

# Comparative assessment of the flow rate of root canal sealers

## Estudo comparativo do escoamento de cimentos obturadores endodônticos

### Abstract

**Purpose:** This study evaluated the flow rate of the Acroseal, AH Plus, Endomethasone N, Sealapex, and ActiV GP according to the standards of the ISO specification 6876/2001.

**Methods:** A volume of 0.05 mL of the cement mixed according to the manufacturer's recommendations was placed on a glass plate. At  $180 \pm 5$  s after the commencement of mixing, the second glass plate was placed on top of the sealer, followed by the weight of mass approximately 100 g to make a total mass on the plate of  $120 \pm 2$  g. Ten min after the start of mixing, the weight was removed and the value of the diameter of the compressed disc of sealer was measured. The mean of three such determinations for each sealer was taken as the flow of the material. The mean values were compared using ANOVA and Tukey's tests.

**Results:** The results obtained were: Acroseal 21.24 mm, AH Plus 22.72 mm, ActiV GP 24.90 mm, Endomethasone N 18.76 mm, and Sealapex 25.15 mm.

**Conclusion:** Only the Endomethasone N did not conform to ISO Specification that requires that a sealer shall have a diameter of not less than 20 mm. The Sealapex achieved the greatest flow, but it did not differ from ActiV GP and AH Plus ( $P > 0.5$ ).

**Key words:** Flow; dental materials; root canal sealers

### Resumo

**Objetivo:** Este estudo avaliou o escoamento do Acroseal, AH Plus, Endomethasone N, Sealapex e ActiV GP de acordo com a especificação ISO 6876/2001.

**Metodologia:** Um volume de 0,05 mL do cimento manipulado de acordo com as recomendações do fabricante foi colocado numa placa de vidro. Aos  $180 \pm 5$  s após o início da espatulação, uma segunda placa de vidro foi colocada sobre o cimento, seguida por um peso de massa de 100 g para fazer um total de  $120 \pm 2$  g. Dez minutos após o começo da manipulação o peso foi removido e o valor do diâmetro do disco de cimento foi mensurado. A média de 3 mensurações para cada cimento foi tomada como o escoamento do material. Os dados foram comparados estatisticamente pelos testes ANOVA e Tukey.

**Resultados:** Os escoamentos obtidos foram: Acroseal 21,4 mm, AH Plus 22,72 mm, ActiV GP 24,90 mm, Endomethasone N 18,76 mm e Sealapex 25,15 mm.

**Conclusão:** Apenas o Endomethasone N não se enquadrou na especificação ISO a qual requer que o cimento tenha um diâmetro não inferior a 20 mm. O Sealapex alcançou o melhor escoamento, mas não foi estatisticamente diferente do ActiV GP e AH Plus ( $P > 0,05$ ).

**Palavras-chave:** Escoamento; materiais dentários; cimentos obturadores

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## Introduction

The main function of the endodontic sealer is to fill the gaps between the gutta-percha points and the walls of the root canal. The sealer also fills the voids between individual gutta-percha points applied during condensation (1). To create and maintain a three-dimensional seal of the entire root canal system, sealers should have adhesiveness, be dimensionally stable, be insoluble to oral and tissue fluids, and have an adequate flow rate. This latter property allows the material to penetrate into irregularities, isthmus fins and ramifications, which increases the likelihood of obtaining an adequate seal of the root canal system (2).

Many types and brands of sealing cements are commercially available. They can be divided into the following types: eugenol-zinc-oxide-based cements, calcium-hydroxide cements, glass ionomers, plastic resins and MTA-based cement. The search for an endodontic sealer that fulfills the requirements for the ideal physicochemical and biologic properties continues even though many different root canal filling materials have been advocated through the years, such as AH Plus, Sealapex and Endomethasone-N. On the other hand, new endodontic sealers have recently been proposed, such as Acroseal and ActiV GP. Thus, it is important to evaluate their properties, including flow.

ActiV GP Sealer (Brasseler Inc., Savannah, GA, USA) is a glass-ionomer-based material indicated for use together with Activ GP gutta-percha points, which provide adhesion between the filling material and the root canal walls (3). It presents good bond strength to root canal dentin (4), but low radiopacity (3) and poor apical seal (5).

Acroseal (Septodont, Saint Maur des Fosses, France) is a calcium hydroxide-based sealer with epoxy resin. It has good radiopacity (3), excellent film thickness (6), however it presents a lower calcium ion release and pH compared with Sealapex (7).

The resin-based epoxy sealer AH Plus (Dentsply De Trey, Konstanz, Germany) is a modified version of AH 26. Some studies have demonstrated that this material presents good radiopacity (8), low solubility (9), high bond strength to root canal dentin (4), excellent flow (2,10), and a thin film thickness (9).

