10.5005/jp-journals-10024-1698

REVIEW ARTICLE

Resilon: Review of a New Material for Obturation of the Canal

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ABSTRACT

Resilon is a thermoplastic synthetic polymer-based endodontic material alternative to gutta-percha. It contains bioactive glass and also radiopaque fillers. It has the same handling properties as gutta-percha. For endodontic retreatment, it may be dissolved with some solvents, such as chloroform or softened with heat. The composition of Resilon and its sealer (Epiphany) bond to dentin and form a monoblock. A review of the literature and a discussion of its properties comparing to other root canal filling materials are presented.

Keywords: Gutta-percha, Obturation, Resilon.

How to cite this article: Mohammadi Z, Jafarzadeh H, Shalavi S, Bhandi S, Kinoshita J-I. Resilon: Review of a New Material for Obturation of the Canal. J Contemp Dent Pract 2015;16(5): 407-414.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Resilon is a thermoplastic synthetic polymer-based filling material with the same handling properties of gutta-percha (GP). Epiphany sealer is a dual curable dental resin composite sealer. Resilon/Epiphany system is comprised of three components as follows:[1,2]

a. A self-etch primer, which contains a sulfonic acid terminated functional monomer, HEMA, water and a polymerization initiator.
b. A dual-curable, resin-based sealer. It contains fillers of calcium hydroxide (CH), bismuth oxychloride, barium glass and silica. The total filler content is 70%.
c. Resilon core material is a thermoplastic synthetic polymer based core contains bismuth oxychloride, bioactive glass and barium sulphate. The fillers content is 65% by weight. The Resilon core materials, similar to GP cones, are available in ISO-sizes in 0.02, 0.04 and 0.06 tapers, as well in accessory sizes.[2] Additionally, pellets of this material are available for use with the Obtura II (Obtura/Spartan, Fenton, MO), USA delivery system.

This review will address its properties comparing to other root canal filling materials.

Sealing Ability of Resilon

Using a dog model, Shipper et al[3] showed that the Resilon 'Monoblock' System was associated with less apical periodontitis, which may be because of its superior resistance to coronal microleakage. Tay et al[4] compared the apical seal quality achieved by GP/AH-Plus and Resilon/Epiphany. Both gap-containing regions and gap-free areas in canals filled with both materials were shown. Maltezos et al[5] evaluated the root end sealing of Resilon/Epiphany to MTA and Super EBA and found that MTA and Resilon/Epiphany leaked significantly less than Super EBA. There was no statistical difference between MTA and Resilon/Epiphany. Aptekar and Ginnan[6] showed that Resilon as the main material of obturation resulted in less microleakage than GP.

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Stratton et al[7] showed that the leakage of Resilon is significantly less than GP/AH-Plus sealer. Biggs et al[8] also revealed that Resilon/Epiphany was not better than GP/AH-Plus or GP/Roth. According to Pitout et al[9], there was no significant difference between GP and Resilon using either the cold lateral condensation or the system B techniques. Bodrumlu and Tunga[10] confirmed the better sealing ability of Resilon compared to GP. Onay et al[11] evaluated the sealing ability of the Epiphany/Resilon, and compared it with the sealing ability of GP, AH-Plus, Epiphany, and Resilon and concluded that Epiphany/GP had the least amount of microleakage than all the other groups and AH-Plus/Resilon showed the greatest microleakage.

Shemesh et al[12] assessed the sealing ability of GP/AH-26 and Resilon/Epiphany and concluded that using glucose penetration model, GP leaked less than Resilon. However, using fluid filtration method, there was no significant difference between GP and Resilon. According to Baumgartner et al,[13] sealing ability of Resilon was not different from GP. Mohammadi and Khademi[14] reported that coronal seal produce by MTA was equal to that produced by Resilon. Pasqualini et al[15] assessed the sealing ability of Resilon and GP and concluded that microleakage of GP was less than Resilon. The better seal of the Resilon compared to GP has been confirmed by Silveira et al[16] and Paque and Sirtes.[17] De-Deus et al[18] showed that Resilon/Epiphany cannot improve the resistance to the bacterial leakage compared with traditional GP/sealer composition.

