Dentinal Bonding Reaches the Root Canal System

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ABSTRACT

Several factors can contribute to the achievement of success with endodontic therapy. After an effective microbial-control phase, an adequate canal and coronal filling will guarantee a high probability of success. Gutta-percha has for many years been widely used as a solid material in root fillings associated with different types of sealers. Even associated with a sealer, this material it is not capable of preventing leakage, as has been shown in many studies. In fact, because of gutta-percha's limitations, the seal of a coronal restoration may be as important as the gutta-percha fill in preventing reinfection of the root canal. Although sealers can form close adhesion to the root canal wall, none is able to bond to the gutta-percha core material. Upon setting, the sealer pulls away from the gutta-percha core, leaving a gap through which bacteria may pass. This article describes a new thermoplastic, synthetic root canal filling material, whose design is based on polyester chemistry, that looks and handles like gutta-percha. It is used in the same manner as most bonding systems. After the usual preparation of the root canal, a self-etch primer is used to condition the canal walls and prepare them for bonding to the resin. The resin sealant is introduced in the root canal. It bonds to the primer and to the resin core material; thus, a "monoblock" is formed without the gaps typical in gutta-percha fillings. Studies have shown that leakage of bacteria with this material is significantly reduced compared with gutta-percha.

CLINICAL SIGNIFICANCE

Although gutta-percha has been used for many years in the endodontic therapy, the development of an adhesive, resin-based filling material with better properties could increase the potential for successful outcomes since a better interface between root canal walls and filling material decreases bacterial microleakage.

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Restoration of endodontically treated teeth is currently undergoing appreciable changes in both concepts and techniques. This is particularly true regarding root canal filling materials and endodontic posts. In the case of the latter, the precision-fitting gold alloy cast post has given way to materials that are comparatively less robust. Rather than using materials with a high elastic moduli, post systems possessing elastic modulus values closer to those of the root itself have become increasingly popular.[1–4]

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The first of these was the carbon fiber post (C-Post, Bisco, Itasca, IL, USA), which possesses a modulus far closer to dentin than either gold alloy or stainless steel posts. Several clinical investigations have demonstrated that endodontically treated teeth restored with the lower-modulus carbon fiber post commonly exhibited a significant lower level of fracture during service. Subsequently, a more esthetic post with an even more closely matched elastic modulus to tooth structure was introduced. Consisting of parallel glass fibers bonded together by means of a dimethacrylate polymer, FibreKor Post (Pentron Technologies, LLC, Wallingford, CT, USA) has exhibited the same type of excellent clinical performance. Another advantage to these nonmetal, prefabricated posts pertains to ease of retrieval when re-treatment is necessary.[5]

The next innovation occurring in the restorative process for endodontically treated teeth consisted of bonding a composite resin luting agent to the walls of the preparation as well as to the surface of the endodontic post. This is accomplished by first acid etching the instrumented chamber and then applying a fourth- to sixth-generation dentin bonding agent to its surface as well as to the endodontic post. First described by Nathanson,[6] the process was further modified by Al-Qassem,[5] who introduced a mechanism by which the bonding agent actually penetrated all the radicular odontoblastic tubules to within several microns of the external surface. Such a technique was shown to increase the fracture resistance of the root by 35%.

The most recent improvement in the process of restoring endodontically treated teeth involves the substitution of a polymer for the conventionally used gutta-percha. Identified as Resilon (Pentron Technologies), this gutta-percha substitute is a thermoplastic, synthetic, polymer composite root canal filling material. Designed based on polyester chemistry, Resilon contains bioactive and radiopaque fillers. Clinically this material can be manipulated in the same manner as gutta-percha but possesses the potential for bonding with a resin-based sealant or bonding agent. It offers the major advantage of preventing bacterial microleakage owing to enhanced sealing. Furthermore, this substitute for gutta-percha is highly radiopaque. The purpose of this review is to summarize what is currently known about the use of Resilon as a root canal filling material.

