dentistry

(Endodontics)

By

Mona Ahmed Abdel Fattah

(B.D.S.- H.D.D.)
Cairo University

Supervised by

Prof. Dr./ Hossam Mohamed Essam El-Din Tewfik

Professor of Endodontics
Faculty of Dentistry, Ain Shams University

Dr./ Ahmed Abdel Rahman Hashem

Lecturer of Endodontics
Faculty of Dentistry, Ain Shams University

Faculty of Dentistry
Ain Shams University

2006

Introduction

The objective of endodontic treatment is to eliminate microorganisms from the root canal system and to fill the intracanal space with proper materials to prevent new bacterial colonization that could maintain or evoke an apical pathosis.

Improvements in root canal instruments and instrumentation techniques facilitated the reach of a success rate of nearly 90% with conventional root canal therapy. However, several factors inherent to the endodontic procedures, such as perforations, instrument breakage, calcifications and anatomic anomalies can lead to treatment failure. In some cases, conventional endodontic treatment is not sufficient to solve the problem and a surgical endodontic intervention is required.

The main objective of a root-end filling material is to provide an apical seal that prevents the movement of bacteria and the diffusion of bacterial products from the root canal system into the periapical tissues. An ideal root-end filling material should be easy to manipulate, dimensionally stable, radiopaque, adhesive to dentine, biocompatible and non-toxic. Various materials have been used as retrograde filling materials. These include but are not limited to: amalgam, gutta-percha, gold foil, zinc oxide eugenol cement, IRM, Super EBA, zinc phosphate cement, polycarboxylate cement, composite resin, dentine adhesives, glass ionomer cement, calcium phosphate cement, and mineral trioxide aggregate.

The main objective of all endodontic procedures is to obtain a hermetic seal between the periodontium and root canal foramina. When this is not possible by orthograde approach, a retrograde technique is used.

A wide variety of materials have been used as retrograde fillings, however, no material have been found that fulfills all or most of the properties for ideal retrograde filling material.

Barry et al (1975)[1]**,** compared the apical sealing provided by gutta-percha root canal filling, heat-sealed gutta-percha, retrograde amalgam filling, and retrograde Durelon filling by observation of dye penetration around the these filling materials in extracted teeth. Results showed no significant difference between gutta-percha, heat-sealed gutta-percha, and retrograde amalgam, and that retrograde Durelon filling showed poor sealing in comparison to gutta-percha and retrograde amalgam filling.

Szeemeta-Browar et al (1985)[2]**,** compared the sealing properties of different retrograde techniques. They used human extracted single-rooted teeth which were instrumented and filled in vitro with a lateral condensation of gutta-percha with sealer, resected and retrofilled. Results showed that lateral condensation produced significantly better seal than any retrograde technique tested except retrofilling with Super EBA cement and that a significantly worse seal was obtained with amalgam retrofill when compared to all retrograde techniques except cold-burnished gutta-percha following apiccectomy.

Negm (1988)[3]**,** studied the effect of varnish and pit and fissure sealants on the sealing capacity of laterally condensed gutta-percha, heat-sealed gutta-percha, and silver amalgam retrofilling techniques. Freshly extracted teeth with single canals were instrumented and filled with laterally condensed gutta-percha and sealer and then treated with the various retrograde techniques. Sealing ability of these techniques was compared using dye penetration technique. The apical foramen of the treated canals was then coated with different sealing materials; HelioSeal (light-activated sealant), Delton pit and fissure sealant (chemically activated sealant), or varnish to examine their effect on the leakage resistance of these materials. Results revealed that laterally condensed gutta-percha, as well as retrograde amalgam filling, produced significantly better seal than heat-sealed gutta-percha and that HelioSeal had significantly improved the sealing capacity of all the materials tested at each time period.

