



ISSN Print: 2394-7489  
ISSN Online: 2394-7497  
IJADS 2019; 5(1): 237-240  
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www.oraljournal.com  
Received: 13-11-2018  
Accepted: 17-12-2018

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## Assessing the flow rate of silicon-based endodontic sealers

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### Abstract

**Introduction:** This study evaluated the flow rate of silicon-based root canal sealers (Roeko Seal, Nano Seal-S) and compared it to an epoxy resin sealer (AH-Plus).

**Material and Methods:** Measurement of the flow rate was conducted by the method prescribed by ISO specification 6876:2012. The sealers were mixed, and a volume of 0.05 mL was dispensed using a graduated plastic 1 mL syringe to a glass slab with the dimensions of 40x40x5mm (20 g). After 3 minutes, a second glass slab was placed with a calibrated weight of 100g making a total load mass of 120g. The sealers were left for an additional 7 minutes has passed, and a digital caliper was used to measure the diameter of the compressed sealer. The data were analyzed using ANOVA and Tukey tests ( $P < 0.05$ ).

**Results:** The average of the mean diameters of the sealers were Roeko Seal (24.46), Nano Seal-S (20.91), and AH Plus (23.62). Statistical analysis of the finding showed that Roeko Seal and AH Plus had significantly higher flow values compared to Nano Seal-S sealer ( $P < 0.01$ ). The difference between Roeko Seal and AH Plus was statistically not significant ( $P = 0.164$ ).

**Conclusion:** Although tested sealers have variable flow rate values, all sealers were within the requirement of the ISO 6876:2012 specifications.

**Keywords:** Dental materials, flow, root canal sealer

### Introduction

Achieving success of root canal treatment is dependent not only on the cleaning and shaping of the radicular canals to eradicate microorganisms but also to guarantee a tight seal from any fluids to prevent re-infection and colonization of pathogens in the root space or in the periapical tissues which can be a crucial factor influencing treatment outcome<sup>[1]</sup>. Therefore, the root canal space should be densely filled with biologically compatible material.

Root canal sealers main function is to fill the voids between the core material and dentinal walls and seal the apical foramen, in addition to filling the accessory and lateral canals to improve the mechanical interlocking of endodontic filling material with root dentin<sup>[2]</sup>.

Polydimethylsiloxane has been commonly used in dental practice due to its properties. It has an extremely low surface tension, which provides a high flow rate, limited dimensional change on setting (0.6-0.2%) and it has low water sorption<sup>[3]</sup>.

Silicon-based sealers have been introduced as substitute root canal filling material. Polydimethylsiloxane based sealers have a distinct feature of minor expansion on setting, the material expands 0.2% after setting providing firm adaptation to dentinal walls decreasing the apical leakage<sup>[4]</sup>. Punjabi *et al.*<sup>[5]</sup>. Found this adaptation of silicone sealers to provide higher fracture resistance of treated teeth potentially strengthening it to a level comparable to that of intact teeth.

Roeko Seal (Roeko, Coltene Whaledent, Langenau, Germany) one of the Silicon-based sealers has been tested and showed very promising properties, these include biocompatibility, insolubility, post-setting expansion, and providing a thin film<sup>[3,4]</sup>.

A new sealer, Nano Seal-S (Prevest Den Pro, Digiana, India) is introduced, it is composed of Polydimethylsiloxane matrix and micro-silver in chemical form. Micro-silver particles are distributed equally in the sealer and being in chemical form means it should not cause corrosion or color changes, it is also highly biocompatible preventing further bacterial progression<sup>[6]</sup>.

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AH-Plus (Dentsply Maillefer, Ballaigues, Switzerland) was chosen for comparison as it is considered the 'gold standard' endodontic sealer. It has a long-term dimensional stability and expansion properties as it is an epoxy resin-based sealer [7].

Flow is regarded as a crucially important property of root canal sealers. It is the sealer capability to infiltrate dentinal wall irregularities and fill the accessory canals of the root canal system. When flow increases, the ability of penetration increases. Conversely, there is a risk of extravasation of material to the periapical space if the flow was excessive which can lead to damaged periodontal tissues [8].

