Root canal filling using Resilon: a review

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IN BRIEF

- Aims to comprehensively review Resilon as a root filling material in practice.
- Highlights that current research although extensive it is of limited quality.
- Suggests that prospective clinical studies comparing Resilon to existing materials are required.
- Concludes that Resilon cannot yet be considered an evidence-based replacement to gutta-percha.

GENERAL

Root canal treatment is achieved by chemo-mechanical debridement of the root canal system followed by filling. The filling material 'entombs' residual bacteria and acts as a barrier which prevents the entrance of oral microorganisms and reinfection of the root canal system through microleakage. However, filling with contemporary root filling materials such as gutta-percha offers limited long-term resistance to microorganisms; as a result other materials such as Resilon have been investigated as alternatives. The aim of this review was to analyse the literature to consider whether Resilon is a suitable root canal filling material. A MEDLINE and Cochrane library search including various keyword searches identified several papers which investigated or discussed Resilon or RealSeal/Epiphany. Analysis of the literature demonstrated that the bulk of the literature is *in vitro* in nature, based largely on leakage-type studies, and demonstrates a wide variety of methodologies with conflicting findings; as a result meaningful conclusions are difficult. Within the limit of these *in vitro* studies Resilon appears to perform adequately in comparison to gutta-percha, however, as a result of the questionable merit of such studies, it cannot presently be considered an evidence-based alternative to the current gold standard gutta-percha. It is imperative that before Resilon is considered as a replacement material, a better understanding of the physical properties of the resin sealer and the reality of the adhesive 'monoblock' are elucidated. The literature also demonstrates a paucity of quality long-term clinical outcome studies which will need to be addressed before firm conclusions can be reached.

INTRODUCTION

The biological aim of endodontic treatment is to eliminate or prevent apical periodontitis.¹ This is achieved by chemo-mechanical debridement of the root canal space followed by obturation. The role of a root canal filling material is to seal the disinfected canal apically, laterally and coronally. If the coronal seal fails the root canal filling should ideally prevent reinfection and the spread of microorganisms and their byproducts towards the tooth apex.²⁻⁴ In addition a root filling material should be easily introduced into the canal, dimensionally stable, biocompatible, bactericidal (or at least discourage bacterial growth), sterile, radiopaque, readily removed and should not stain tooth structure.⁵ Finally, the root canal filling material should

strengthen the remaining root structure.⁶

Gutta-percha has been the obturation material of choice for many years. It has a proven track record, is considered the 'gold standard' and possesses many of the features of an ideal root filling material. However, it does not bond to tooth structure and its ability to prevent leakage has been questioned.⁷⁻¹⁶ In addition, it does not strengthen endodontically treated teeth⁶ and it is not possible to completely remove it during retreatment.^{17,18}

In an attempt to address these shortcomings the use of materials which bond to the root canal dentine have been investigated; these include glass ionomers¹⁹ and resins.²⁰ Several resin sealers such as AH-26/AH-plus (Dentsply Maillefer, Ballaigues, Switzerland), Endorez (Ultradent Products, South Jordan, Utah, USA) Realseal (Pentron Clinical Technologies, Wallingford, Connecticut, USA) and Epiphany (Sybron Dental Specialities, Orange, California, USA) have recently become available. The aim of these resin bonding systems is to allow for the adhesion of the obturation material, sealer and dentine to one another

with the aim of creating a 'monoblock'; this forms a hermetic seal increasing resistance to fracture.⁶ A potential drawback of bonding to the tooth surface is the inability to remove the material effectively during retreatment.²¹

Resilon (Resilon Research, LLC, Madison, Connecticut, USA) is a thermoplastic synthetic polymer-based root canal obturation material that was introduced in 2004.²² It contains methacrylate resin, bioactive glass, barium sulphate and bismuth oxychloride.^{22,23} It is claimed that the handling characteristics are similar to gutta-percha, and therefore traditional obturation techniques can be used.²² The accompanying sealant Epiphany/RealSeal is a dual-curable resin based composite (RBC) sealer. The matrix is a mixture of Bisphenol A epoxy (Bis-GMA), urethane dimethacrylate (UDMA) and hydrophilic dysfunctional methacrylates, while the filler consists of calcium hydroxide, barium sulphate, barium glass and silica.²³