Shaw et al (1989) **[4]**, investigated apical sealing efficacy of two amalgam reverse filling techniques versus cold-burnished Gutta-percha. Thirty-six extracted human single-rooted teeth were instrumented and obturated, and divided into three experimental groups and one control group. Each experimental group was subjected cold-burnishing of gutta-percha, amalgam reverse filling or amalgam reverse filling in conjunction with cavity varnish. Dye penetration technique was used to evaluate leakage. Results showed that amalgam with cavity varnish demonstrated significantly less dye penetration than the other experimental groups.

Thirawat and Edmunds (1989) **[5]**, investigated the sealing ability of amalgam used with cavity varnish, EBA cement, glass ionomer cement, light cured composite resin, dentine bonding agent, and light cured composite resin with dentine bonding agent when used as retrograde filling materials and compared it to conventional laterally condensed gutta-percha. Microleakage was assessed using dye penetration technique. Results showed that non of the materials produced perfect seal and that glass ionomer cement, light cured composite resin, light cured composite resin with dentine bonding agent and dentine bonding agent alone produced less leakage than conventional laterally condensed gutta-percha, amalgam with cavity varnish and EBA cement.

Ansari et al (2003) **[6]**, compared the sealing capabilities of amalgam, glass ionomer cement, zinc oxide eugenol cement and gutta-percha with zinc oxide eugenol sealer when used as retrograde filling materials following apicectomy.

Fifty freshly extracted human single rooted teeth were instrumented and obturated using laterally condensed gutta-percha and zinc oxide eugenol was used as a sealer. The access opening was sealed with cavit. Apical root resection was done by removing three millimeters of each apex at 90 degrees to the long axis of the tooth, and then 3mm deep root-end cavity was prepared. The teeth were retrofilled with amalgam, glass ionomer cement, zinc oxide eugenol cement or not retrofilled. Sealing was evaluated using dye penetration technique. Results showed that all teeth sealed with zinc oxide eugenol cement and those with no retrograde fillings showed leakage and dye penetration.

Vignaroli et al (1995)*[7]*, evaluated the sealing ability of four dentine bonding agents on the resected root ends. They applied Amalgambond (AMB), Scotchbond Multi Purpose (SMP), Prisma Universal Bond 3 (PUB3) or All-Bond 2 (AB2) to the resected root ends without class I preparation. Half of the roots in each group were contaminated with blood before bonding. Microleakage was measured at various time intervals, from 1 to 24 weeks using fluid filtration technique. Results showed that all dentine bonding agents significantly reduce apical microleakage at all time intervals and that blood contamination did not adversely affect the sealing ability of AMB, PUB3 or SMP and that blood contamination significantly increased microleakage in AB2 group after 12 and 14 weeks.

Fogel and Peikoff (2001)*[8]*, evaluated the microleakage of various root-end filling materials using a fluid filtration system. Sixty extracted human single-rooted teeth were prepared; the apical 2 to 3 mm of each root was resected perpendicular to the long axis. A fine-medium gutta-percha point was placed into the canal and wedged by pulling the overextended portion apically and cutting off the excess to support the placement of the root-end fillings. Root-end preparations were ultrasonically prepared to a depth of 3 mm. Teeth were divided into five experimental and two control groups. In the experimental groups the root-end cavities were filled with Permite C (zinc-containing admixed amalgam), IRM, Super-EBA, Clearfil Liner Bond-2 (self-etching, self-priming dentin bonding agent) or MTA. Results showed that amalgam root-end fillings demonstrated significantly more microleakage than Super-EBA, dentin-bonded resin, or mineral trioxide aggregate. There was no significant difference between amalgam and IRM. However, IRM was also not significantly different from the other three groups. There were no significant differences between the other three groups.

***Murray et al (2004)*[9],** evaluated the sealing ability of four self-etching adhesives placed over blood-contaminated/uncontaminated resected root apices without root-end preparation. Forty-four extracted single rooted maxillary incisors and canines were cleaned and shaped. The apical 3 mm were resected at 90 degrees to the long axis of the root. Four self-etching adhesives (Clearfil SE Bond, One-Up Bond F, Unifil Bond, and ABF) were applied over the control and contaminated surfaces. After light-curing the resins, the sealed roots were stored in 37°C water for 24 hours before testing leakage using fluid filtration device. Results showed that no significant differences were noted in the sealing effectiveness among the adhesives applied to contaminated or uncontaminated groups and that all contaminated groups had significantly higher leakage than their uncontaminated pairs.

