

# Filling of simulated lateral canals with gutta-percha or thermoplastic polymer by warm vertical compaction

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**Abstract:** The aim of this study was to evaluate the ability of gutta-percha and a thermoplastic synthetic polymer (Resilon) to fill simulated lateral canals, using warm vertical compaction. Forty-five single-rooted human teeth were prepared using the rotary crown-down technique. Artificial lateral canals were made at 2, 5, and 8 mm from the working length (WL) in each root. The specimens were divided into three groups (n = 15), according to the filling material: Dentsply gutta-percha (GD), Odous gutta-percha (GO), and Resilon cones (RE). The root canals were obturated using warm vertical compaction, without endodontic sealer. The specimens were subjected to a tooth decalcification and clearing procedure. Filling of the lateral canals was analyzed by digital radiography and digital photographs, using the Image Tool software. The data were subjected to the Kruskal-Wallis and Dunn tests at 5% significance. RE had the best filling ability in all root thirds ( $p < 0.05$ ), with similar results for GO in the coronal third. In the middle and apical thirds, GD and GO had similar results ( $p > 0.05$ ). Resilon may be used as an alternative to gutta-percha as a solid core filling material for use with the warm vertical compaction technique. The study findings point to the potential benefit of the warm vertical compaction technique for filling lateral canals, and the study provides further information about using Resilon and gutta-percha as materials for the warm vertical compaction technique.

**Keywords:** Gutta-Percha; Endodontics; Root Canal Filling Materials.

## Introduction

The goal of endodontic treatment is the three-dimensional filling of the root canal system after its cleaning and shaping.<sup>1</sup> Several root canal filling materials and techniques have been developed<sup>2</sup> and studied, aiming to completely fill the root canals, their ramifications, and any anatomical variations, which are frequently observed.<sup>3,4,5</sup> Different endodontic obturation techniques have been evaluated regarding the homogeneity of the obturation<sup>6</sup> and volume of voids and gaps in the root canal obturation.<sup>7</sup>

Root canal filling is generally accomplished by using a solid core material associated with an endodontic sealer. Gutta-percha is the most widely used solid material due to its physical and chemical stability and its ability to be plasticized by heating.<sup>8</sup> The thermal plasticization property

allows gutta-percha to be used during root canal filling by warm vertical compaction, as described by Schilder.<sup>1</sup> Warm vertical compaction can be performed using equipment such as Touch'n Heat and System B, where the temperature of the condensers can be controlled.<sup>9</sup> Warm compaction of filling materials using the Touch'n Heat system has demonstrated its ability to seal simulated lateral canals.<sup>9,10</sup>

Resilon was proposed in 2004 as a solid core root canal filling material (Resilon Research, LLC, North Branford, USA). This material is a thermoplastic synthetic polymer containing bioactive glass, bismuth oxychloride, and barium sulfate.<sup>11</sup> Resilon shows thermoplastic ability similar to gutta-percha.<sup>12</sup> Karr *et al.*<sup>13</sup> carried out a study using a variation of the warm vertical compaction technique and observed that gutta-percha and Resilon presented similar ability to fill lateral grooves and depressions in root canals.

The ability to fill lateral canals is important in evaluating root canal filling materials for clinical use, according to the filling technique to be used. Simulated lateral canals can be made in artificial<sup>14,15</sup> or natural teeth.<sup>16,17</sup> Root canal fillings may be evaluated using radiographic examination,<sup>16</sup> tooth decalcification and clearing methods,<sup>10</sup> or by an association of methods.<sup>17</sup>

The effectiveness of the warm vertical compaction technique depends on the thermal plasticization property of the material to be used. Gutta-percha and Resilon can be plasticized by heating, and, as such, can be used for this root canal filling technique. The aim of this study was to evaluate the ability to fill simulated root canals using warm vertical compaction with three different solid core endodontic materials: Resilon and two brands of gutta-percha.