Bodrumlu and Tunga[19] assessed the coronal sealing ability of GP/AH-26 sealer, GP/AH plus sealer and Epiphany/Resilon and found that although all of the root canal filling materials tested yielded a satisfactory seal, the Epiphany exhibited the least coronal leakage. Raina et al[20] evaluated the apical leakage of canals obturated with GP/AH Plus or Resilon/Epiphany using warm vertical condensation technique and concluded that both of them sealed 17 mm canals. They also found that Resilon/Epiphany did not create a monoblock root filling that did not leak. Using a glucose penetration model, Kaya et al[21] assessed the sealing ability of Resilon and GP along the canals and showed that GP/AH-Plus allowed similar patterns of glucose penetration to Resilon/Epiphany. Using a fluid filtration model, Wedding et al[22] compared the sealing ability of GP and Resilon and concluded that sealing ability of GP was significantly less than Resilon. Zmener et al[23] compared the effect of different levels of canal moisture on the coronal seal after filling with Resilon/Epiphany, resin-coated GP/EndoRez, and GP/Grossman's sealer. They showed that dye leakage was affected by the degree of the moisture.

Shin et al[24] assessed the sealing ability of Resilon and GP on *Enterococcus faecalis*. They showed that obturation with Resilon and a resin-based sealer induced a significant reduction in the bacterial counts. Using a fluid filtration model, Jack and Goodell[25] compared coronal leakage between GP with a glass-ionomer intra-orifice barrier and Resilon alone. They concluded that sealing ability of GP is better than Resilon. Using a bacterial leakage model, Fransen et al[26] showed that there is no significant difference between the sealing ability of ActiV GP/glass ionomer sealer, Resilon/Epiphany and GP/AH Plus. Nagas et al[27] indicated that obturation techniques had no significant effect on the leakage values. Oddoni et al[28] compared the coronal and apical leakage of AH-Plus with GP to that of Epiphany with Resilon. Findings revealed that AH-Plus with GP and Epiphany with Resilon provided the same coronal seal, whereas Epiphany with Resilon provided the best apical seal. Kocak et al[29] revealed that there is no difference between the sealing ability of GP and Resilon. Williamson et al[30] compared the coronal sealing ability of Resilon/Epiphany and GP/sealer with cold lateral or warm vertical condensation techniques and concluded that there is no significant difference. Kokorikos et al[31] revealed that leakage of root canals filled with Resilon/Epiphany system increased by time lapse.

Hirai et al[32] showed that the sealing ability of GP/AH-Plus sealer was better than Resilon/Epiphany. It has been demonstrated that irrigation with 2% chlorhexidine (CHX) increased resistance of root-filled teeth with Resilon to saliva leakage.[33] Karapinar-Kazandağ et al[34] revealed that sealing ability of Resilon did not seem to be superior that of GP. de Almeida-Gomes et al[35] compared coronal and apical microleakage of root canals filled with Resilon/Epiphany or GP/Grossman sealer, using either lateral condensation or System B technique. Results demonstrated that there were no differences between GP/Grossman sealer and Resilon/Epiphany and obturation techniques (lateral condensation and system B technique) in coronal or apical leakages.

Using fluid filtration method, Santos et al[36] assessed the immediate and long-term sealing ability of Resilon. Findings revealed that Epiphany/Resilon showed more leakage than AH-Plus/GP, regardless of the coronal sealing condition. According to Kqiku et al,[37] root canal fillings with Epiphany/Resilon showed less dye penetration than lateral condensation of GP and Gutta-Flow sealer. Bodrumlu et al[38] evaluated the effect of irrigation with sodium hypochlorite (NaOCl), CHX, and MTAD on the sealing ability of canals obturated with Resilon. Their results indicated that CHX irrigation

solution exhibited higher apical leakage values than did MTAD and NaOCl and MTAD group showed the least leakage values. Al-Hadlaq et al[39] showed that the single cone Resilon obturation technique was inferior to cold lateral compaction of Resilon or GP. According to Shashidhar et al,[40] using both lateral compaction and vertical compaction techniques, showed that sealing ability of Resilon was significantly better than GP. Punia et al[41] indicated that Resilon provided better apical seal than GP. Kqiku et al[42] revealed that canals obturated with Resilon/Epiphany showed less apical leakage than those obturated with GP/AH-Plus. Using a bacterial leakage model, Kangarlou et al[43] showed that there was no significant difference between the sealing ability of GP/AH-26 and Resilon/Epiphany. Wang et al[44] evaluated the effects of the use of CH on the sealing ability of Resilon and concluded that CH cannot adversely affect the seal produced by Resilon. According to Pasqualini et al,[45] CH did not have a considerable impact on the apical seal.