Resilon is an FDA approved thermoplastic synthetic polymer material, based on Polyester. It also contains Bioactive Glass, Bismuth Oxychloride and Barium Sulphate. (65% filler by weight) It is a fully polymerized resin, slightly stiffer than gutta-percha but it can go around curves as well due to the filler components that make it flexible. It is slightly more radio-opaque that gutta-percha. It looks exactly like gutta-percha except for the white color. The Resilon material is supplied with a dentin primer and a dual cure sealer (Epiphany).

Epiphany Primer is a self-etch primer, which contains sulfonic acid terminated functional monomer, HEMA, water, and polymerization initiator. The preparation of the dentin through these chemical agents may prevent shrinkage of the resin filling away from the dentin wall and aid in sealing the roots filled with Resilon material.

Shipper et al (2004)*[10]*, evaluated microbial leakage in roots filled with a thermoplastic synthetic polymer-based root canal filling material (Resilon) and compared it to that of gutta-percha. One hundred and sixty five human single-rooted teeth were instrumented and randomly divided into eight experimental and three control groups of 15 roots each. Roots were filled using lateral and vertical condensation techniques; with gutta-percha and AH 26 sealer (groups 1 and 2), gutta-percha and Epiphany sealer (groups 3 and 4), or Resilon and Epiphany sealer (groups 5 and 6) and then tested for microbial leakage of S.mutans. Groups 7 and 8 were filled with Resilon and Epiphany sealer and E.Faecalis was used to test the leakage. Control groups were filled with Resilon or gutta-percha without sealer. Results showed that Resilon showed significantly less leakage than gutta-percha, in which approximately 80% of specimens with either techniques or sealer leaked.

Li et al (2005)*[11]*, investigated the antimicrobial potential of Epiphany Root Canal Sealant with Primer (Pentron Corp.). Samples of Epiphany sealant with Primer were prepared following manufacturers' instructions. Diffusion method was used to examine the antimicrobial potential of Epiphany sealant with Primer. Inhibitory effects of the test agents on S. mutans and E. faecalis were examined by measuring the diameter of the inhibition zone after incubation for 24, 48 hours and 7 days. Results showed that Epiphany Root Canal Sealant with Primer showed significant inhibitory effects on S. mutans and E. faecalis.

King et al (2005)*[12]*, evaluated the susceptibility of Resilon (polycaprolactone-based root filling material) degradation by alkaline hydrolysis. They prepared 0.5-mm thick, 15-mm wide disks of Resilon and Obtura gutta-percha by compressive molding of the materials at 80°C, and immersed these disks in 20% sodium ethoxide (NaOH in ethanol) for 20 or 60 minutes. Control disks were immersed in ethanol for 60 minutes. The disks examined with field-emission scanning electron microscopy (FE-SEM) for the hydrolysis of the resin components, and energy dispersive X-ray analysis (EDX) of the subsurface fillers. Additional non-hydrolyzed disks of Resilon and Obtura gutta-percha were prepared for transmission electron microscopy (TEM) of the polymer lamellae structure. FE-SEM examination revealed that Resilon was susceptible to alkaline hydrolysis. The original smooth polymer surface was partially hydrolyzed after 20 min of sodium ethoxide immersion, exposing crystalline regions within the polymer and subsurface glass and bismuth oxychloride fillers and that more severe hydrolysis occurred after 60 min of sodium ethoxide treatment, causing complete exposure of the fillers within pitted regions. Gutta-percha was unaffected after immersion in sodium ethoxide. TEM revealed electron-dense fillers and the presence of lamellae-like structures within the polymer matrix in both Resilon and gutta-percha, confirming the semi-crystalline nature of the polymers. They concluded that, as pure polycaprolactone is known to be susceptible to both alkaline and enzymatic hydrolyses, the observation that alkaline hydrolysis occurs to the polycaprolactone-based Resilon suggests that enzymatic hydrolysis and microbial biodegradation of this material may also take place.

