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Comparison of the Physical Properties of Three Resin-Based Root Canal Sealers: An In-Vitro Study

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A B S T R A C T

Objectives: This in-vitro study aimed to evaluate the physical properties of three resin-based root canal sealers, including BETA-RCS, AH26, and Adseal.

Materials and Methods: Flowability, film-thickness, solubility, and radiopacity of BETA-RCS, AH26, and Adseal sealers were evaluated according to ISO 6876/2012 specifications. Three samples of each sealer were used to test each of the properties.

Results: The results revealed that the flow rate (mm) of BETA-RCS, Adseal, and AH26 were 23.06±1.58, 22.5±4.23, and 21.85±1.71, respectively. Film-thickness values (µm) for BETA-RCS, Adseal, and AH26 sealers were 52.33±2.51, 18.66±0.57, and 52±2, respectively. No significant difference was observed regarding film-thickness between AH26 and BETA-RCS (P>0.05), while Adseal showed significantly lower film-thickness (P<0.05). The highest and lowest solubility were related to BETA-RCS and Adseal, respectively. However, all sealers had acceptable solubility and radiopacity.

Conclusion: The findings of the current study suggested that all three root canal sealers including BETA-RCS, AH26, and Adseal had similar properties based on ISO 6876 standard criteria. As such, they could be viable choices for facilitating effective root canal procedures. Further long-term clinical studies are warranted to assess their performance and success rates in actual endodontic cases.

Keywords: Epoxy Resin-Based Root Canal Sealer; Solubility; Root Canal Filling Material

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INTRODUCTION

Endodontic treatment is aimed at preventing or healing apical periodontitis, which may appear as a result of bacterial infection of the root canal space. Adequate root canal shaping, cleaning, and filling are prerequisites of endodontic treatment. Chemomechanical preparation is of prime importance because of the complex root canal anatomy and microbial biofilm [1]. The primary etiologic factors of apical periodontitis are the necrosis of the pulp tissue and microbial infection [2]. Obturation materials, which are used for root canal therapy, should seal the canal without any leakage in order to eliminate the residual microorganisms or their toxins. Besides, the minimum degradation property is expected from an ideal sealer in order to obtain the lowest gap at the junction of dentin and the sealer [3]. An ideal root canal sealer should have adequate setting time, biocompatibility, dimensional stability, insolubility to tissue fluids, and adhesion to canal walls [4]. long-term success of the root canal filling can be achieved with an ideal sealer along with a proper filling procedure to decrease subsequent microleakage and infection [5].

The requirements cited by the American National Standards Institute/American Dental Association for a sealer include <50µm film thickness, <3% solubility, and <20mm flowability [6]. Commercially available sealers have different chemical properties, including calcium hydroxide-based, resin-based, glass-ionomer-based, silicone-based, zinc-oxide eugenol, and bioceramic-based sealers [7]. AH26 is a Popular sealer because of the flow, working time, low solubility, and the ability to adhere to dentinal walls [8,9]. In this regard, Ashraf et al. [8] have shown that AH26 has a better flow with no difference in terms of film thickness, solubility, and radiopacity compared to ES-A and ES-B. Besides, Lee et al. [4] have reported that Adseal and EndoSeal MTA have clinically acceptable physicochemical properties, while the setting feature of BC and MTA Fillapex do not set completely.

Not all available root canal sealers comply with standards. Therefore, it is critical to determine the physicochemical properties of commercially available endodontic types of cement [10]. When a new endodontic sealer is launched, clinicians may seek information regarding its physicochemical properties, biocompatibility, and root canal sealing ability [5]. This in vitro study was undertaken to assess the solubility, film thickness, flow, and radiopacity of three resin-based root canal sealers: BETA RCS, AH26, and Adseal.

MATERIALS AND METHODS

The study was conducted on experimental root canal sealers: AH26 (Dentsply, De Trey, Konstanz, Germany), Adseal (Adseal, Meta biomed, Cheongju, South Korea), and BETA RCS (Beta Dent, Tehran, Iran). All materials were mixed according to the manufacturer's instructions. Film thickness, solubility, flow, and radiopacity of the tested sealers were determined as outlined in the International Standard ISO6876/2012 for dental root canal sealing materials [11].