## Methodology

This research project was approved by the Research Ethics Committee of the Dental School of Araraquara – UNESP (27/09). Forty-five single-rooted human teeth were selected for this study. The teeth were decoronated, and the root length was standardized at 15 mm. All specimens had a single root canal and its apical diameter corresponded to a #20 or smaller K-file. The entire root canal length was measured by introducing a #10 K-file (Dentsply-Maillefer, Ballaigues, Switzerland) up to

the apical foramen. The working length (WL) was established by subtracting 1mm from the entire length.

Biomechanical instrumentation of the root canals was performed using the rotary crown-down technique, with K3 files (Sybron Endo, Orange, USA), sizes 25.12, 25.10, 25.08, 25.06 and 25.04, until encountering resistance, and sizes 25.02, 30.04, 35.04, and 40.04, up to the WL. A solution of 2.5% sodium hypochlorite was used for irrigation.

After the root canals were prepared, the teeth were subjected to a tooth decalcification and clearing procedure using a technique described by Venturi *et al.*<sup>10,18</sup> First, the specimens were decalcified in a solution of 5% hydrochloric acid (Hexis Científica S/A, Jundiaí, Brazil), which was changed every 24 hours for approximately 5 days, until the teeth became rubber-like in texture. Afterwards, #8 and #10 K-files were inserted through the labial and lingual root surfaces at 2, 5, and 8 mm from the WL up to the main root canal, creating the simulated lateral canals. The specimens were then washed in running water and dehydrated by soaking in serial concentrations of alcohol: 80% for 12 hours, 90% for one hour, and 99% for three hours. Finally, the roots were immersed in methyl salicylate (Vetec Química Fina Ltda., Rio de Janeiro, Brazil), in order to render the tissues transparent.

The specimens were then removed from the methyl salicylate solution and wiped with alcohol, also used for irrigating the root canals to remove residual methyl salicylate. After drying the root canals, the specimens were obturated using the Touch'n Heat system (model 5004, Analytic Technology, Redmond, USA). The specimens were divided into three different groups (n = 15), according to the filling material used: (GD) – Dentsply 40.04 gutta-percha cones (Dentsply Ind. e Com. Ltda., Petrópolis, Brazil); (GO) – Odous FM (microtipped) gutta-percha (Odous De Deus Ind. e Com Ltda., Belo Horizonte, Brazil); or (RE) – Resilon 40.04 cones (Resilon Research, LLC, North Branford, USA).

In the GO group, the cones were trimmed using a #15 surgical scalpel (BD – Becton Dickinson Indústrias Cirúrgicas Ltda., Rio de Janeiro, Brazil) and fitted snugly into a #40 diameter cone. After cone-fitting, a plugger (Buchanan Plugger F, Sybron

Endo, Orange, USA) was inserted into the canal up to 3 mm from the WL, and the power level was set at 7. Subsequent apical condensation was performed with a #1 Schilder plugger (Odous De Deus Ind. e Com Ltda., Belo Horizonte, Brazil). Backfill was carried out by compacting heated increments of filling material with Schilder pluggers #2 through #5, until the canal was completely filled. Since the goal of this study was to evaluate the filling ability of solid core materials, no sealers were used.

After obturation of the canals, radiographs (Kodak RVG 6100, Kodak Dental Systems, Atlanta, USA) were taken using a Spectro 70X Electronic X-ray unit (Dabi-Atlante, Ribeirão Preto, Brazil). The root position and focus-film distance were standardized. Then, specimens were once again soaked in methyl salicylate, after which standardized digital photographs were taken (Nikon D80, Tokyo, Japan).

The radiographic and photographic images showing the root canal fillings in each specimen were imported into the Image Tool software (UTHSCSA Image Tool for Windows version 3.0, San Antonio, USA). The amount of filling material visualized in each lateral canal was calculated and expressed as a

percentage of linear extension (length of the lateral canal that was filled, in relation to its entire length in mm) and of filled area (area occupied by the filling material inside the lateral canal, in relation to its entire area in mm<sup>2</sup>). The results were analyzed and subjected to the Kruskal-Wallis test at 5% significance.