Endomethasone (Septodont, Saint Maur des Fosses, France) is a zinc oxide-eugenol based root canal sealer that has antibacterial activity (11), and apical sealing capacity (12). However, Endomethasone is cytotoxic (13), fact that can be explained by the formaldehyde release after setting of this material (14). In attempt to solve this problem, it has been developed Endomethasone N, which does not contain paraformaldehyde in its composition.

Sealapex (SybronEndo, Orange, CA, USA) is a calcium hydroxide-based sealer that has antibacterial activity (15), good biological properties (16), high pH and calcium ion release (7), and good radiopacity (3). The manufacturer of Sealapex has recently modified its formulation by adding bismuth trioxide to improve its radiopacity and increase its shelf life (3).

The aim of the current study was to investigate the flow of three new root canal sealers (Acroseal, ActiV GP and Sealapex new formulation) and to compare the results with those of two products that have been on the market for some time (AH Plus and Endomethasone N).

## Methodology

Flow test for Acroseal (Septodont, Saint-Maur-des-Fosses, France), ActiV GP (Brasseler USA), AH Plus (Dentsply DeTrey, Konstanz, Germany), Endomethasone N (Septodont, Saint-Maur-des-Fosses, France) and Sealapex (Dentsply DeTrey, Konstanz, Germany) root canal sealants were measured according to the standards of the International Organization for Standardization (ISO) specification 6876/2001 second edition (17) which includes the tests of the physicochemical properties of dental root canal sealing materials.

A volume of 0.05 mL of the cement mixed according to the manufacturer's recommendations was placed on a glass plate 40 mm x 40 mm and approximately 5mm thick using a graduated disposable 1-mL syringe. At  $180 \pm 5$  s after the commencement of mixing, it was placed the second glass plate carefully and centrally on top of the sealer, followed by the weight of mass approximately 100 g to make a total mass on the plate of  $120 \pm 2$  g. Ten min after the start of mixing, the weight was removed and the values of the maximum and minimum diameters of the compressed discs of sealer were measured by a digital calliper (Mitutoyo MTI Corporation, Tokyo, Japan). If the diameters agree to within 1 mm, the mean of the two diameters (maximum and minimum) was taken as the flow of the sample. If the major and minor diameter discs were not uniformly circular or did not match within 1 mm, the test was repeated.

The mean of three samples for each sealer ( $n=3$ ), expressed to the nearest millimeter, was taken as the flow of the material (group). Data were recorded directly onto coding sheets and then stored in a computer. The mean values were compared statistically using ANOVA and Tukey tests. Statistical analysis was performed by using SPSS 16.0 for Mac software and a value of  $P < 0.05$  was considered significant.

## Results

The ISO Specification 6876 requires that a sealer shall have a diameter of not less than 20 mm. The sealers Acroseal (Septodont, Saint-Maur-des-Fosses, France), AH Plus (Dentsply DeTrey, Konstanz, Germany), ActiV GP (Brasseler, USA) and Sealapex (Dentsply DeTrey, Konstanz, Germany) conformed to ISO Specification 6876 standards as the results were  $21.24 (\pm 0.52)$ ,  $22.72 (\pm 1.75)$ ,  $24.90 (\pm 1.61)$  and  $25.15 (\pm 1.73)$  mm respectively. Only the Endomethasone N (Septodont, Saint-Maur-des-Fosses, France) sealer did not conform to ISO Specification 6876 as the result was  $18.76 (\pm 0.84)$  mm. The Tukey test showed statistical difference among the cements (Table 1).

**Table 1.** Flow rate of the root canal sealers Endomethasone N, Acroseal, AH Plus, ActiV GP and Sealapex.

Root canal sealer	Flow rate				
	1 <sup>st</sup> sample	2 <sup>nd</sup> sample	3 <sup>rd</sup> sample	Mean	Standard Deviation
Endomethasone N	19.25	19.25	17.78	18.76*	0.84
Acroseal	20.65	21.39	21.68	21.24*†	0.53
AH Plus	23.59	20.70	23.87	22.72†‡	1.75
ActiV GP	23.04	25.99	25.67	24.90†‡	1.61
Sealapex	27.07	24.71	23.68	25.15‡	1.73

\*, †, ‡ Means followed by similar labels were not significantly different ( $P > 0.05$ ).