MATERIAL PROPERTIES

Dentin bonding used in restorative dentistry has been applied to endodontic treatment with promising results reported, particularly with resin sealers.[7,8] A few studies have evaluated the potential of using dentin bonding agents and resins as obturation materials in nonsurgical root canal treatment.[9–11] Reasons for not using resins have centered on questionable results owing to difficult and unpredictable methods of delivery of the material into the root system and the inability to re-treat the canal if necessary.[11] However, it has been acknowledged that these materials may have the potential to enhance the root canal seal by reducing microleakage from both apical and coronal directions, thereby contributing to the success of orthograde root canal treatment.

Resilon is a thermoplastic, synthetic, polymer-based root canal core filling material that contains bioactive glass and radiopaque fillers. It performs like gutta-percha, has the same handling properties, and for re-treatment purposes may be softened with heat or dissolved with solvents such as chloroform. Because it is a synthetic, polymer-based composite, the resin sealer attaches to it, as well as to the bonding agent used to penetrate into the dentin tubules, forming a "monoblock" composed of filling material, resin sealant, bonding agent, and dentin (Figure 1). This monoblock does not occur when gutta-percha is used as the core material because the sealer, even if resin based, does not bind to gutta-percha and tends to pull away from the gutta-percha on setting.

The core material of Resilon is similar to gutta-percha in that

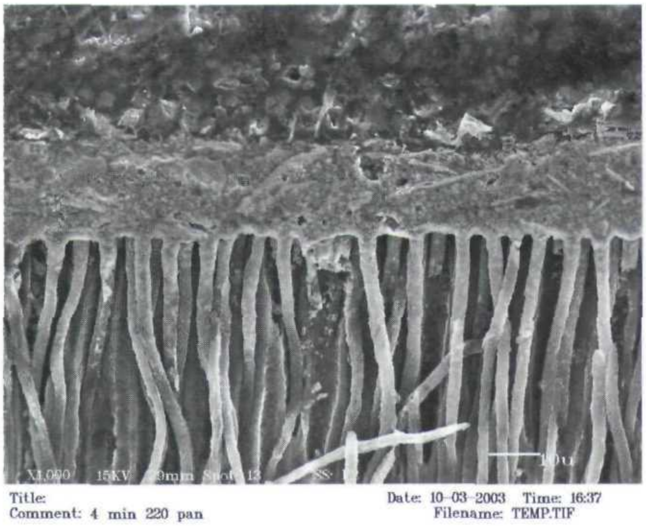

Figure 1. Scanning electron microscopy image demonstrating the continuity between resin tags in dentinal tubules, the hybrid layer, Epiphany sealant, and Resilon.

Figure 2. Resilon plugs, master and accessory cones, Epiphany sealant, and Epiphany primer.

there are master cones and accessory cones in different sizes. In addition, Resilon pellets are available, which can be used for backfilling with warm thermoplasticized techniques. Also needed to complete the canal filling is a self-etch primer (Epiphany primer, Pentron Clinical Technologies) and a dual-curable, polymer, composite sealer (Epiphany sealant, Pentron Clinical Technologies) (Figure 2).

The polymer matrix is a mixture of dimethacrylate, ethoxylated dimethacrylate, urethane dimethacrylate, and hydrophilic difunctional methacrylates. It contains fillers of calcium hydroxide, barium sulfate, barium glass, and silica. The total filler content in the sealer is about 70% by weight.