Film thickness

Two 5mm thick glasses were used and thickness was determined using a digital caliper. The sealer (0.5mL) was placed on the center of one glass plate, and the other plate was located centrally to the sealer. They were mixed for 180 seconds, and a 150N load was applied vertically on the center of the plates. After 10 minutes, the load was removed and the total thickness of the two plates was measured using a digital caliper. The difference between the two measurements was indicative of the film thickness of the materials. The sample size for each studied sealer was three (N=3).

Solubility

A modified ISO 6876 specification was used to evaluate the solubility of the sealers. The specimens were molded based on ISO specification using Teflon ring molds (diameter: 20mm; height: 1.5mm). For each material, three samples were fabricated. Before setting, a nylon thread was inserted into the sealers to help the samples hung and immerse in distilled water throughout the experiment. Following the setting, samples were taken out from the molds, and the remnants of the material particles were removed by a brush. Samples were weighed, and cellophane was filmed over the top of the glassware. Subsequently, the samples that were hung with a nylon thread were inserted into the glassware containing deionized distilled water without the walls being touched. The containers were then stored in an incubator at 37°C and 9% relative humidity for 24 hours. Afterward, the samples were removed and gently washed with distilled water, dried with filter paper, placed in an oven for 24 hours, and weighed again. The experiment was repeated three times for each sealer (N=3). Solubility was measured as weight loss (initial mass – final mass) and expressed as the percentage of the original mass.

Flow

As per the requirements of the American National Standards Institute/American Dental Association, a homogenous mixture of the sealer (0.5mL) was placed on a polished glass plate. Three minutes later, another plate with a mass of 20±2g was placed, and 100N was centrally loaded on the top of the plate. Ten minutes after the mixing was initiated, the load was removed and the averages of

maximum and minimum diameters of the compressed disc were measured with a digital caliper. If the difference between both diameters was not more than 1mm, the results were recorded. The experiment was repeated three times for each sealer (N=3).

Radiopacity

Three cylindrical samples from each sealer were prepared (N=3). A glass plate was used to ensure that the excess sealer was removed and the top surface was flat. Metallic rings (10mm internal diameter and 1mm thickness) were kept at 37°C and 95% relative humidity until the blocks of cement were completely set. The thickness of each sealer was checked with a digital caliper. The images of the specimens were taken on occlusal films along with an aluminum step wedge. The dental X-ray machine was used with exposure parameters set at 70kVp, 10mA, 0.3 seconds, and a focus-film distance of 30cm. All films were processed in an automatic developing machine [12]. Each specimen and each step were measured 10 times to obtain the final density value of each sealer.

Statistical analysis

Statistical analysis was performed using the Kruskal-Wallis test to evaluate the differences between sealers. For multiple comparisons, the Mann-Whitney Wilcoxon test was used. Bonferroni correction was applied to assess the significance level. The presence of normal distribution was confirmed in a pilot analysis.

RESULTS

As Table 1 indicates, the flow rate of all studied sealers was higher than 17mm, which is within the standard range. There were no significant differences between the flow rates of the three sealers (P>0.05). Also, the film thickness of AH26 and BETA RCS was approximately 50µm, and for Adseal, it was smaller than 50 µm. No significant difference was found in film thickness between AH26 and BETA RCS sealers (P>0.05), while Adseal had a significantly lower film thickness than the other two sealers (P<0.05).

The non-parametric findings of the studied sealers are presented in Table 2.

Table 1. Flow and film thickness of the studied sealers

Sealer		Mean±SD	Min	Max
Adseal	**Flow**(mm)	22.5±4.23	17.9	26.24
	Film thickness (µm)	18.66±0.57	18	19
BETA RCS	**Flow**(mm)	23.06±1.58	21.30	24.37
	Film thickness (µm)	52.33±2.51	50	55
AH26	**Flow**(mm)	21.85±1.71	19.94	55
	Film thickness (µm)	52±2	50	54

SD: standard deviation; Min: minimum; Max: maximum

Table 2. Comparison of the studied sealers using Mann-Whitney U test

	Sealer		Z	P
Flow	AH26	ADSEAL	-0.65	0.51
	AH26	BETA RCS	-1.09	0.27
	ADSEAL	BETA RCS	-0.21	0.82
Film thickness	AH26	ADSEAL	-1.99	0.04
	AH26	BETA RCS	-0.22	0.82
	ADSEAL	BETA RCS	-1.99	0.04

Solubility and radiopacity of the studied sealers are reported in Table 3. As it can be seen, the highest solubility was related to BETA RCS (0.6%) and the lowest to Adseal (0.07%)., however, all the sealers had an acceptable solubility and radiopacity (Table 3).