Versiani et al (2005)[(13)]**,** evaluated the solubility of Epiphany root canal sealant. Cement samples of 1.5mm thickness, 20mm in diameter were prepared and left to set for a period corresponding to three times the setting time. The samples were weighed and immersed in 50ml of deionized distilled water for 7 days, then removed, dried and weighed again to determine the mass loss of each sample, expressed as percentage of original mass. Results showed that the mean value of solubility was 3.34%, which is higher than the ADA recommendations (3%).

Benzley et al (2005)[(14)]**,** examined the extent to which Resilon/Epiphany (a resilon-based obturating system) is able to penetrate the intra-canal dentinal tubules. Four extracted human single-rooted teeth were prepared and filled with Resilon/Epiphany obturation system. Epiphany sealer was given adequate time to set before the teeth were sectioned longitudinally to expose the dentine/resilon interface. The samples were examined with Scanning Electron Microscope (SEM) at ~2000X. Results showed that the tooth filled with resilon showed visible penetration of the material into the dentinal tubules and that the number of filled tubules was much greater in the coronal region with virtually no tubules being filled in the apical region.

Tay et al (2005)[15]**,** compared the ultrastructural quality of the apical seal achieved with Resilon/Epiphany and gutta-percha/AH Plus. Extracted human single-rooted teeth were prepared, debrided with NaOCl and EDTA, and obturated with either Resilon/Epiphany or gutta-percha/AH Plus. Samples were examined for gaps along canal walls using SEM, and for apical leakage using a transmission electron microscopy (TEM). SEM revealed both gap-free regions, and gap-containing regions in canals filled with both materials, TEM revealed the presence of silver deposits along the sealer-hybrid layer interface in Resilon/Epiphany, and between the sealer and gutta-percha in the controls. They concluded that a complete hermetic apical seal cannot be achieved with either root filling materials.

Shaw et al (2006)[16]**,** evaluated the sealing properties of four endodontic sealers (PCS/Kerr, TopSeal/Dentsply, GuttaFlow/Coltène, Epiphany/Pentron). Sixteen extracted human single-rooted teeth were sectioned into 10 mm long root segments. Each root was prepared, debrided with 17% EDTA and 3% sodium hypochlorite solution, rinsed with 0.9% saline and obturated using either gutta-percha with PCS, TopSeal, GuttaFlow or Epiphany points with Epiphany sealer. Sealing was evaluated after 24 hours using fluid filtration technique, and fluid flow (indicating leakage of the seal) was measured every 30 seconds for 24 hours. Results showed that materials were significantly different in leakage at all times, and that Epiphany had the lowest leakage of the materials tested.

Maltezos et al (2006)[17]**,** compared the root-end sealing of the Resilon/Epiphany system (RES) to Pro Root MTA and Super-EBA using a bacterial leakage system. Fifty-five extracted teeth were instrumented, root-ends were resected and ultrasonically prepared. Root-end preparations were filled with Resilon/Epiphany system, Pro-Root MTA or Super-EBA. Streptococcus salivarius was introduced coronally and the apical 4 mm were immersed in BHI culture medium with phenol red indicator. Bacterial leakage was monitored every 24 hours for four weeks. Results showed that RES and MTA leaked significantly less than Super-EBA, and that there was no statistical difference between RES and MTA. They concluded that RES may be a viable option as a root-end filling material with good surgical isolation.