A series of recent studies have claimed that Resilon has several characteristics which offer an improvement over gutta-percha.^{22,24,25} However, attention has tended

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Table 1 Studies which demonstrated Resilon to be statistically superior to gutta-percha in preventing leakage

Reference	Type of study	Apical or coronal seal investigated	Leakage model	Duration	Sample size (number of canals)
Shipper <i>et al.</i> 2004 ²²	<i>In vitro</i>	Coronal	Bacterial	30 days	156
Shipper <i>et al.</i> 2005 ²⁶	Animal (dog)	Coronal	Bacterial	14 weeks	56
Aptekar and Ginnan 2006 ⁴⁹	<i>In vitro</i>	Apical	Dye	3 months	66
Sagsen <i>et al.</i> 2006 ⁵⁰	<i>In vitro</i>	Apical	Fluid filtration	Immediate	36
Stratton <i>et al.</i> 2006 ⁵¹	<i>In vitro</i>	Coronal	Fluid filtration	Immediate	140
Tunga and Bodrumlu 2006 ⁵²	<i>In vitro</i>	Apical	Dye	Immediate	42
Tunga and Bodrumlu 2006 ⁵³	<i>In vitro</i>	Coronal	Fluid filtration	Immediate	66
Bodrumlu and Tunga 2007 ⁵⁴	<i>In vitro</i>	Coronal	Dye	Immediate	72
Ishimura <i>et al.</i> , 2007 ⁵⁵	<i>In vitro</i>	Coronal	Dye	30 days	32
Verissimo <i>et al.</i> 2007 ⁵⁶	<i>In vitro</i>	Apical	Dye	7 days	70
Wedding <i>et al.</i> 2007 ⁵⁷	<i>In vitro</i>	Coronal	Fluid filtration	90 days	46
Kocak <i>et al.</i> 2008 ⁵⁸	<i>In vitro</i>	Apical	Dye	3 days	55
Shin <i>et al.</i> 2008 ⁵⁹	<i>In vitro</i>	Coronal	Bacterial	4 weeks	160
Duggan <i>et al.</i> 2009 ⁶⁰	Animal (dog)	Coronal	Bacterial	16 weeks	66
Moura-Netto <i>et al.</i> 2009 ⁶¹	<i>In vitro</i>	Apical	Dye	Immediate	60
Nawal <i>et al.</i> 2011 ⁶²	<i>In vitro</i>	Coronal	Bacterial	30 days	40

to focus on the advantage or otherwise of the resin sealers over conventional sealers rather than the obturation system in comparison to gutta-percha.²⁶ The aim of this review was to analyse the literature assessing Resilon in order to investigate firstly whether it is a suitable root canal filling material and also whether it is an evidence-based alternative material to gutta-percha.

REVIEW

Search strategy

A MEDLINE and Cochrane library search up to May 2011 was conducted using various keyword combinations including the terms 'Resilon', 'Epiphany', 'RealSeal' and 'Resin sealer'. In addition, bibliographies of all relevant papers and previous review articles were hand-searched. Any relevant work published in the English language and presenting pertinent information related to Resilon was considered for inclusion in the review. The combinations of search terms produced a list of 205 publications from MEDLINE and other sources. Initially, these titles and abstracts were screened. Thereafter, full text analysis was performed of the potentially relevant publications. Publications from the same

author discussing identical issues were identified and the more relevant publications were selected for this review. Finally the articles were allocated to several categories for analysis according to the ideal requirements of a root filling material.⁵

