

## Evaluation of Apical Sealing Ability of Resilon

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### Abstract:

**Background:** This study was conducted to evaluate the efficiency of Resilon in achieving an adequate apical seal, and to compare it with Gutta-percha.

**Materials and Methods:** Sixty single rooted human teeth were selected and decoronated at the cement-enamel junction. The teeth were sectioned such that 14 mm of the root length remained. Working length was established, and cleaning and shaping were carried out using hand files. The canals were enlarged to size 40. Any tooth requiring further enlargement, were discarded. Canals were irrigated using 5.25% NaOCl, and smear layer was removed using 17% ethylenediaminetetraacetic acid. Teeth were divided into four groups. Group 1 consisted of 15 samples obturated with laterally condensed Resilon using Epiphany as the sealer. Group 2 consisted of 15 samples obturated with laterally condensed Gutta-percha using AH plus as the sealer. Group 3 and Group 4 served as the positive and negative control, respectively. Teeth were then studied using dye penetration method followed by clearing technique. The cleared teeth were then studied under the microscope to measure the extent of leakage, and the results were statistically analyzed.

**Results:** The apical leakage seen with Resilon and Epiphany system was significantly less when compared with Gutta-percha and AH plus sealer.

**Conclusion:** Resilon and Epiphany system achieved a superior apical seal when compared with Gutta-percha. However, further studies have been conducted to evaluate its clinical performance.

**Key Words:** AH plus, apical leakage, dye penetration, Epiphany, Gutta-percha, resilon

### Introduction

Seltzer and Bender developed the cognitive dissonance in endodontics as early as 1965 showing that the success of

endodontic treatment includes three essential elements, *viz.* thorough debridement, sterilization, and complete obturation.<sup>1</sup> The objectives of obturation in endodontics are the total obliteration of the root canal system and to develop a bacterial impermeable seal at the apical foramen. It has been shown that the thoroughness with which the root canal system is sealed is a major determinant in endodontic success. Strindberg recorded a higher proportion of failure in cases where the radiographs revealed poor adaptation and shrinkage of the root filling. Grossman found that the most common cause of failure in endodontically treated teeth was a poorly filled canal. In agreement, Allen attributed more than 90% of the failures to incomplete sealing, while Ingle attributed 60% of the failures to the same reason.<sup>2</sup>

In spite of the techniques used for obturation, and considering that most of the root canal sealers traditionally used do not provide adhesion to the tooth structure, a microscopic space is likely to exist between the sealer and the tooth structure, preventing the establishment of a hermetic seal.<sup>2</sup>

Since its introduction in 1941 by Callahan, Gutta-percha has been considered as the "gold standard" filling material to obturate root canal system, as it fulfills most of the requirements set by Grossman for an ideal obturating material.<sup>3</sup> A sealer is used along with Gutta-percha to fill the anatomical variations that cannot be mechanically debrided or chemically irrigated in to. The Gutta-percha fills the majority of the root canal system and acts as a carrier for the sealer.<sup>4</sup> It does not bond to the internal tooth structure, resulting in the absence of a complete seal. This produces a poor barrier to bacterial microleakage and is considered to be one of the weakest points in root canal therapy.<sup>4</sup> Hovland and Dumsha stated that all root canal sealers leak, but there is probably a critical level of leakage that is unacceptable for healing which leads to endodontic failure. They also found that this leakage could occur at the interface of the sealer to dentin, sealer to Gutta-percha, through the sealer itself or by dissolution of the sealer.<sup>5</sup>

Many attempts have been made to resolve the problem through variations in obturation technique including vertical and lateral condensation and the use of reverse-fill (obtura II) or touch and heat (system B) systems. These methods have reduced microleakage to a certain degree but have still failed to eliminate the problem.<sup>3</sup>

Shipper and Trope suggested that a resin core root canal filling that could bond to the root canal wall is desirable. The material

should have an excellent apical fit, be bonded with dentin bonding system to a resin sealer, and the sealer itself should bond with the canal wall.<sup>6</sup>