This study aim was to assess the flow rate physical property of silicon-based sealers (Roeko Seal, Nano Seal-S) and compare it to a conventional epoxy resin sealer (AH-Plus).

### Material and Methods

Three endodontic sealers were tested in this study: Roeko Seal, Nano Seal-S and AH Plus. (Table 1) Measurement of the flow rate was conducted by the method instructed by the International Organization for Standardization (ISO) specification 6876:2012 third edition [9].

Mixing was done based on the manufacturer's instructions and a volume of 0.05 mL was dispensed using a graduated plastic 1 mL syringe to a glass slab with the dimensions of 40mm x 40mm with a thickness of 5mm (20 g).

After 3 minutes, a second glass slab was positioned on the top of the sealer carefully in the center. A calibrated weight of 100g was then placed on the second glass slab, making a total load mass of 120g. (Fig. 1)

The sealers were left for an additional 7 minutes, and a digital caliper (SEAT tools, Kaohsiung City, Taiwan) was used to measure the diameter of the compressed sealer. (Fig. 2)

To validate the test, two criteria were applied: The highest and lowest diameters difference could not be more than 1.0mm, and the shape of the disc is uniform without irregularities. The test was repeated until these criteria were fulfilled. The mean value of the five measurements was calculated and the final average of three samples (n=3) presented to the nearest millimeter was considered the flow rate of the material (group).

Statistical comparison of the mean values was performed using ANOVA and Tukey tests. Finding were analyzed using SPSS 24.0 software for Windows and a value of  $P < 0.05$  was considered significant.

### Results

Taking into consideration the compressed sealer mean diameter, the finding showed that Roeko Seal exhibited diameters varying from 23.96 to 25.04 mm, Nano Seal-S from 20.54 to 21.52mm, and AH Plus from 23.37 to 23.92. The average of the mean diameters of the sealers Roeko Seal, Nano Seal-S, and AH Plus. were 24.46 mm, 20.91 mm, and 23.62 mm, respectively.

The results of statistical analysis by Tukey test revealed that Roeko Seal and AH Plus had flow values significantly higher than Nano Seal-S sealer ( $P < 0.01$ ). No significant difference was found between Roeko Seal and AH Plus ( $P = 0.164$ ).

### Discussion

The ISO 6876 specifications are the most widely used, it states that sealers should form a diameter of at least 20mm. [9] In this study, all tested sealers shown flow above the recommended minimum values by international standards. RoekoSeal showed the best flow, followed by AH plus and Nano Seal-S showing the least flow barely surpassing the ISO

recommendation. As for homogeneity, AH Plus presented better results than Roeko Seal and Nano Seal-S, showing lower standard deviation values: 0.28, 0.54, and 0.53, respectively. (Table 2)

There are several factors that affect the infiltration of endodontic sealers within root canals. It includes, the dimension of dentations, accessibility to the ramifications, the used obturation technique, and the sealer's flow rate is suggested to be the most important [10].

The high flow rate observed in Roeko Seal and the post setting expansion contributed to its superior sealing ability, De-Deus *et al.* [11] observed that silicon-based sealers presented significantly fewer contaminated samples (15%) compared to other tested sealers.

These results coincide with Gençoglu *et al.* [3] study who found silicon-based sealers to have the best microleakage results. It also showed good adaptation to dentinal walls and better penetration into dentinal tubules under scanning electron microscope according to Leski and Pawlicka [12].

Voids within sealer mass increase the possibility of leakage. Fortunately, Roeko Seal demonstrated the highest quality obturation with the least voids in a Micro-CT 3D analysis by Wolf *et al.* [13].

Conversely, according to Barbizam *et al.* [14], silicon-based sealers were not as effective compared to Grossman's sealer when it comes to filling artificial simulated canals.

In the present study, Nano Seal-S showed the lowest flow rate value; however, it was superior to the minimum requirement by the ISO specification. This means Nano Seal-S will probably penetrate with more difficulty in irregularities of root canal walls than the other tested sealers.