Fracture resistance/root strengthening

Endodontically treated teeth are considered more susceptible to fracture²⁷ and a proposed advantage of adhesive obturation systems, such as Resilon, is to reduce this by creating a 'monoblock'.²⁸ Advocates of the system claim that a mechanically homogenous unit is formed between the root dentine and the obturation material, reinforcing the root.^{6,22} However, the unpredictable nature of intra-radicular dentine bonding has led to uncertainty over the Resilon/Epiphany 'monoblock'.²⁹ Successful bonding of Epiphany to dentine has been shown to be difficult to achieve in even simple root canal systems where gap formation was common at the interface between the sealer and root canal wall.²⁹ The unpredictable bond between Epiphany and root canal dentine has been attributed to polymerisation shrinkage,³⁰ incomplete sealer-polymerisation as a result of

residual uncured monomer,³¹ or as a result of the complex mechanical and anatomical challenge of root canal bonding.³²⁻³⁴ Therefore, at present the clinical reality of a 'monoblock' is questionable.³⁵⁻³⁷

Early studies compared the fracture resistance of roots obturated with Resilon/Epiphany compared to gutta-percha and an epoxy resin sealer.^{6,24} It was concluded that the Resilon system increased fracture resistance. This was corroborated by a later study comparing resin-based obturation system to gutta-percha.²⁵ Other studies have found the opposite when Resilon was used in immature roots; perhaps this is due contraction stress during polymerisation.³⁸⁻⁴⁰ Concerns have been raised about the strengthening effect of the Resilon/Epiphany system as the modulus of elasticity between dentine and Resilon differs,^{41,42} this is likely to lead to breakdown of the adhesive bond. Other studies have demonstrated that Resilon is not mechanically stiff enough to give mechanical support to dentine after root canal treatment.⁴³⁻⁴⁶

Sealing ability/leakage

Over the last five years a plethora of leakage studies comparing the sealability of Resilon and gutta-percha have been

Table 2 Studies in which there was no statistical difference between Resilon and gutta-percha in preventing leakage

Reference	Type of study	Apical or coronal seal investigated	Leakage model	Duration	Sample size (number of canals)
Tay <i>et al.</i> 2005 ³⁶	<i>In vitro</i>	Apical	Dye	3 hours	20
Biggs <i>et al.</i> 2006 ⁶³	<i>In vitro</i>	Coronal	Fluid filtration	Immediate	96
Dutra <i>et al.</i> 2006 ⁶⁴	<i>In vitro</i>	Apical	Dye	7 days	40
Pitout <i>et al.</i> 2006 ⁶⁵	<i>In vitro</i>	Coronal	Bacterial and dye	72 hours and 3 months	110
Baumgartner <i>et al.</i> 2007 ⁶⁶	<i>In vitro</i>	Coronal	Bacterial	50 days	36
Bodrumlu & Tunga 2007 ⁶⁷	<i>In vitro</i>	Apical	Fluid filtration	Immediate	70
De-Deus <i>et al.</i> 2007 ⁶⁸	<i>In vitro</i>	Coronal	Bacterial	9 weeks	80
Kaya <i>et al.</i> 2007 ⁶⁹	<i>In vitro</i>	Coronal	Glucose penetration	30 days	156
Muñoz <i>et al.</i> 2007 ⁷⁰	<i>In vitro</i>	Coronal	Bacterial	30 days	26
Raina <i>et al.</i> 2007 ⁷¹	<i>In vitro</i>	Apical	Fluid filtration	Immediate	22
Shemesh <i>et al.</i> 2007 ⁷²	<i>In vitro</i>	Coronal	Glucose penetration	4 weeks	50
Silveria <i>et al.</i> 2007 ⁷³	<i>In vitro</i>	Apical	Dye	Immediate	108
Belli <i>et al.</i> 2008 ⁷⁴	<i>In vitro</i>	Coronal	Fluid filtration	24 weeks	44
Fransen <i>et al.</i> 2008 ⁷⁵	<i>In vitro</i>	Coronal	Bacterial	65 days	73
Kocak <i>et al.</i> 2008 ⁵⁸	<i>In vitro</i>	Apical	Dye	3 days	55
Hollanda <i>et al.</i> 2009 ⁷⁶	<i>In vitro</i>	Coronal	Bacterial	60 days	40
Lyons <i>et al.</i> 2009 ⁷⁷	<i>In vitro</i>	Coronal	Bacterial	28 days	80
Kazandağ <i>et al.</i> 2010 ⁷⁸	<i>In vitro</i>	Coronal	Glucose penetration	3 weeks	120
Shokouhinejad <i>et al.</i> 2010 ⁷⁹	<i>In vitro</i>	Coronal	Bacterial	60 days	100