## Results

Tables 1 and 2 list the percentages of lateral canal filling achieved by each material. In the coronal third, Resilon showed greater filling ability, with a significant difference ( $p < 0.05$ ) from Dentsply gutta-percha. In the middle and apical thirds, Resilon showed greater filling percentages than the other materials tested ( $p < 0.05$ ). Both types of gutta-percha had similar results ( $p \geq 0.05$ ). Figure 1 shows the radiographic images and photographs of the decalcified and cleared specimens.

## Discussion

Resilon is recommended as a core material for root canal obturation using warm vertical compaction, enabled by its thermoplastic properties. Tanomaru Filho *et al.*<sup>19</sup> showed that Resilon offers greater

**Table 1.** Radiographic analysis of filling material penetration into simulated lateral canals made in each third (mean percentages).

Location/parameter	Dentsply	Odous	Resilon
Coronal/extension	41.55 <sup>b</sup> (±35.97)	65.28 <sup>a,b</sup> (±33.54)	64.56 <sup>a</sup> (±41.46)
Coronal/area	41.20 <sup>b</sup> (±35.61)	65.67 <sup>a,b</sup> (±33.29)	64.42 <sup>a</sup> (±41.28)
Middle/extension	56.43 <sup>b</sup> (±34.60)	58.95 <sup>b</sup> (±36.66)	80.87 <sup>a</sup> (±32.99)
Middle/area	56.44 <sup>b</sup> (±34.86)	59.45 <sup>b</sup> (±35.98)	80.84 <sup>a</sup> (±32.64)
Apical/extension	48.08 <sup>b</sup> (±37.49)	29.73 <sup>b</sup> (±39.48)	99.08 <sup>a</sup> (±3.80)
Apical/area	49.55 <sup>b</sup> (±36.49)	30.46 <sup>b</sup> (±39.49)	99.78 <sup>a</sup> (±1.21)

Different letters indicate a statistically significant difference.

**Table 2.** Analysis of filling material penetration into simulated lateral canals made in each root third – photographs of decalcified and cleared specimens (mean percentages).

Location/parameter	Dentsply	Odous	Resilon
Coronal/extension	52.96 <sup>b</sup> (±34.93)	81.69 <sup>a</sup> (±23.03)	84.36 <sup>a</sup> (±30.52)
Coronal/area	53.04 <sup>b</sup> (±34.70)	79.13 <sup>a</sup> (±24.95)	79.27 <sup>a</sup> (±32.61)
Middle/extension	68.23 <sup>b</sup> (±34.91)	71.85 <sup>b</sup> (±34.51)	91.17 <sup>a</sup> (±24.28)
Middle/area	74.64 <sup>b</sup> (±32.94)	65.07 <sup>b</sup> (±35.17)	87.54 <sup>a</sup> (±26.82)
Apical/extension	55.43 <sup>b</sup> (±38.87)	36.75 <sup>b</sup> (±38.66)	100.0 <sup>a</sup> (±0.0)
Apical/area	47.29 <sup>b</sup> (±38.40)	44.18 <sup>b</sup> (±40.59)	100.0 <sup>a</sup> (±0.0)

Different letters indicate a statistically significant difference.



**Figure 1.** Analysis of filling material penetration into simulated lateral canals: radiograph (A) and photograph (B) of a specimen after decalcification and clearing.

thermoplastic ability than gutta-percha. Moreover, the thermal behavior of Resilon is similar to that of gutta-percha,<sup>12,20</sup> thus supporting its indication as an alternative to gutta-percha.