There are no previous flow rate studies about Nano Seal-S, so it is only possible to contrast the results obtained with Nano Seal-S to those obtained with the other sealers.

The sealer chemical composition was reported to be the main factor determining the flow characteristics of sealer. However, Kaplan *et al.* [15] concluded that the final consistency and the setting reaction of sealers can be the main influencers of flow, not the composition.

Our finding can be explained by these findings, as Roeko Seal and Nano Seal-S are both silicon-based sealers, but the flow rate of Roeko Seal was significantly higher than Nano Seal-S. They differ in Nano Seal-S fast setting as it only requires 10-15 minutes to set, compared to 45-50 minutes for Roeko Seal.

Another explanation could be the addition of silver in Nano Seal-S, Seung *et al.* [6] fabricated a modified resin sealer incorporated with silver and found a significant decrease in flow but within standards. According to the same study, silver improved the antibacterial efficacy of the sealer against *E. faecalis*. This means Nano Seal-S could have improved antibacterial properties compared to Roeko Seal which showed no inhibition zones in an agar diffusion study conducted by Aal-Saraj *et al.* [16].

AH plus showed similar flow values to the previous reports. The high flow property of AH Plus can be justified by having epoxy resin in its composition, as it known to improve flow rate [7-9].

It is crucial to emphasize the limitation of the ISO 6876:2012 specifications flow test. Almeida *et al.* [17] found that despite some sealer not complying to the ISO 6876 specification they were able to fill 0.1mm arterial canal. Other factors may also complicate the flow of root canal sealer, including: tapered or curves canals, insertion of gutta-percha points, and the presence of smear layer. [18]

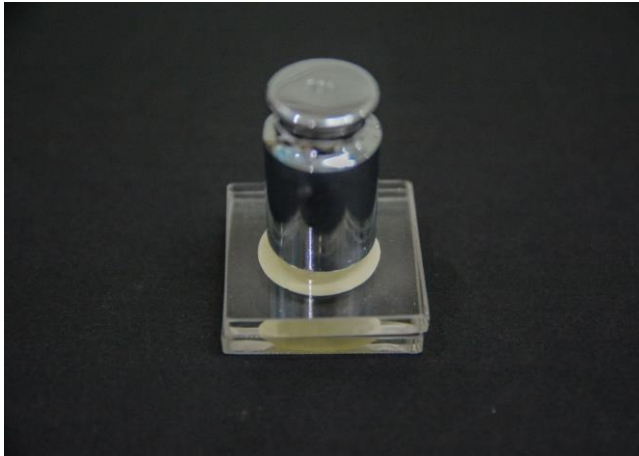
**Table 1:** The tested root canal sealers, their composition and manufacturers.

Sealer	Composition	Manufacturer
Roeko Seal	Polydimethylsiloxane, silicone oil, Parafin, Hexachloride platinum acid, zirconium dioxide.	Roeko, Langenau, Germany
Nano Seal-S	Polydimethylsiloxane, Micro-Silver powder, Silicone Oil, Platinum Catalyst, Zirconium Dioxide, Paraffin Liquid.	Prevest Den Pro, Digiana, India.
AH Plus	AH Plus Epoxy resins, zirconium oxide, iron oxide, calcium tungstate, silicone oil	Dentsply/Maillefer, Konstanz, Germany

**Table 2:** Flow rate of the root canal sealers: Roeko Seal, Nano Seal-S, and AH Plus.

Root canal sealer	Flow rate				
	Sample 1	Sample 2	Sample 3	Mean	Standard Deviation
Roeko Seal	25.04	23.96	24.39	24.46*	0.54
Nano Seal-S	20.54	20.68	21.52	20.91	0.53
AH Plus	23.92	23.58	23.37	23.62*	0.28

\* Means with no statistically significant difference ( $P>0.05$ ).

**Fig 1:** calibrated weight placed on the second glass slab.**Fig 2:** digital caliper used to measure the compressed sealer diameter.

### Conclusion

Considering this study experimental nature and despite the observed differences in the flow values of the tested root canal sealers, all materials were Complied to the ISO 6876:2012 specifications.

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