Table 3 Studies which demonstrate gutta-percha to be statistically superior to Resilon in preventing leakage

Reference	Type of study	Apical or coronal seal investigated	Leakage model	Duration	Sample size (number of canals)
Onay <i>et al.</i> 2006 ⁸⁰	<i>In vitro</i>	Apical	Fluid filtration	Immediate	70
Shemesh <i>et al.</i> 2006 ⁸¹	<i>In vitro</i>	Coronal	Fluid filtration and glucose penetration	8 weeks and 56 days	120
Paqué & Sirtes 2007 ⁸²	<i>In vitro</i>	Apical	Fluid filtration	Immediate/16 months	90
De-Deus <i>et al.</i> 2008 ⁸³	<i>In vitro</i>	Coronal	Fluid filtration	14 months	40
Jack & Goodell 2008 ⁸⁴	<i>In vitro</i>	Coronal	Fluid filtration	Immediate	34
Pasqualini <i>et al.</i> 2008 ⁸⁵	<i>In vitro</i>	Apical	Bacterial	47 days	88
Saleh <i>et al.</i> 2008 ⁸⁶	<i>In vitro</i>	Coronal	Bacterial	135 days	110
De Bruyne & De Moor 2009 ⁸⁷	<i>In vitro</i>	Apical	Capillary flow porometry	6 months	60
Korkorikos <i>et al.</i> 2009 ⁸⁸	<i>In vitro</i>	Apical	Fluid filtration	12 months	98
Hirai <i>et al.</i> 2010 ⁸⁹	<i>In vitro</i>	Apical	Fluid filtration	Immediate	64
Santos <i>et al.</i> 2010 ⁹⁰	<i>In vitro</i>	Coronal	Fluid filtration	Immediate/180 days	82

published; these studies form the bulk of the scientific research on Resilon. All of this literature is *in vitro* in nature comparing gutta-percha to Resilon/Epiphany and other sealers. Although the clinical relevance of these studies has been questioned^{47,48}, their

conclusions are worthy of discussion due to a paucity of clinical data on Resilon. Several studies suggest that Resilon reduces leakage compared to gutta-percha (Table 1);^{22,26,49-62} others suggest no difference (Table 2),^{36,63-79} while some report increased leakage

with Resilon compared to gutta-percha (Table 3).⁸⁰⁻⁹⁰ However, analysis of leakage studies must be carried out with caution as a 'superior' result has a different meaning depending on the technique employed. For example, in a dye penetration test a

reduced line of colour adjacent to the root filling material suggests a 'superior' result, while in a bacterial leakage test a 'superior' result occurs when bacteria reach the lower collection chamber later.

It is not clear what accounts for this variability, however, it may be due to a lack of standardisation and reliability of leakage studies, which hinders comparison.⁹¹ Other possible causes of experimental variation include unpredictable setting of resin materials in moist canals,⁹² chelating agents affecting the bond quality,⁹³ certain irrigants affecting polymerisation⁹⁴⁻⁹⁶ or the type of curing light affecting polymerisation shrinkage and subsequent leakage.⁹⁷ All these *in vitro* leakage studies are evaluated over a number of days or weeks and it has been suggested that this may give a false perspective of the behaviour of resin sealers as they may degrade⁸⁸ or hydrolysis with time.^{35,98} Therefore, before any meaningful conclusions can be made long-term evaluations and clinical studies are necessary.