After finishing the instrumentation, the root canals must be flushed with 17% ethylene diaminetetraacetic acid and saline solution or chlorhexidine (Figure 3) to remove residual sodium hypochlorite and then dried with sterile paper points. The Resilon points or plugs are placed into a disinfectant for 60 seconds. Two to three drops of the primer are dispensed into the mixing well. The root canal walls are coated with the primer using a pipette, syringe, or paper point soaked in primer (Figure 4A and B). Excess primer is removed using paper points, leaving the internal surfaces moist with primer. The remaining solvent can be evaporated with a gentle air spray for 5 seconds. Sealer is dispensed onto a mixing pad and placed with a master cone (Figure 4C) or lentulo spiral kept 3 mm from the apex and rotating no faster than 300 revolutions per minute. The canal is then filled with Resilon core material using the preferred technique (Figure 5). When the Resilon core filling is completed, the coronal surface is light cured for 40 seconds to create an immediate coronal seal

Figure 3. Syringes containing 2% chlorhexidine and 17% ethylenediaminetetraacetic acid.

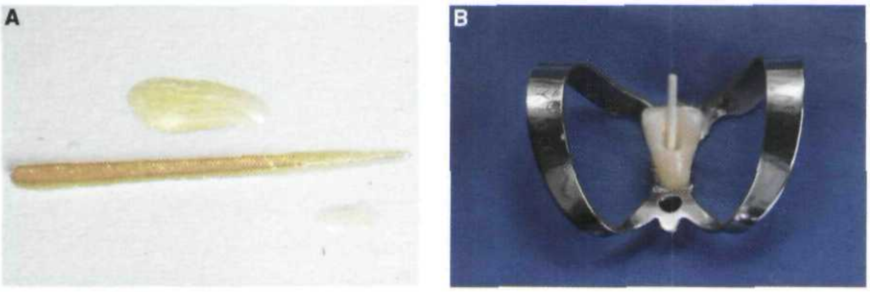

Figure 4. A, *Paper point soaked with primer.* B, *Paper point soaked with primer inside the root canal.* C, *Resilon master cone with sealer.*

(Figure 6). The deeper resin sealer then polymerizes by chemical curing during the following 30 to 60 minutes.

RESEARCH AND CLINICAL IMPLICATIONS

Important basic studies have been performed on the Resilon material. Toxikon Corporation (ISO project no. 01-4421-G1) performed *Salmonella typhimurium* and *Escherichia coli* reverse mutation assay, which demonstrated that Resilon is nonmutagenic.[12] The Epiphany sealant was evaluated and scored using the skin sensitization Kligman maximization test and received a grade 1 reaction, which is considered not significant according to Magnusson and Kligman.[13] Resilon is nontoxic and has been approved by the US Food and Drug Administration.

The sealing efficacy of a root canal filling material is its most basic function in endodontic treatment and this has been evaluated. Shipper and colleagues evaluated coronal leakage using *Streptococcus mutans* and *Enterococcus faecalis* through gutta-percha versus Resilon by two different filling techniques.[14] A total of 120 roots were prepared and randomly divided into eight groups of 15 roots each. Roots were filled using lateral and vertical condensation techniques with gutta-percha and AH 26 (Dentsply Tulsa Dental,