Resilon, a thermoplastic synthetic polymer based root canal filling material has been introduced as an alternative to Gutta-percha and traditional root canal sealers. Resilon material is a polymer based thermoplastic resin containing bioactive glass, bismuth oxychloride, and radio opaque fillers. It is used with the composite sealer "Epiphany" that is a mixture of dimethacrylate, ethoxylated dimethacrylate, urethane dimethacrylate, and hydrophilic difunctional methacrylates.<sup>7</sup> According to its manufacturer, Epiphany sealer bonds both to dentin and also to the root canal filling material. It performs, handles, and looks like Gutta-percha, hence also called as resin-percha.<sup>8</sup> It is biocompatible, radio opaque, and solubilized by chloroform in case of re-treatments. In addition, when used in conjunction with a resin based sealant or bonding agent it forms a "Monoblock" within the canals that bonds to the dentinal walls.<sup>9</sup> According to the manufacturers, the Resilon material resists leakage six times better than traditional Gutta-percha cones. Furthermore, it is claimed by the manufacturers that Resilon strengthens the root canal following obturation by about 20%.<sup>10</sup>

The success of root canal treatment is dependent on the development and maintenance of the seal of the root canal system. Microleakage tests are the most favorable *in vitro* methods to evaluate the sealing efficiency of root canal fillings or sealers. There are several methods for evaluating the apical sealing of root canal sealers, such as bacterial penetration, fluid transportation, clarification, penetration of radioisotopes, electrochemical methods, and chromatography.<sup>11</sup> The most common method is dye penetration using organic dyes which were reported for the first time by Grossman to study the sealing ability of the temporary filling material.<sup>12</sup> It represents a simple and inexpensive technique and is still the most popular one.<sup>13</sup>

The clearing technique recommended by Okumura, provides a three-dimensional (3D) view of the internal anatomy of a root canal without the loss of dentinal substance, making it easier to view the leakage area. It is simple, fast, preformed with substance low in toxins and does not require complex equipments.

The present study was undertaken based on the foundation of two studies of Shipper and Trophe<sup>6</sup> and Tay *et al.*<sup>14</sup> The purpose of this study was to examine the resistance to apical dye penetration Resilon and compare it to Gutta-percha using lateral condensation obturating technique.

### Materials and Methods

This *in-vitro* study was done to evaluate the apical sealing ability of Resilon and Epiphany and to compare it with Gutta-percha using AH plus as sealer using lateral condensation.

The study was conducted in the Department of Conservative Dentistry and Endodontics, and Department of Oral Pathology, Yenepoya Dental College, Mangalore after obtaining an Ethical Clearance - YUEC 309/28/11/11.

### Materials used for the study

1. Resilon points 0.02 taper (size 20-40) and Epiphany (Resilon Sealer, Pentron U.S.A)
2. Gutta-percha - greater taper 0.02 taper (six 20 to 40) and AH plus, root canal sealer (Dentsply, Germany)
3. 5% sodium hypochlorite solution
4. Normal saline solution
5. India ink
6. Glass ionomer cement
7. 5% nitric acid
8. Ethyl alcohol 80% and 100%
9. Methyl salicylate.

### Instrumentation

Sixty single rooted completely formed teeth were used for the study. The crowns of each tooth were removed at the cement-enamel junction. The lengths of all the roots were prepared approximately 14 mm from the coronal surface to the apex of the root. Instrumentation was performed using RC prep and copious irrigation with 5.25% sodium hypochlorite. Any tooth requiring a master apical file size larger than 40 was discarded. After completion of instrumentation, the canals were irrigated with 10 ml of 17% ethylenediaminetetraacetic acid (EDTA) solution for 60 s to remove the smear layer followed by 5.25% NaOCl. The teeth were then rinsed with 10 ml saline and randomly divided as follows:

Group 1: Lateral condensation of Resilon with Epiphany sealer (15 teeth)

Group 2: Lateral condensation of Gutta-percha with AH plus sealer (15 teeth)

Group 3: Positive control (10 teeth)

Group 4: Negative control (10 teeth).

### Obturation of the samples

The canals were dried with paper points, and standardized Gutta-percha points and Resilon points that fit the tug back at working length were selected as master points.

Group 1: Lateral condensation of Resilon with Epiphany sealer. After instrumentation, a self-etching primer (Epiphany Primer, Pentron Clinical Technologies) was placed into the canal. The excess primer was then removed using paper points. The sealer was placed using lentulospiral and roots were filled using cold lateral condensation of Resilon core material and Epiphany sealer. The coronal surface of the root filling was light cured for 40 s to polymerize the surface of the dual cured methacrylate sealer. Two layers of nail polish were painted over the root surface to seal it except the apical 2 mm.