Gu et al (2006)[18], compared the ability of six endodontic sealants (methacrylate-based (Epiphany and EndoRez), gel-powder epoxy-based (AH 26 and EZ-Fill), and gel-gel epoxy-based (AH Plus and EZ-Fill Auto) to prevent dye leakage when used with a single cone technique. Thirty human single rooted teeth prepared and obturated. For the epoxy samples, the sealant was applied to the canals using a bi-directional spiral and a medium gutta percha point was used. For the Epiphany samples, the bonding agent was applied with a paper point, the sealant with a lentulo, and a medium resilon point was used. For the EndoRez samples, the sealant was applied using the Navi-Tip and a single medium EndoRez point was used. Sealing ability was evaluated using dye penetration method. Results showed that gel-gel epoxy-based sealants showed the least leakage followed by gel-powder epoxy-based and that methacrylate-based sealants (Epiphany and EndoRez) showed the highest leakage scores.

In the past, leakage of root-end filling materials has been measured by penetration of dyes, isotopes, microorganisms, or electrochemical means. All of these techniques have been shown to have a variety of shortcomings. Fluid filtration method presents several advantages over the common dye penetration method: the samples are not destroyed, permitting the evaluation of the sealing efficiency over time; the results are automatically recorded avoiding any operator bias and the results are very accurate because very small volumes can be recorded.

Derkson et al (1986)[19]***,*** described a new in vitro method for microleakage measurement of selected restorative materials. Extracted human third molars were sectioned at the cemento-enamel junction and crown segments were placed on pieces of Plexiglass and attached to filtration apparatus. Phosphate buffered saline containing 0.1% Trepan blue dye was introduced into the pulp chambers of the crown segment at a constant pressure of 15 psi. The measurement of movement of the air bubble in the micropipette per unit time quantities the permeability of each crown segment in ml/min.

Pommel and Camps (2001)[20]***,*** evaluated the influence of the measurement time and the pressure on the outcome of a fluid filtration test. Thirty-six roots were prepared and filled with Thermafil. Roots were divided into two groups; 18 tested with a low pressure (15 cm H_2O) and 18 with a high pressure (150 cm H_2O). The leakage along the filling material was recorded at three minutes, one hour and 24 hours. Results showed that fluid flow decreased with an increased measurement time and was higher in the high pressure group. They concluded that standardization to compare the results from various studies is needed.

Pommel et al (2001)[21]***,*** compared three methods of evaluation of the apical seal. Thirty-six central maxillary incisors were filled according to three different techniques (Thermafil, warm vertical condensation, and the single cone technique). The apical leakage was then measured with three different methods on the same tooth (fluid filtration method, electrochemical method, and dye penetration method). Fluid filtration method revealed that the single cone technique showed the largest apical leakage, Thermafil showed a moderate leakage, and the vertical condensation showed the least leakage. Electrochemical method failed to show a difference in leakage among the three filling techniques. Dye penetration method showed that single cone technique and vertical techniques. No correlation was found among the results obtained with the three methods of evaluation. Therefore, several studies are necessary before comparing the apical seal obtained with various filling techniques.

Aim of the Study

The aim of the present study will be to compare the sealing ability of thermo-plasticized Resilon versus thermo-plasticized gutta-percha when used as a root end filling materials with and without root end cavity preparation.

Materials and Methods

1. Preparation of Samples:

Sixty freshly extracted human single rooted teeth with mature apices will be used in this study.

The clinical crowns of all teeth will be removed at the cemento-enamel junction using a diamond stone in a high speed hand piece with water coolant.

All root canals will be cleaned and shaped using Gates Glidden drills and Flex-O-files with 5.25% sodium hypochlorite as an irrigant. Working lengths will be determined by placing # 10 file in the canal until visible at the apical foramen and subtracting 1mm. The canals will then be enlarged to # 60 master apical file.

***2. Classification of Samples*:**

Experimental samples will be randomly divided into two equal groups (30 samples each) according to the type of root canal filling material used.

- Group I: Enlarged root canals will be obturated using thermo-plasticized gutta-percha with AH26 sealer.
- Group II: Enlarged root canals will be obturated using thermo-plasticized Resilon with Resilon sealer.