In one animal leakage study Resilon/Epiphany was compared to gutta-percha/AH-26 sealer and the resolution of induced apical periodontitis monitored.²⁶ The study was carried out over six months on seven Beagle dogs. It was concluded that there was a comparative reduction in apical periodontitis compared to gutta-percha; it must be stressed however that the authors had a financial interest in the Resilon system.

Biocompatibility

Several *in vitro* studies have investigated the biocompatibility of Resilon without sealer and reported it to compare favourably to gutta-percha⁹⁹⁻¹⁰¹ This has been corroborated in an animal study.¹⁰² Other studies have compared Resilon to gutta-percha and concluded that Resilon was more biocompatible,¹⁰³ however, another demonstrated the opposite.¹⁰⁴ It was suggested that a reason for Resilon's potential cytotoxicity may be due to the biodegradability of Resilon by enzymes and alkaline hydrolysis, which would expose the more toxic polymer matrix.^{36,98}

Epiphany sealer has been shown to be cytotoxic when compared to zinc oxide eugenol and epoxy-resin based sealers^{100,105-110} with one study suggesting that it became more cytotoxic with increased exposure time.¹¹¹ However, it has also been

demonstrated that although Epiphany was cytotoxic it did not effect the viability of human leucocytes.¹¹² The reported cytotoxicity may be due to the leakage of uncured monomer from the oxygen inhibition layer,^{100,101,113,114} or due to the degradation of the sealer in an aqueous environment.¹¹⁵⁻¹¹⁷ The Bis-GMA and UDMA contained within the Epiphany bonding agent are another potential source of cytotoxicity.^{99,101,105,118} However, several *in vivo* studies have shown the biocompatibility of Epiphany to be acceptable.¹¹⁹⁻¹²⁴

Physical properties

Setting times

Resilon's manufacturers claim that an immediate coronal seal can be produced by light curing for 40 seconds, while the remaining sealer sets in 25 minutes (RealSeal/Epiphany instructions, SybronEndo 2010). However, the reality of this has been questioned. It has been found that in anaerobic conditions, it will set in 30 minutes, but in aerobic conditions it can take up to three weeks, suggesting that Resilon will not completely set in the periradicular tissues should it be extruded.¹¹³

Radiopaque

Resilon/Epiphany has demonstrated acceptable radiopacity, exceeding the minimal radiopacity equivalent of 3 mm of aluminum, as recommended by the American National Standards Institute (ANSI) and the American Dental Association (ADA)¹²⁵⁻¹²⁷ (Figs 1a and 1d).

Staining

Resilon has the potential to cause tooth staining as it is susceptible to enzymatic and alkaline hydrolysis.^{36,98} This biodegradation may result in the leaching of dyes from the material. The formation of a precipitate and associated colour change has also been noted when Resilon is disinfected with 20% chlorohexidine.¹²⁸ However, a one-year clinical study reported no staining associated with Resilon.¹²⁹

Bacteriocidal/sterile

Resilon and Epiphany, when investigated individually and in combination, have demonstrated no significant antibacterial or antifungal effect.¹³⁰⁻¹³⁴ One study concluded that Epiphany may

Fig. 1a Preoperative radiograph of 16

Fig. 1b Postoperative radiograph of a 16 obturated with vertically condensed gutta-percha and an epoxy-resin sealer

Fig. 1c Preoperative radiograph of 26

Fig. 1d Postoperative radiograph of a 26 obturated with vertically condensed Resilon and Real Seal sealer. Note the similar radiopacity of the two materials (Figs 1b and 1d)

actually enhance bacterial growth¹³⁵ and another that *Enterococcus faecalis* was resistant to Epiphany.¹³³ Interestingly, in the latter study it was demonstrated that the Epiphany primer inhibited microbial growth using an agar diffusion method; however, this is unlikely to be clinically relevant.¹³³