Group 2: Lateral condensation of Gutta-percha with AH plus sealer. These roots were filled with Gutta-percha and

AH plus sealer using a cold lateral condensation technique. After obturation of the canal, 3 mm of coronal portion of the canal was restored with glass ionomer cement. The obturated root was then dried, and two layers of nail varnish were painted over the root surface to seal it except the apical 2 mm.

Group 3: Positive control (10 roots), 5 roots each were obturated with Resilon and Gutta-percha cones, respectively, but without sealer. Two layers of nail varnish were painted over the root surface to seal it except the apical 2 mm.

Group 4: Negative control (10 roots) similarly, 5 roots each were obturated with Resilon and Gutta-percha, respectively, but without sealer. Two layers of nail varnish were painted over the root surface to cover the surface of the root as well as the canal orifice coronally and apically.

Dye penetration and clearing of samples - All samples were stored in saline solution at 37°C for 48 h. For apical leakage estimation, samples were immersed in India ink at 37°C for 3 days. They were thoroughly washed with tap water, and nail varnish was carefully removed with a Lecrons carver and the teeth were dried for 24 h before clearing.

Samples were first cleared by placing them in 5% nitric acid for 5 days to decalcify. Nitric acid was changed daily and agitated three times a day. After decalcification, the samples were rinsed in running tap water. The dehydration process consisted of a series of ethyl alcohol rinses with 80% solution for 12 h and 100% ethyl alcohol rinse for 24 h to complete the dehydration process. The dehydrated samples were then placed in methyl salicylate until they were clear and transparent (Figure 1a).

#### Specimen evaluation

The quality of the apical seal of each specimen was observed under a stereomicroscope with a micrometer eyepiece. The amount of dye leakage was measured from the tip of root to the most coronal extent of dye penetration within the root canal space. The amount of dye penetration was measured and recorded to the nearest 1/10 mm, which is equal to 0.09 mm. Figure 1b shows the dye penetration as seen for both the key groups under the stereomicroscope.

#### Statistical analysis

At the completion of the leakage study, the values which were recorded in mm were submitted for statistical analysis using Tukey's test.

#### Results

The positive control specimen revealed a full leakage throughout the length of the root canal while negative control samples showed no dye penetration at all. The mean of the depth of dye penetration of both the groups is as shown in Table 1.

Table 1: Group statistics.

Group	n	Mean	SD	Minimum	Maximum
Resilon with Epiphany sealer	15	0.8880	0.8290	0.00	2.70
Gutta-percha with AH plus sealer	15	2.1960	0.4772	1.53	3.33
Positive control	10	14.000	0.0000	14.00	14.00
Negative control	10	0.000	0.0000	0.00	0.00

SD: Standard deviation

The statistical analysis of variance showed the highly significant difference among the apical leakage groups ( $P < 0.005$ ). Resilon core material and Epiphany sealer exhibited the least mean apical leakage values (0.8880, standard deviation [SD] - 0.8290) among the teeth filled with Gutta-percha using AH plus sealer (2.1960, SD - 0.4772). Gutta-percha with AH plus sealer showed significantly more leakage when compared with Resilon and Epiphany sealer ( $P < 0.005$ ).

Graph 1 shows the graphical representation of the mean dye penetration of the all the groups.

#### Discussion

3D sealing of the root canal is one of the main goals of endodontic treatment and is essential for preventing apical and coronal leakage in the root canal system. Dye penetration studies are commonly used to evaluate the apical seal because they are easy to accomplish and do not require sophisticated materials.<sup>15</sup>

Microleakage as related to endodontics refers to the movement of fluid and microorganisms along the interface of the dentinal walls and the root canal filling material or through the voids within the root filling materials. Studies have indicated that microleakage, whether from an apical or coronal direction adversely affects the success of root canal therapy.<sup>16</sup> Many anatomical parameters and clinical considerations influence microleakage during the course of non-surgical root canal treatment, including patient co-operation, canal anatomy, root morphology, operator skill, root canal sealing, and choice of filling materials.<sup>15</sup>

Lateral condensation of Gutta-percha has remained the most widely used method of obturating root canals. It is often used as a control for evaluating the sealing ability of many new obturation techniques. The advantage of this technique includes its predictability, relative ease of use, conservative preparation, and controlled placement of materials. As shown in numerous *in-vitro* studies Gutta-percha fillings leak at an alarming rate. Thus, it would be advantageous to replace Gutta-percha with a filling material that can prevent leakage at all levels of the root canal system.