The ability of root canal filling material to fill and seal irregular ramifications of the root canal system is important to achieve endodontic treatment success.<sup>21</sup> In this study, the filling material was observed in all lateral canals. Since the purpose of the study was to compare the filling ability of Resilon with that of two different types of gutta-percha in simulated lateral canals, no endodontic sealer was used, allowing better evaluation of the core materials individually. In clinical conditions, the use of a sealer may further enhance the flow of filling materials into the lateral canals of the root canal system. The use of human teeth rendered transparent by a decalcification and clearing protocol described by Venturi *et al.*<sup>18</sup> allowed three-dimensional internal visualization of the root canal filling within the simulated lateral canals, and complemented the radiographic analysis.<sup>22</sup> The results of the present study showed that both analyses (3D visualization and radiography) had similar results. Using similar methodology, Tanomaru-Filho *et al.*<sup>3,4,5</sup> showed that gutta-percha and Resilon are solid core materials with lateral canal filling ability when used with different thermoplastic systems.

Ramifications of the root canal system generally range in diameter from 50 to 150  $\mu\text{m}$ .<sup>10</sup> Such small diameters, together with their location within the root canal system, may affect the filling of lateral canals. In this study, #8 and #10 K-files were used to create the simulated lateral canals. Venturi *et al.*<sup>10</sup> and Venturi<sup>23</sup> observed that natural apical ramifications were often left incompletely filled after warm vertical compaction. However, the technique used in this study proved safer, by promoting less extrusion of filling material than the Termafil technique.<sup>24</sup> After root canal obturation with the warm gutta-percha vertical compaction technique using BeeFill® 2in1, Wolf *et al.*<sup>25</sup> showed that none of the root-canal-filled teeth were free of gaps. Warm vertical compaction produced a significantly greater volume of gutta-percha and a significantly lower percentage of voids than those resulting from cold lateral compaction.<sup>26</sup>

Resilon demonstrated greater ability to fill lateral canals than the other materials evaluated, especially in the apical third of the root. Oddoni *et al.*<sup>27</sup> showed that Epiphany with Resilon provides better apical than coronal sealing. In the coronal third, Resilon had better results than Dentsply gutta-percha, but showed a filling ability similar to Odous gutta-percha. Karr *et al.*<sup>13</sup> employed a variation of the warm vertical compaction technique, to compare the flow of Resilon and of gutta-percha, associated with an endodontic sealer, into lateral groves and depressions of natural teeth. In contrast to the observations reported in the present study, the cited authors reported similar results for Resilon and gutta-percha. In the present study, the Buchanan plugger was inserted up to 3 mm from the WL. At this level, Karr *et al.*<sup>13</sup> found the highest flow values for gutta-percha. Karabucak *et al.*<sup>15</sup> analyzed the behavior of Resilon and different types of gutta-percha, using different thermoplastic delivery systems (Calamus and Obtura II) in single or multiple increments. These authors observed that Obtura Flow gutta-percha showed greater penetration into simulated lateral canals than Resilon.

The chemical composition of Resilon and gutta-percha may influence their ability to fill simulated root canals. The melting point of Resilon and gutta-percha are relatively the same; however, the endothermic enthalpy change and the specific

heat of gutta-percha are lower than those of Resilon.<sup>12</sup> In addition, the thermoplasticity of Resilon is higher than that of conventional and thermoplastic gutta-percha.<sup>19</sup> The thermoplastic properties of Resilon are attributed to the addition of polycaprolactone, which has a melting point of 60°C,<sup>28</sup> making it indicated for thermoplastic obturation techniques.<sup>5,15,19</sup> Gutta-percha cones are composed of barium sulfate, zinc oxide, wax, resin and gutta-percha, but the proportions of these components are not constant.<sup>14</sup> The percentage of inorganic components in the formulation of commercially available gutta-percha may affect its thermal properties.<sup>29</sup> Greater flow has been reported for cones containing higher percentages of gutta-percha in their formulation.<sup>14</sup> The mean of the percentage by weight of gutta-percha points in

Odous cones is 18.8, and that of Dentsply is 0.04 is 15.7.<sup>30</sup> In the present study, Odous gutta-percha had better results than Dentsply gutta-percha in the coronal third, which suggests the presence of a greater percentage of gutta-percha in its formulation.

## Conclusion

Based on the methodology used and the results obtained, Resilon may be considered an appropriated alternative for gutta-percha as a solid core material for filling root canals by warm vertical compaction.

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