Table 3. Solubility and radiopacity of the studied sealers

Sealer	Solubility (%)	Radiopacity *
Adseal	0.07	based on ISO 6876
BETA RCS	0.6	based on ISO 6876
AH26	0.1	based on ISO 6876

* Compared to 3mm Aluminum

DISCUSSION

The physical, chemical, and biological properties of root canal sealers are significant for their biocompatibility and success of treatment. Various root canal sealers have been launched to the market with variable properties and prices. Thus, one needs to

consider the physical and economical characteristics when selecting a sealer.

According to the findings of the current study, the flow rate of all tested sealers was higher than 17mm, which is within the standard range (ISO 6876/2012). This result is different from the study of Razmi et al. [13], where a flow rate of 15.6mm for AH26 was reported. Although this value is unacceptable according to the latest ISO standards, it is per BS EN ISO 6876/2001 standard. In the present study, the solubility of all tested sealers was smaller than 3%. The results of solubility were similar to those reported by Razmi et al. [13]. Also, the same physical properties and chemical characterization were reported by Ashraf et al. [8]. The film thicknesses of AH26 and BETA RCS were approximately similar (nearly 50µm). However, the film thickness of Adseal was significantly lower than 50µm. Milani et al. [14] also showed that the film thickness of AH26 was larger than 50µm. Moreover, Razmi et al. [13] reported an acceptable ISO range (24µm) for the film thickness of AH26. Indeed, one may hypothesize that the higher range of film thickness in the study of Razmi et al. [13] compared to previous investigations, might be due to the accuracies of the digital calipers employed in different studies.

Dimensional changes represent the shrinkage or expansion of the material after setting. Song et al. [5] demonstrated that Adseal had the highest dimensional change amongst the subjects, which might be related to high water absorption after polymerization. Evaluation of the solubility and the dimensional change of the sealers using micro-computed tomographic scanning has been suggested to provide more reliable results [15]. Additionally, Hidalgo et al. [10] reported that Adseal had acceptable solubility, radiopacity, and flow rate, complying with the ISO 6876/2012 standard. On the other hand, our findings indicated that AH26 had acceptable solubility as also seen in the study by Azadi et al. [9], where AH26, Topseal, 2-Seal, Acroseal, and Roeko Seal Automix sealers conformed with the defined standards in terms of solubility.

Adequate flow is an important characteristic of root canal sealers to seal apical foramen and spaces between the gutta-percha cone and the dentinal wall. However, a higher flow increases the risk of sealer extrusion into periodontal tissue [16]. Song et al. [5] showed that Adseal had a significantly higher flow rate, while no difference was reported between AHplus, Adseal, and Acroseal sealers by Marciano et al. [6]. The findings of the present study revealed a similar flow rate between BETA RCS, Adseal, and AH26 sealers. As mentioned earlier, an acceptable flow and film thickness are essential for sealer application in root canals. In the current study, the highest flow rate belonged to Beta RCS (23.06mm) and the lowest to AH26 (21.85mm). However, all the sealers had an acceptable flow rate and radiopacity. All sealers had acceptable results in agreement with a previous report by Ashraf et al. [8] and ISO 6876/2012 standard criteria. According to ISO standards, the minimal radiopacity of a root canal sealer has to be equivalent to 3mm of aluminum. Lastly, Song et al. [5] reported that Adseal had acceptable radiopacity, which complies with our findings and those of previous reports.

The present study focused on some aspects of an appropriate root canal sealer. However, other tests such as setting time, X-ray diffraction analysis, and Fourier-transform infrared spectroscopic analysis are suggested for future research to evaluate the entire physical properties of available root canal sealers.

CONCLUSION

Within the limitations of the current study, it can be concluded that BETA-RCS, AH26, and Adseal sealers displayed acceptable properties based on ISO 6876/2012 standard criteria. Beta RSC showed acceptable results similar to the other commercially available ADseal and AH26 sealers.

CONFLICT OF INTEREST STATEMENT

None declared.

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