Resilon, a thermoplastic synthetic polymer based root canal filling material has the same handling properties of Gutta-percha. Based on the polymer of polyester, Resilon contains



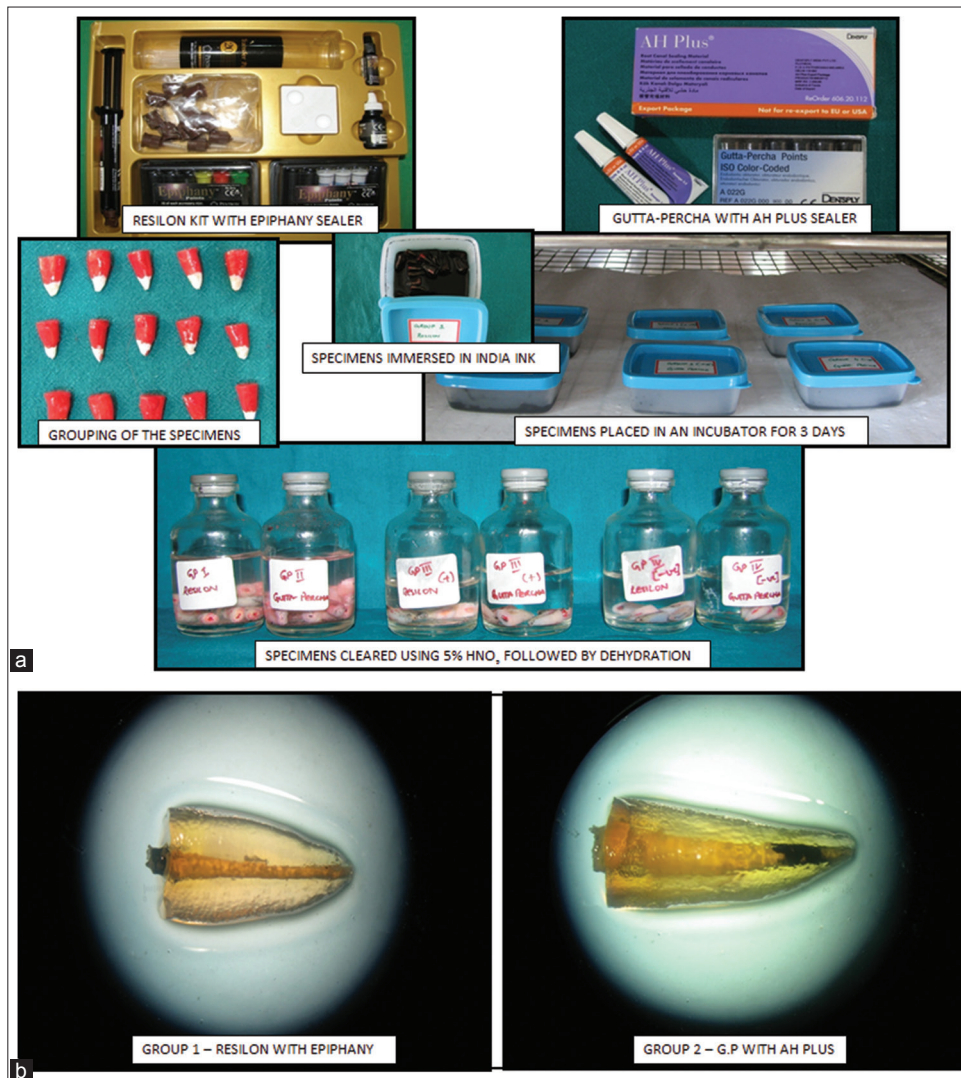
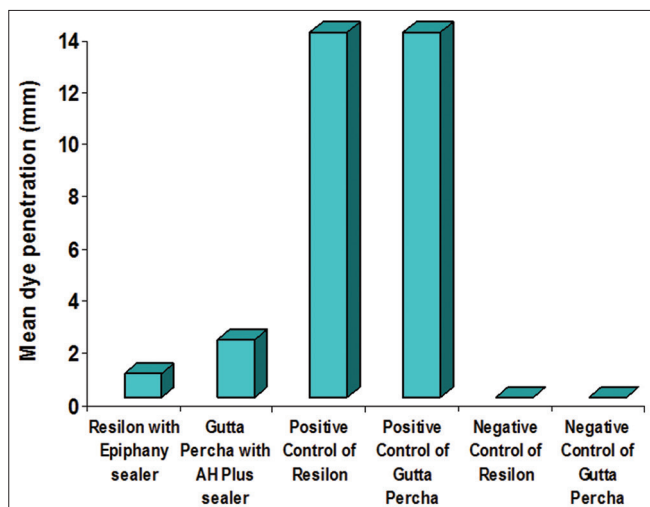