Each experimental group will be subdivided into three equal subgroups according to the method of apical treatment:

- Subgroup (A) of groups I and II: will have their resected root surface unsealed.
- Subgroup (B) of groups I and II: will have their resected root surface sealed with either self etch adhesive (group I) or Resilon sealer (group II).
- Subgroup (C) of groups I and II: retrocavities 3mm in depth will be prepared and filled with either thermo-plasticized gutta-percha (group I) or thermo-plasticized Resilon (group II).

3. Material Application:

Irrigation with sodium hypochlorite and hydrogen peroxide will be done. After the last irrigation with sodium hypochlorite, 17% EDTA will be used to remove the smear layer. The canals will be washed with water. 12% chlorhexidine gluconate will be used as the final rinse. The excess chlorhexidine will be dried with paper points. The self-etch primer will be placed into the canals with paper points, allowed to remain for 30 seconds and then removed with paper points.

All materials will be mixed and inserted into the canals according to manufacturers' instructions.

4. Root Resection:

The apical 3mm of all samples will be resected with a fissure bur in a high speed hand piece under water spray, at 90 degrees to the long axis of the tooth.

5. Method of Evaluation:

The sealing ability of the tested materials will be evaluated using the fluid filtration technique.

The technique in brief is as follows:

The fluid filtration apparatus consists of a pressurized tank of nitrogen gas, a fluid dye reservoir, polyethylene tubing containing an in-line 25-µl micropipette, a microsyringe assembly. The root segment will be attached to the vial-tube assembly. Microleakage measurements will be done by delivering nitrogen gas at a constant pressure of 20 psi to the fluid reservoir, which contains a beaker of red dye in 0.9% sterile saline. Before use, fresh dye solution will be syringe-filtered through micropore cellulose-acetate membrane. The Polyethylene tubing connecting the pressurized dye solution to the micropipette will be subsequently connected to the vial-tube assembly. A 5-min pressurization preload of the system will be completed before taking readings to allow for relaxation of the tubing. A 1-mm nitrogen bubble will be introduced into the tubing with the microsyringe until it reaches the micropipette. Linear movement of the bubble will be viewed against an endodontic ruler that is graduated in 0.5-mm increments.

References

1. **Barry GN, Heyman RA, Elias A:** Comparison of apical sealing methods. A preliminary report. Oral Surg Oral Med Oral Pathol; 39: 806-11, 1975.

2. **Szeremeta-Browar TL, VanCura JE, Zaki AE:** A comparison of the sealing properties of different retrograde techniques: an autoradiographic study. Oral Surg Oral Med Oral Pathol; 59: 82-8, 1985.

3. **Negm MM:** The effect of varnish and pit and fissure sealants on the sealing capacity of retrofilling techniques. Oral Surg Oral Med Oral Pathol; 66:483-8, 1988.

4. **Shaw CS, BeGole EA, Jacobsen EL:** Apical sealing efficacy of two reverse filling techniques versus cold-burnished Gutta-percha. J Endod; 15: 350-4, 1989.

5. **Thirawat J, Edmunds DH:** Sealing ability of materials used as retrograde root fillings in endodontic surgery. Int Endod J; 22: 295-8, 1989.

6. **Ansari SR, Qayyum Z, Khitab U:** A comparison of sealing capabilities of amalgam, GIC and zinc oxide eugenol cement when used as retro grade filling materials (in vitro study). J Ayub Med Coll Abbottabad; 15:43-6, 2003.

7. **Vignaroli PA, Anderson RW, Pashley DH:** Longitudinal evaluation of the microleakage of dentin bonding agents used to seal resected root apices. J Endod; 21: 509-12, 1995.

8. **Fogel HM, Peikoff MD:** Microleakage of root-end filling materials. J Endod; 27: 456-8, 2001.

9. **Murray MJ, Loushine RJ, Weller RN, Kimbrough WF, Pashley DH:** Use of self-etching adhesives to seal resected apices. J Endod; 30: 538-40, 2004.

10. **Shipper G, Orstavik D, Teixeira FB, Trope M:** An evaluation of microbial leakage in roots filled with a thermoplastic synthetic polymer-based root canal filling material (Resilon). J Endod; 30: 342-7, 2004.