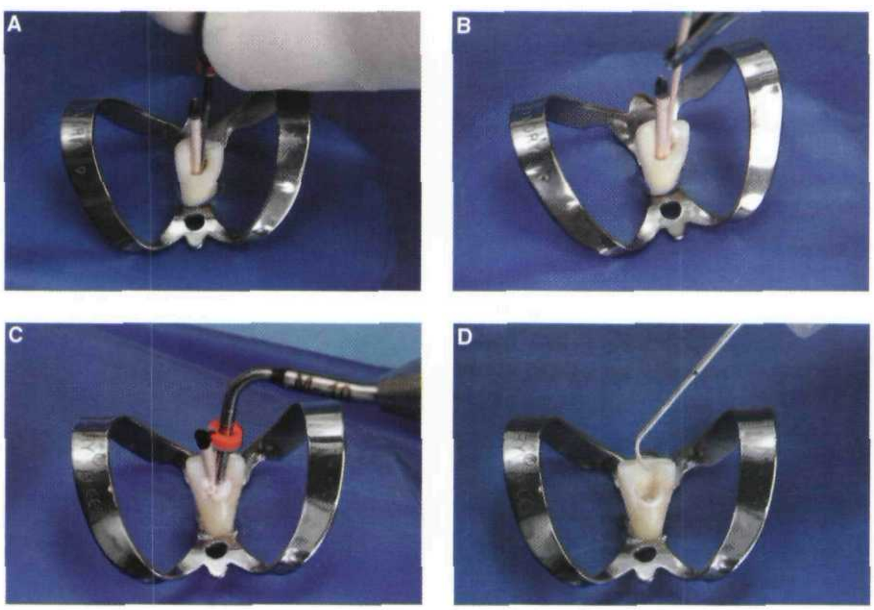

Figure 5. The canal is filled with Resilon core material. A *and* B, *Lateral condensation technique.* C, *Vertical condensation using System B (Sybron Dental Specialties, Orange, CA, USA) and Obtura II (Spartan/Obtura, Fenton, Missouri, USA).* D, *Vertical condensation using Obtura II to backfill.*

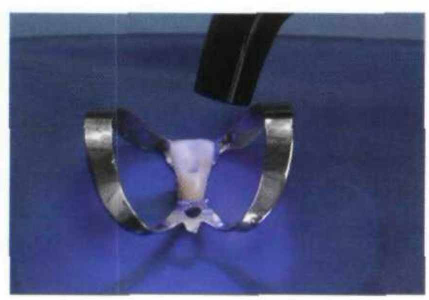

Figure 6. Filling material is light cured.

Tulsa, OK, USA) sealer (groups 1 and 2) or with gutta-percha and Epiphany sealant (groups 3 and 4). Groups 5 and 6 were filled with Resilon and Epiphany sealant using the lateral or vertical condensation techniques. Groups 7 and 8 were identical to groups 5 and 6, respectively, except that only *E. faecalis* was used to test the leakage for these groups. Positive and negative control groups were used. Resilon showed significantly less coronal leakage (1 or 2/15 specimens) than did gutta-percha, with which approximately 80% of the specimens leaked.

The Resilon core is able to bond to the resin sealer which, in turn, attaches to the self-etched root. This forms the monoblock, which is highly resistant to bacterial penetration. One of the potential disadvantages of root canal treatment is the weakening of the root owing to the removal of dentin during instrumentation and also to the filling techniques (lateral or vertical condensation). Since Resilon is a bonded resin system, it has the potential to strengthen the root, as is suggested by the following in vitro study.

Teixeira and colleagues showed that root canals filled with Resilon were more resistant to fracture than roots filled with gutta-percha and AH 26 sealer,[15] indicating that the monoblock is important not only for the resistance of bacterial penetration through the material but also for holding the root together. Eighty single-canal extracted teeth were prepared and randomly divided into five groups: lateral and vertical condensation with gutta-percha, lateral and vertical condensation with Resilon, and a control group with no filling material. Data were subjected to analysis of variance (ANOVA) and Fisher's test at 95% CI using the SPSS 9.0 software (Chicago, IL, USA). Comparison among groups was performed. The ANOVA revealed a significant difference between treatments ($p = .037$). The root resistance fracture values of Resilon vertical and lateral groups were superior to those of gutta-percha–AH 26 sealer lateral and vertical groups. However, no significant difference was observed among filled groups and the nonfilled group (control). Since, clinically, we would not leave instrumented canals unfilled, it appears that the resin-filled

Figure 7. Clinical case filled using the lateral condensation technique (A). Clinical case filled using the hybrid technique—System B and Obtura II at time of filling (B) and at the 3-month follow-up (C). (Courtesy of Fabricio Teixeira, DDS, MSc, PhD)