Figure 1: (a) Methodology, (b) dye penetration as seen under the stereomicroscope.



Graph 1: Mean dye penetration analysis of all the groups.

bioactive glass bismuth oxychloride and barium sulfate. The overall filler content is approximately 65% by weight. Epiphany sealer is dual curable in which the resin matrix is a mixture of Bis

gamma methacrylate (GMA), ethoxylated Bis GMA, urethane dimethacrylate, and hydrophilic difunctional methacrylates. It contains filler made of calcium hydroxide, barium sulfate, barium glass, and silica. The total filler content in the sealer is approximately 70% weight. 40 s of light will cure the coronal 2 mm of the canal, whereas the entire filling will then self-cure in approximately 15-30 min. Unlike previous resin filling materials that could not be effectively removed from the canal, Resilon can be softened and dissolved like Gutta-percha with solvents like chloroform.<sup>17</sup> It was shown according to one study that Resilon/Epiphany was effectively removed with k3 files or liberatory rotary files, it consumed less time and the amount of residual filling material on the walls was least when k3 files were used.<sup>18</sup>

In the present study, laterally condensed Gutta-percha with AH plus sealer was compared with Resilon and Epiphany sealer using dye penetration and clearing technique to evaluate the degree of apical microleakage and to determine which of these obturating materials provide best marginal seal. The positive

control groups (Resilon and Gutta-percha without sealer) leaked within 24 h. Resilon was tested without sealer because it is suggested that this material adapts so close to the canal wall that sealer may not be necessary.

Cleaning the dentinal surface by removing the smear layer is an essential step in the process of successful root canal treatment.<sup>19</sup> The smear layer resulting from root canal instrumentation acts as a physical barrier interfering with the adaptation and penetration of the sealer into the dentinal tubules, which might contribute to increasing microleakage occurrence.<sup>11</sup> In this present study, 17% EDTA was used during and after instrumentation to remove smear layer, this enhancing the adherence of the sealer to the dentin walls. In addition to 17% EDTA, Epiphany primer was applied to the dentin wall of the root canal that was to be filled with Resilon; this process prepares the root surface through an etching process that creates finger like dentinal projections. This allows for a lock and key type bond between the tooth and the sealer and core material.<sup>3</sup> This preparation of the dentin prevents shrinkage of the resin filling away from the dentin walls and aids in sealing.<sup>17</sup>

Both the tested root canal filling materials and the associated sealers allowed some leakage. The results obtained from Group 1, Resilon with Epiphany sealer is significant when compared with Group 2, Gutta-percha with AH plus sealer. The mean leakage of Resilon with Epiphany sealer was lower than that of Gutta-percha and AH plus. (The results were analyzed by Tukey HSD test, which gave a highly significant  $P > 0.05$  value).