## Discussion

The flow test can be conducted by means two international standards: American Dental Association (ADA) no. 57 (American National Standards/American Dental Association 1983) or International Standards Organization (ISO)-6876 (International Organization for Standardization 2001). The only differences between ADA and ISO standards are the volume analysed and the minimum diameter of spread, thus to test the ISO 6876 specification, the volume of sealer is 0.05 mL ( $\pm 0.005$  mL) and each compressed disc shall have a diameter not  $< 20$  mm (10). In the present study, ISO 6876 specification was the standard of choice because it has been widely used (10,18,19). In addition, a smaller volume of the sealer request for this test allowed an easier manipulation of the material.

Several properties of root canal sealers have been studied, such as setting time, solubility, disintegration, film thickness, dimensional changes after setting, biocompatibility, and antimicrobial activity. It is also important that a root canal sealer have suitable flow to enter the narrow irregularities in dentin, accessory canals and voids between master and accessory cones.

Extreme reduction in flow and working time results in an inability to work effectively with a material, increasing the chances of a void being created (18). Several factors may influence the penetration of endodontic sealers within confined areas of the root canal system. Among them, the obturation technique used, the contact area, the dimension of irregularities, accessibility to the complexities, and the sealer's flow rate seem to play an important role in allowing sealer penetration (2). On the other hand, the sealer should flow into accessory anatomy and between gutta-percha cones, without increasing the risk of periapical extrusion (20).

The flow rate of the endodontic sealers is determined by a number of factors. The effects of the powder/liquid ratio on the properties of two commercially available zinc oxide-eugenol-based root canal sealers (Cortisolmol and Pulp Canal Sealer EWT) was evaluated by Camps et al. (19). An increased powder/liquid ratio led to a decreased flow, an increased radiopacity and a decreased amount of eugenol released. Thus, the endodontists can prepare the zinc oxide-eugenol-based root canal sealers at their chosen

consistency according to the filling technique they use. In the present study, all root canal sealers were mixed following powder/liquid or paste/paste ratio and handling suggested by their manufacturers.

The effect of aged eugenol (up to 180 days) on the flow of Grossman root canal sealer has been evaluated (21). There were statistically significant differences between groups, with a higher flow for aged eugenol. The authors concluded that time affects eugenol, with consequent effects on Grossman sealer.

Pécora et al. (22) evaluated the importance of the correct manipulation of endodontic sealers, correlating it with flow rate and with the consequent obturation of root canals. The Endomethasone root canal sealer, in ideal consistency or with an excess of eugenol, did not present the necessary flow rate to penetrate into the simulated root canals, differently from the ideally manipulated Grossman sealer. The poor flow of the Endomethasone has been justified (10,22) by the lack of resin in its composition. On the other hand, the resin-based sealer AH Plus showed suitable flow as already described (2,10).

The composition of the sealers seems to be the main factor related to their flow characteristics (10). However, Kaplan et al. (23) assessed the flow of five endodontic sealers (Procosol, AH 26, Endomethasone, Sealapex and Endion) and concluded that the different results obtained suggest that the factor determining flow may not be the composition, but their final consistency and the setting reaction. Our findings corroborate this statement, because even though Acroseal and Sealapex are both paste/paste and calcium hydroxide-based endodontic sealers, flow rate of Sealapex was significantly higher.

The present study used the recently modified formulation of Sealapex root canal sealer that has a 2-year shelf life instead of the 1-year shelf life of the previous formulation. One of the major alterations was the replacement of the radio-pacifier (ie, from barium sulfate to bismuth trioxide) (24). The biocompatibility of the new Sealapex has been negatively affected (24), but its radiopacity (3) and flow have not.

Activ GP is a recently introduced root canal sealer that has no report on its flow property. However, others glass ionomer-based endodontic sealers have already been evaluated, such as Endion and Ketac-endo. It has been shown (18,23,25)

that glass ionomer-based sealers have acceptable flow rate. It's important to highlight some limitations of the flow test of the ISO specification 6876/2001. The present study represents a comparative evaluation among some root canal sealers, however clinically they may have a different pattern. Almeida et al. (10) did not find correlation between the flow required by the ADA 57 and ISO 6876 specifications and the sealer's ability to fill 0.1 mm artificial lateral canals. The flow of endodontic sealers may be complicated by tapered and curved canals and by the insertion of a gutta-percha

point. In addition, flow may also be affected by dentine tubules and a smear layer (25).

Based on the results obtained from this *in vitro* study, it was concluded that the flow rate of Acroseal, AH Plus, Activ GP and Sealapex conformed to ISO specification 6876/2001 for endodontic filling materials. On the other hand the flow value of Endomethasone N was lower than those considered acceptable for the ISO specification 6876/2001. Further *in vitro* and *in vivo* studies may help to elucidate if sealers that have good flow really assist in root canal filling.

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