Fracture Resistance

According to Teixeira et al,[46] obturation of the canals with Resilon increased the resistance to fracture of endodontically treated teeth (ETT) when compared with standard GP systems. Stuart et al[47] studied the reinforcement and strengthening ability of GP, Resilon, and a self-curing composite resin in endodontically treated immature teeth. Sagsen et al[48] revealed that there was no difference between the fracture resistance of roots filled with Resilon/Epiphany, GP/AH-26 sealer and GP/MCS sealer. Wilkinson et al[49] investigated the fracture resistance gained by filling root canals of simulated immature teeth with either Resilon, GP, a self-curing flowable composite resin, or a self-curing hybrid composite resin. Findings revealed that only self-curing hybrid composite resin increased the fracture resistance significantly. A study revealed that filling the root canal with Resilon increased the resistance to vertical root fracture.[50] Ulusoy et al[51] evaluated the fracture resistance of roots obturated with AH-26 sealer and GP, Resilon and Epiphany, Ketac-Endo Aplicap and GP and showed that the use of AH26 + GP increased the fracture resistance of instrumented canals compared with Resilon+Epiphany and Ketac-Endo Aplicap + GP.

Grande et al[52] compared Resilon in conjunction with either Epiphany or a nonbonding endodontic sealer to EndoRez and GP with regards to the physical properties and flexural stress of dentin cylinders and the flexural stress of Resilon and GP. Results showed that tested materials and their recommended adhesive procedures had not the ability of influencing the mechanical properties of dentin. Ribeiro et al[53] showed that Resilon was not able to increase the root fracture resistance in canals submitted to chemomechanical preparation. Hemalatha et al[54] showed that Resilon cannot increase the root strengthening and showed no difference in reinforcing immature teeth when compared with thermoplastisized GP. Chadha et al[55] showed that teeth obturated with Resilon/Epiphany had less fracture resistance than those obturated with GP/AH-Plus. Hanada et al[56] demonstrated that roots obturated with Resilon/Epiphany had significantly lower resistance to vertical fracture than those filled with GP/Sealapex. Baba et al[57] showed that Resilon increased the resistance to fracture of ETT when compared with GP. Monteiro et al[58] revealed that teeth obturated with Resilon were more resistant to fracture than those obturated with GP.

Retreatment of Resilon-filled Canals

Ezzie et al[59] showed that chloroform combined with rotary files is more able in Resilon removal compared to heat. de Oliveira et al[60] compared the remaining filling material and working time when removing Resilon/Epiphany and GP/AH 26. The teeth filled with Resilon/Epiphany and retreated with K3 rotary files demonstrated the least residual material. There was no significant difference between the Resilon/Epiphany and GP/AH 26 when the Liberator files were used. In the roots filled with Resilon/Epiphany, the filling material was removed faster than those filled with GP/AH 26. Hassanloo et al[61] showed that Epiphany was retreatable with and without chloroform, with fewer efficacies than GP and AH-Plus.

Cunha et al[62] assessed the obturation removal and re-instrumentation working time of canals filled with Resilon/Real Seal in comparison with canals filled with GP/AH-Plus. Results revealed that the Resilon/Real Seal system was removed in greater quantities from the canal walls compared with GP cones and the AH-Plus. Time was not a significant factor. Under SEM analysis, the teeth presented material remnants in the 3 analyzed thirds. Resilon was better removed from the canal than the GP cones and the AH Plus. Taşdemir et al[63] evaluated the ability of removal of fillings using Resilon/Epiphany, EndoTwinn, GuttaFlow, and GP with AH-Plus sealer. Results revealed that there was no significant difference among these techniques regarding the amount of residual material in the canal. Iizuka et al[64] compared the amount of canal enlargement when Epiphany/Resilon, SuperBond/GP, SuperBond/Resilon, and Canals N/GP were removed with K3 files with or without heat-softening. In terms of canal enlargement, there were no significant differences between these groups.