The results of the present study are in accordance with the studies of Shipper *et al.*, they compared lateral and vertical condensation of Gutta-percha and AH 26 with lateral and vertical condensation of Resilon and Epiphany sealer when exposed to *Streptococcus mutans*. They found the Resilon and Epiphany sealer leaked significantly less than the Gutta-percha groups.<sup>17</sup> In another study, Shipper and Trope compared bacterial leakage of lateral and vertical condensation of Gutta-percha with AH 26 sealer and Resilon and Epiphany sealer. The microorganism used was *Enterococcus faecalis* in addition to *S. mutans*. Again, the Resilon and Epiphany sealer groups leakage significantly less than the Gutta-percha groups.<sup>6</sup>

In another study by Aptekar and Ginnan, they compared apical leakage between Resilon and Gutta-percha over an interval of 10 days, 1 month, and 3 months. They concluded that Resilon consistently resulted in less microleakage than Gutta-percha at all three-time intervals.<sup>3</sup> Bodrumlu and Tunga in their study compared the sealing ability between Resilon Epiphany system and Gutta-percha with AH 26 sealer and concluded that both groups produced a satisfactory seal. However, Resilon and Epiphany sealer showed the least apical leakage. Thus, these studies mentioned above indicate that Resilon and Epiphany sealer provide the best seal.<sup>15</sup>

The findings of the present study differ from the studies of Tay *et al.*, Hashem and Hossam, Gesi *et al.*, and Tay *et al.* concluded that the quality of apical seal achieved with Resilon core material and Epiphany sealer is not superior to Gutta-percha and a conventional epoxy-resin sealer.<sup>14</sup> Hashem and Hossam showed that the samples obturated with Gutta-percha cones had a better seal than samples obturated with Epiphany cones.<sup>10</sup> Discrepancies between the two studies are probably because of differences in methodology. In the study by Gesi *et al.*, Gutta-percha exhibited higher interfacial strength than Resilon.<sup>20</sup> Studies conducted by Pitout *et al.*,<sup>21</sup> Biggs *et al.*,<sup>22</sup> Epley *et al.*,<sup>23</sup> and Kocak *et al.*<sup>24</sup> concluded that there was no difference between Gutta-percha and Resilon/Epiphany system at sealing root canals.

One study also demonstrated that though initially Resilon/Epiphany groups prevented fluid movement to the same degree as Gutta-percha/AH plus groups, they lost their sealing capacity eventually and showed gross leakage when tested at 16 months interval.<sup>25</sup> This shows that further long term studies are mandatory to evaluate the effectiveness of the apical seal.

The results of the present study showed that the Epiphany obturating system is a promising root canal obturating material with a good sealing ability. Results obtained by an *in-vitro* study cannot be directly evaluated clinically, but they do permit a reasonable comparison.

The disadvantages of Epiphany sealer is that it requires an additional step that is etching and drying process. Although studies have shown that there are several advantages of Resilon over Gutta-percha, further research is required to support and confirm them. Concerns lie in the operator's ability to place primer and sealer in the apical portions of the root canals, and also over the potential for biodegradability of Resilon/Epiphany system; as the filling material contains polycaprolactone.<sup>3</sup>

Polycaprolactone, the raw material of Resilon cones, is susceptible to enzymatic and alkaline hydrolysis, serving as nutrients for bacteria that remain viable after chemomechanical root canal preparation.<sup>7</sup> The Epiphany sealer presents higher solubility (3.41%) and dimensional alteration (expansion 8.1%) values than those considered acceptable by the ADA, but show an extensive release of calcium, raising the pH of the media, and giving it bactericidal power.<sup>7</sup> Therefore, clinical studies should be conducted to confirm whether this presence of apical leakage could compromise the periapical tissue repair.

## Conclusion

The present study evaluated the apical sealing ability of Gutta-percha with Resilon using dye penetration and clearing technique. In the study, Resilon core material and Epiphany sealer showed significantly less apical microleakage than Gutta-percha used with AH plus sealer. On the basis of these

findings, it can be concluded that Resilon/Epiphany system has the potential to replace Gutta-percha. However, data from *in vitro* studies cannot be directly applied clinically. Further, long term investigations should be conducted on Resilon and Epiphany system which can help validate its use.