Table 4 Studies on the removal of Resilon compared to gutta-percha root fillings

Reference	Gutta-percha control sealer	Time taken for removal	Residual material	Solvent/Heat used	Removal technique employed
Ezzie <i>et al.</i> 2006 ¹³⁷	AH Plus	Resilon quicker	Less with Resilon	Chloroform or Heat	ProFile rotary Nickel Titanium files (NiTi)
de Oliveira <i>et al.</i> 2006 ¹³⁸	AH 26	Resilon quicker	Less with Resilon	Chloroform	K3/Liberator rotary NiTi
Schirrmeister <i>et al.</i> 2006 ¹³⁹	AH sealer	No significant difference	Less with Resilon	None	RaCe rotary NiTi/Hedström files
Cunha <i>et al.</i> 2007 ¹⁴⁰	AH Plus	No significant difference	Less with Resilon	Chloroform	K files
Hassanloo <i>et al.</i> 2007 ¹⁴¹	AH sealer	Resilon removal slower	More with Resilon	+/- Chloroform	K3 rotary NiTi
Bodrumlu <i>et al.</i> 2008 ¹⁴²	AH Plus	Resilon quicker	Less with Resilon	+/- Chloroform	Gates Glidden
Hammad <i>et al.</i> 2008 ¹⁴³	various sealers	Not investigated	Less with Resilon	None	ProTaper rotary NiTi/K files
Iizuka <i>et al.</i> 2008 ¹⁴⁴	Superbond and Canals N	Resilon removal slower	Not measured	+/- Heat +/- d-limonene-based solvent	K3 rotary NiTi
Somma <i>et al.</i> 2008 ¹⁴⁵	Kerr Pulp Canal Sealer + EndoRez	Resilon removal slower	More with Resilon	Chloroform only used with Gates Glidden + Hedström group	Mtwo rotary NiTi /ProTaper NiTi Taper/Gates Glidden + Hedström files
Taşdemir <i>et al.</i> 2008 ¹⁴⁶	Gutta Flow System/ EndoTwinn System + AH Plus	Resilon removal slower	No significance difference	Chloroform	Mtwo Rotary NiTi
Ring <i>et al.</i> 2009 ¹⁴⁷	AH sealer	"Realseal" removed faster	More debris remaining with 'Realseal'	Chloroform/Orange Solvent	EndoSequence rotary NiTi/ ProTaper rotary NiTi
Zarei <i>et al.</i> 2009 ¹⁴⁸	AH 26 sealer	No significant difference	More debris remaining with Resilon (p = 0.009)	Chloroform	RaCe rotary NiTi
Fenoul <i>et al.</i> 2010 ¹⁴⁹	MMSeal (an epoxy based rein sealer)	No significant difference	No significant difference	Tetrachloro-ethylene based solvent	R-Endo rotary NiTi and Hedström files
Marfisi <i>et al.</i> 2010 ¹⁵⁰	AH plus sealer	No significant difference	Less with Resilon	None	ProTaper rotary NiTi Mtwo Rotary NiTi Twisted File

Removal of Resilon

An ideal requirement of a root canal filling material is that it should be readily retrievable to facilitate post-space preparation or retreatment. Although gutta-percha is considered relatively easy to remove it has been found that regardless of technique employed, complete removal of gutta-percha is not possible during retreatment.^{18,17,136} An advantage of Resilon is that it can be removed in a similar manner to gutta-percha (Table 4).¹³⁷⁻¹⁵⁰ A series of studies have compared the removal of Resilon to gutta-percha with the time taken for removal and residual material remaining the main variables investigated. Most studies have concluded that Resilon is readily removable using a variety of techniques. As with the sealability studies the results have been contradictory with some studies demonstrating the amount of residual debris to be less than that of gutta-percha root fillings,^{137-140,142} while others have found the opposite.^{141,145,148} The variation between these studies maybe attributable to Resilon/Epiphany not completely setting before retreatment and therefore being easier