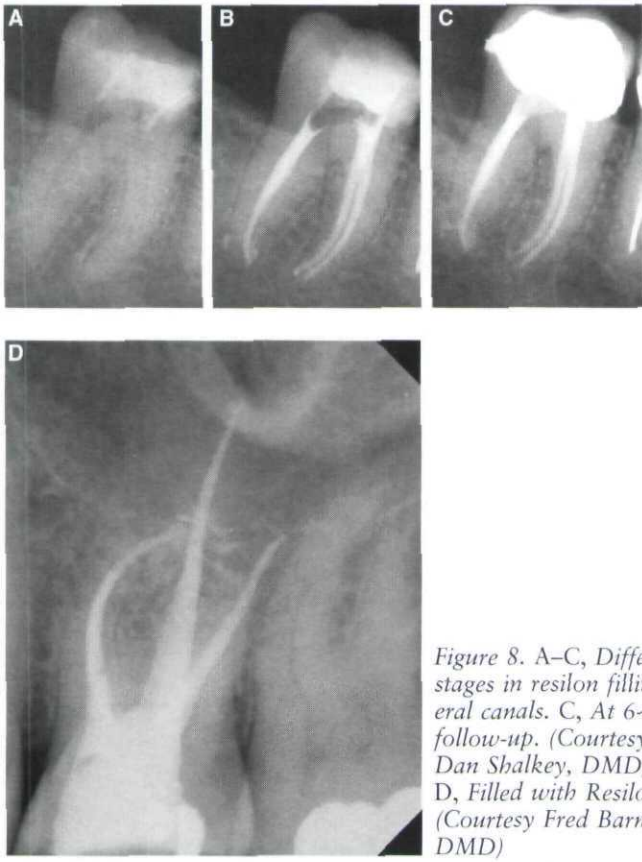

Figure 8. A–C, *Different stages in resilon filling lateral canals.* C, *At 6-month follow-up. (Courtesy of Dan Shalkey, DMD)* D, *Filled with Resilon. (Courtesy Fred Barnett, DMD)*

roots were stronger compared with those filled with gutta-percha.

Clinically, Resilon is highly radiopaque and handles well with both cold (Figure 7A) and heated root canal filling techniques (Figure 7B and C). It appears to be biocompatible, and the sealant has considerable flow through accessory canals (Figure 8). No untoward postoperative pain has been reported by clients who have received the system, and some cases have shown healing in a short period of time (see Figures 7B and C and 8D).

CONCLUSIONS

The aim of this article was to review a new material and a different concept of root canal filling. Despite the fact that gutta-percha has been used for many years for root canal treatment, new materials and techniques have been developed that may increase the potential for successful outcomes by creating a better interface between root canal walls and filling material, resulting in a decrease in bacterial microleakage. Further studies are necessary to confirm Resilon's clinical performance as a replacement for gutta-percha.

DISCLOSURE

The author Martin Trope is a paid consultant for Pentron Clinical Technologies LLC, Wallingford, CT, USA. He is also a paid consultant for Resilon Research, North Branford, CT, manufacturer of the material discussed in this article.

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COMMENTARY

DENTINAL BONDING REACHES THE ROOT CANAL SYSTEM

John S. Olmsted, DDS, MS*

The authors have approached the problem of endodontic therapy success with a technique and material to improve the seal of the root canal system from apex to coronal tooth structure. Although gutta-percha has been used for many years as the root canal filling material of choice, the development of an adhesive, resin-based filling material with better properties would increase the potential for successful results. An improved interface with the dentinal walls and root canal filling material decreases bacterial microleakage.

Resilon is nontoxic, and the material has earned approval from the US Food and Drug Administration. The sealing efficacy of Resilon with Epiphany sealant has been shown to be superior to that of gutta-percha with various sealers and techniques. The Resilon core bonds to the tooth structure to form a monoblock, which improves the strength of the tooth.

This new material can be used with different condensation techniques; it is adaptable to lateral condensation, vertical condensation, Obtura heated technique, or mechanical compaction. Resilon with Epiphany sealer has been used in our practice over the past 6 months as the root canal filling material of choice for over 800 patients. Initially encouraging results will nurture further investigation of this most promising new root canal filling material and technique.

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