## References

1. Seltzer S, Bender IB. Cognitive dissonance in endodontics. 1965. J Endod. 2003;29(11):714-9; discussion 713.
2. Zidan O, ElDeeb ME. The use of a dentinal bonding agent as a root canal sealer. J Endod 1985;11(11):176-8.
3. Aptekar A, Ginnan K. Comparative analysis of microleakage and seal for 2 obturation materials: Resilon/epiphany and gutta-percha. J Can Dent Assoc 2006;72(3):245.
4. De Oliveira DP, Barbizam JV, Texeria FB. Comparison between Gutta-percha and Resilon removal using two different techniques in endodontic techniques in endodontic re-treatment. J Endod 2006;32(4):362-3.
5. Hovland EJ, Dumsha TC. Leakage evaluation *in vitro* of the root canal sealer cement Sealapex. Int Endod J 1985;18(3):179-82.
6. Shipper G, Trope M. *In vitro* microbial leakage of endodontically treated teeth using new and standard obturation techniques. J Endod 2004;30(3):154-8.
7. Veríssimo DM, do Vale MS, Monteiro AJ. Comparison of apical leakage between canals filled with gutta-percha/AH-plus and the resilon/epiphany system, when submitted to two filling techniques. J Endod 2007;33(3):291-4.
8. Pawinska M, Kierklo A, Marczuk-Kolada G. New technology in endodontics: The resilon-epiphany system for obturation of root canals. Adv Med Sci 2006;51 Suppl 1:154-7.
9. Teixeira FB, Teixeira EC, Thompson JY, Trope M. Fracture resistance of roots endodontically treated with a new resin filling material. J Am Dent Assoc 2004;135(5):646-52.
10. Hashem AA, Hossam MT. An evaluation of apical leakage in root canals obturated by a new thermoplastic synthetic polymer based root canal filling material. Available from: <http://www.Researchgate.net/publication/265266126>. [Last accessed on 12 Jul 2015].
11. Dutra F, Barroso JM, Carrasco LD, Capelli A, Guerisoli DM, Pécora JD. Evaluation of apical microleakage of teeth sealed with four different root canal sealers. J Appl Oral Sci 2006;14(5):341-5.
12. Veríssimo DM, do Vale MS. Methodologies for assessment of apical and coronal leakage of endodontic filling materials: A critical review. J Oral Sci 2006;48(3):93-8.
13. AliGhamdi A, Wennberg A. Testing of sealing ability of endodontic filling materials. Endod Dent Traumatol 1994;10(6):249-55.
14. Tay FR, Loushine RJ, Weller RN, Kimbrough WF, Pashley DH, Mak YF, et al. Ultrastructural evaluation of the apical seal in roots filled with a polycaprolactone-based root canal filling material. J Endod 2005;31(7):514-9.
15. Bodrumlu E, Tunga U. Apical leakage of resilon obturation material. J Contemp Dent Pract 2006;7(4):45-52.
16. Richard GB, Philip SB, James H, Hart F. The efficacy of four root canal obturation techniques in preventing apical dye penetration. J Endod 1989;119:633-7.
17. Shipper G, Ørstavik 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 2004;30(5):342-7.
18. de Oliveira DP, Barbizam JV, Trope M, Teixeira FB. Comparison between gutta-percha and resilon removal using two different techniques in endodontic retreatment. J Endod 2006;32(4):362-4.
19. De Moor RJ, Hommez GM. The long-term sealing ability of an epoxy resin root canal sealer used with five gutta percha obturation techniques. Int Endod J 2002;35(3):275-82.
20. Gesi A, Raffaelli O, Goracci C, Pashley DH, Tay FR, Ferrari M. Interfacial strength of Resilon and gutta-percha to intra-radicular dentin. J Endod 2005;31(11):809-13.
21. Pitout E, Oberholzer TG, Blignaut E, Molepo J. Coronal leakage of teeth root-filled with gutta-percha or resilon root canal filling material. J Endod 2006;32(9):879-81.
22. Biggs SG, Knowles KI, Ibarrola JL, Pashley DH. An *in vitro* assessment of the sealing ability of resilon/epiphany using fluid filtration. J Endod 2006;32(8):759-61.
23. Epley SR, Fleischman J, Hartwell G, Cicalese C. Completeness of root canal obturations: Epiphany techniques versus gutta-percha techniques. J Endod 2006;32(6):541-4.
24. Kocak MM, Er O, Saglam BC, Yaman S. Apical leakage of epiphany root canal sealer combined with different master cones. Eur J Dent 2008;2(2):91-5.
25. Paqué F, Sirtes G. Apical sealing ability of resilon/epiphany versus gutta-percha/AH Plus: Immediate and 16-months leakage. Int Endod J 2007;40(9):722-9.