Somma et al[65] compared the effectiveness of Hedström manual technique, Mtwo, and ProTaper retreatment system a in the removal of GP, Resilon and EndoRez. Results revealed that all instruments left remnants of filling material on the canal irrespective of the filling material. Karabucak et al[66] revealed that Resilon flowed better into lateral canals when a single backfill technique was used. Bodrumlu et al[67] assessed the efficacy of gates glidden drill, a gates glidden drill plus chloroform and System B in removing laterally compacted Resilon/Epiphany and GP/AH Plus and concluded that removal of Resilon/Epiphany would create fewer remnants and also faster than GP/AH-Plus removal using gates glidden drills (with or without chloroform).

Zarei et al[68] assessed the amount of residual filling material in canals obturated with Resilon or GP. They concluded that the possibility of remaining Resilon on the canal wall was more than GP. Fenoul et al[69] compared the efficacy of the R-Endo rotary system and hand instrumentation technique in removing GP or Resilon from the canal. They showed that there was no significant difference between these techniques, both of them left filling material mainly in the apical third of the canal. Tanomaru-Filho et al[70] evaluated the effectiveness of orange oil, eucalyptol, and xylol solvents on Resilon and conventional and thermoplastic GP and concluded that xylol had the best effect, especially on Resilon and conventional GP. Orange oil and eucalyptol were more effective on thermoplastic GP. Marfisi et al[71] evaluated the efficacy of Mtwo Retreatment files, ProTaper Retreatment files, and Twisted Files for removal of Resilon and GP. None of them were able to remove the whole of filling material. Faria-Junior et al[72] also revealed that tetrachloroethylene was the most effective solvent on conventional GP. Azar et al[73] showed that solubility of Resilon in chloroform was significantly more than GP. They also presented more solubility of Resilon over the time.

Cytotoxicity

According to Merdad et al,[74] cytotoxicity of set AH-Plus/GP was comparable with set Epiphany/Resilon. Onay et al[75] evaluated biocompatibility of GP, Resilon, and Epiphany and concluded that at each of these periods, there was no difference in the reaction of implanted materials up to 8 weeks. The reaction intensity diminished after 4 weeks, continued through the 8 weeks period. Bodrumlu et al[76] in an animal study concluded that there is no difference in tissue reaction between GP and Resilon for 7, 15 and 30 days. Leonardo et al[77] evaluated *in vivo* the response of the periapical tissues after obturation with GP or Epiphany/Resilon and new Sealapex with or without coronal restoration. They showed that canals filled with Epiphany/Resilon, with coronal restoration, had significantly less periapical inflammation than those filled with GP/Sealapex, with coronal restoration.

Donadio et al[78] showed that the cytotoxicity of GP and Activ GP was greater than that of the Resilon. Economides et al[79] assessed the anti-proliferative effect of Resilon and two GP (Roeko and Dentsply) on two cell lines (L929 and RPC-C2). In the RPC-C2A, Resilon was more cytotoxic than Dentsply, but no significant differences were found between Roeko GP and Resilon. Resilon was more cytotoxic than GP. The cytotoxicity was time dependent and increased after 2 days. Garcia-Lda et al[80] assessed the biocompatibility of Epiphany/Resilon and showed slight inflammatory response after 6 weeks.

Antimicrobial Activity

Bodrumlu and Alaçam[81] assessed the activity of Resilon against *Pseudomonas aeruginosa, Staphylococcus aureus, Enterococcus faecalis, Porphyromonas endodontalis,* and *Candida albicans*. Resilon had antimicrobial effect only against *Staphylococcus aureus* during the first 24 hours. However, after 48 and 72 hours, it no longer inhibited the growth of *Staphylococcus aureus*. Gomes et al[82] evaluated the possible residual antibacterial effects of Resilon disinfected with 2% CHX and 5.25% NaOCl against *Porphyromonas gingivalis* and *Enterococcus faecalis* and showed that Resilon exposed to CHX for 10, 20 and 30 minutes demonstrated residual antibacterial effect.