to remove,^{113,133} or that the canals were retreated to two sizes larger than the apical size before filling which would enhance the efficacy of retreatment.¹⁵¹⁻¹⁵³ Ezzie and co-workers¹³⁷ found that Resilon left less residual debris in the apical third of the root canal; this may be due to the fact that effective removal of the smear layer and subsequent bonding is difficult to achieve in this area.^{154,155} The vast majority of studies have compared Resilon/Epiphany to gutta-percha and epoxy resin cement, however, this may prevent accurate extrapolation to other gutta-percha sealers as epoxy resins are associated with a higher level of residual debris than other cements.¹⁵⁶

Chloroform has been recommended by the manufacturers as an aid in removal of Resilon (RealSeal/Epiphany instructions, SybronEndo 2010). However, resin sealers are not dissolved by chloroform and it has an adverse effect on bond strength of Resilon/Epiphany when reobturating.^{157,158}

Clinical outcome studies

Randomised prospective clinical outcome studies comparing two different treatments

are the gold standard in medical research. These studies are uncommon in endodontics and those published are often of low quality.¹⁵⁹ To date only one clinical study has compared Resilon/Epiphany to gutta-percha/Kerr's sealer and it concluded that the outcome for both materials was not statistically different.¹⁶⁰ However, this was a retrospective study with follow-up ranging from one month to two years; in addition there was only a limited number in each group. Other case-series studies have reported only on the outcome of Resilon/Epiphany obturated teeth without comparing to gutta-percha.^{129,161} In one retrospective study post-treatment radiographs were examined after one year and it was concluded that Resilon healing rates were similar to that of gutta-percha obturated canals.¹⁶¹ However, the review period was short, the numbers of teeth relatively small and there was no clinical examination. The short-term clinical effectiveness of Resilon/Epiphany was corroborated in a prospective study with both clinical and radiographic assessment being used to evaluate outcome.¹²⁹ This study was

preliminary in nature with only a small number of teeth treated and reviewed after one year.

CONCLUSIONS

Root canal filling is a key step in non-surgical endodontic treatment. The majority of recent studies have focused on the relative ability of Resilon to resist leakage; however, the results have been largely inconclusive with a group of studies suggesting Resilon is superior to gutta-percha and another group the opposite. The heterogeneity of methods employed within these studies makes comparison difficult and the clinical relevance of these *in vitro* studies is dubious. What can be concluded, however, is that although there is evidence to suggest that Resilon performs better and indeed worse than gutta-percha in leakage studies, it is difficult to extrapolate meaningful clinical conclusions from this literature. Perhaps a more relevant way of assessing the efficacy of Resilon would be to assess outcome *in vivo*; unfortunately these studies are time consuming and rare within endodontics. The literature suggests that Resilon is not stiff enough to strengthen residual root structure; however, more information is required on the nature of the adhesive bond between sealer and root dentine and whether the reported *in vitro* 'monoblock' is translated clinically. The predictability of bonding in the apical reaches of the root canal remains to be elucidated as the use of resin sealers and bonding within the root canal is relatively new. The techniques and materials are likely to evolve over the next few years; this may lead to an improvement in both our knowledge and results. In terms of biocompatibility and physical properties Resilon appears to perform well comparing favourably to gutta-percha, although there are concerns regarding the cytotoxicity of the Epiphany sealer. Definitive conclusions cannot be reached as yet with regard to ease of removal compared to gutta-percha, however, it appears to compare favourably to gutta-percha using a variety of removal techniques. There is an absence of randomised clinical outcome studies comparing gutta-percha to Resilon and until these are available it is impossible to adequately assess Resilon as a replacement for gutta-percha which has an established research track record

over many years. These outcome studies, perhaps through large multicentred trials, should form the focus of attention rather than further *in vitro* leakage studies. The issue of whether Resilon is a suitable material is impossible to adequately assess at present and only time will tell if it proves an evidence-based alternative or replacement for gutta-percha.

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