Bond Strength of Resilon to Dentin

An important advantage of the Resilon/Epiphany obturation system has been considered to be its ability to create a monoblock in the canal.[83,84] However, Gogos et al[85] have shown that the monoblock in the canal is more achieved by combining Resilon with epoxy resin-based sealers rather than Epiphany. Teixeira et al[46] assessed the fracture resistance of ETT filled with either Resilon or GP and showed that the mean fracture loads of the Resilon group is higher than GP. However, Gesi et al[86] concluded that Resilon/Epiphany shows lower interfacial strength than GP/AH-Plus.

Skidmore et al[87] showed that the bond strength to dentin is significantly higher in the Resilon/Epiphany as compared to the GP/Kerr Pulp Canal Sealer. Pawińska et al[88] also showed that Resilon has better adhesion ability to intra-radicular dentin than GP. However, some other studies have found different results. Fisher et al[89] concluded that roots filled with GP/AH-Plus exhibited higher bond strength compared with Resilon/Epiphany. Sly et al[90] and Ureyen Kaya et al[91] showed that the push-out bond strengths of Resilon/Epiphany were lower than

GP/conventional root canal sealer. Other studies have concluded that the bond strength of Epiphany/Resilon is similar to the GP/AH Plus[92] and GP/Sealer 26[93]

An important factor may affect the bond strength of the filling material to dentin is the chemical irrigants used during canal preparation which may alter the chemical composition of the dentin and the interaction between dentin and resin-based sealer. Rocha et al[83] evaluated the influence of 2% CHX and 2.5% NaOCl on the resin sealer/dentin bond strength of AH Plus/GP and Epiphany/Resilon and concluded that AH Plus/GP exhibited higher bond strength than Epiphany/Resilon, regardless of the irrigant used. CHX had no influence on the push-out bond strength of either sealer. In another study, Kumar et al[94] showed that CHX, EDTA, NaOCl, and MTAD cannot affect the push-out bond strength of Resilon/Epiphany. Also, Shokouhinejad et al[95] showed that the bond strength of Resilon/Epiphany is not different after irrigation with MTAD+NaOCl or EDTA+NaOCl. De-Deus et al[96] showed that the soft chelating irrigation can optimize the bonding quality of Resilon/Epiphany. Also, it has been demonstrated that chloroform used for retreatment may have an adverse effect on the bond strength of Resilon/Epiphany.[97]

Disinfection of Resilon

According to Royal et al,[98] MTAD, 5.25% NaOCl, and 2% CHX were all effective in rapid disinfection of GP and Resilon, and a 1 minute immersion was sufficient for disinfection. Dumani et al[99] evaluated the efficiency of NaOCl and CHX on Resilon that were artificially contaminated with *Enterococcus faecalis* or *Candida albicans*. They showed that 1 and 5% NaOCl were effective for Resilon disinfection. Zand et al[100] also showed that 0.5 to 5.25% NaOCl is effective for disinfection of Resilon within only 1 minute; however, CHX was unable to disinfect Resilon during this time.

Post Space Preparation and Sealing Ability

Bodrumlu et al[101] showed no difference in microleakage between Resilon/Epiphany and GP/AH-Plus-filled canals after immediate preparation; however, there was significant difference between Resilon/Epiphany and GP/AH-Plus in delayed preparation of the post space. Lyons et al[102] compared the sealing ability of Resilon/Epiphany after immediate *vs* delayed post space preparation and concluded that there is no significant difference between them.

Monticelli et al[103] showed that the seal achieved with one-step obturator is less than separate Resilon followed by a 24 hours delay prior to the post placement. Attam and Talwar[104] showed that immediate post space preparation was associated with less microleakage than delayed preparation when both 5 and 3 mm of apical filling remained.

CONCLUSION

Resilon which is a thermoplastic synthetic polymer-based filling material can be considered as a suitable material for root canal filling. A major advantage of this material comparing previous resin filling materials is that it can be softened and dissolved with solvents. However, for its widespread usage in endodontics, most studies should be performed on it.

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