

## PHYSICAL PROPERTIES OF AN ENDODONTIC SEALER CONTAINING CALCIUM SILICATE

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### ABSTRACT

**Background:** The main objective of endodontic therapy is to adequately clean and seal the root canal system. According to Grossman et al, idealistically root canal sealers must be dimensionally stable, produce a tight seal after setting and exhibit an adequate setting time. They should also be insoluble and provide adequate adhesion with the root canal walls.

Therefore, the present study was conducted to evaluate some physio-chemical characteristics of novel poly-dimethyl-siloxane gutta-percha calcium-silicate containing sealer (GuttaFlow bioseal) in contrast with a commercially available zinc oxide and eugenol sealer (ZnO/E).

**Materials and Methods:** Flow, setting time, working time, film thickness and dimensional changes were evaluated for Guttaflow bioseal and contrasted to a commercially available zinc oxide and eugenol sealer (ZnO/E) following the ADA specification number 57.

**Results:** In Flow, setting time and working time tests; ZnO/E sealer showed higher mean values than that of GuttaFlow bioseal with an extremely significant difference, while film thickness of GuttaFlow bioseal was significantly higher than that of ZnO/E sealer. Results of dimensional changes test showed a significant difference between both sealers, where GuttaFlow bioseal exhibited a positive mean value, while ZnO/E exhibited a negative mean value.

**Conclusions:** It can be concluded that; GuttaFlow bioseal might be an acceptable substitute to zinc oxide and eugenol sealer. New researches in-vivo and in-vitro should be postulated for better interpretation of the physical properties of endodontic sealers.

**KEYWORDS:** polydimethylsiloxane-guttapercha sealer calcium silicate-containing sealer, GuttaFlow bioseal, flow testing, setting time, working time, film thickness, dimensional changes.

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## INTRODUCTION

Endodontic treatment is essential in order to adequately clean and efficiently seal the root canal system. 3D sealing is considered crucial in the obturation of root canals as to avoid any microbial leakage, consequently, preventing re-infection and creating an encouraging atmosphere for the repair of periapical tissues<sup>(1-3)</sup>. Endodontic fillings comprise a monoblock material composed of a core obturating material combined with a sealer<sup>(4)</sup>.

The reason behind incorporation of sealers in the obturation of the root canals is to fill the microspaces between the canal walls and the core material, in addition to the accessory and lateral canals thus creating a hermetic antibacterial seal<sup>(5)</sup>.

According to Grossman et al<sup>(6)</sup>, idealistically sealers must be dimensionally stable; creating a hermetic seal when set and they should exhibit a slow setting time thus ensuring a sufficient working time. Also, they must be insoluble in tissue fluids and they must be adequately adhered to the canal walls.

A large number of endodontic sealers are commercially available. However, zinc oxide and eugenol root canal sealers are still representing the golden standard in endodontics; due to their long history of success, in addition to their positive qualities that outweighed their limitations<sup>(7,8)</sup>.

Recently, GuttaFlow bioseal has been introduced, which combines the required properties of

both; sealer and gutta-percha. Manufacturers claim that it combines all the advantages of thermo-plasticized gutta percha systems<sup>(9)</sup>, in addition to its excellent sealing ability and adaptability to the root canal walls, which is attributed to its increased flowability and the fact that it expands by 0.2% when it sets<sup>(3,9,10)</sup>.

It is composed of gutta-percha powder, polydimethylsiloxane and silver particles<sup>(11)</sup>. In addition to some bioactive substances, which initiate the biological tissues to release natural repair products that help in the regeneration of periapical tissues<sup>(2,12)</sup>.

Accordingly, the present study aimed to assess some physical properties of novel poly-di-methylsiloxane gutta-percha calcium-silicate containing sealer (GuttaFlow bioseal) and contrast it with that of a commercially available zinc oxide and eugenol sealer (Zical).

## MATERIALS AND METHODS

Materials used were; GuttaFlow bioseal (Coltène/ Whaledent Inc., Switzerland) and a Zinc-oxide and eugenol based root canal sealer (Zical, Prevest Denpro Limited India).

Flow, setting time, working time, film thickness and dimensional changes of the two sealers were evaluated and contrasted following the American National Standards Institute/American Dental Association (ANSI/ADA) specification number 57 for endodontic sealing materials<sup>(6)</sup>.

TABLE (1): Tested sealers and their; commercial name, manufacturer, composition and Lot no of

Commercial name	Manufacturer	Composition	Lot #
GuttaFlow bioseal	Coltene/Whaledent Inc. Switzerland.	Gutta-percha powder particles, polydimethylsiloxane, platinum catalyst, zirconium dioxide, calcium salicylate, nano-silver particles, paraffin, coloring, bioactive glass ceramic*	H84160
Zical	Prevest Denpro Limited India.	Powder bottle: Zinc oxide, bismuth subcarbonate, barium sulphate, sodium borate, iodoform and hydrogenated resin Liquid bottle: Eugenol oil.	1521802

**Flow**

Directly after mixing of the two tested sealers, a plastic disposable syringe was used to aspirate the sealers; a volume of zero point five milliliter of each sealer was aspirated on the center of a glass slab. At one hundred and eighty seconds ( $\pm 5$  s) from the start of mixing, another glass slab was adjusted on top of each sealer, then a custom made load applying device giving a total mass of one hundred and twenty grams. The weight was then removed after ten minutes from the beginning of the mixing. Averages of the major and minor diameters of the samples were recorded using a digital caliper.

The means of seven values expressed to the nearest mm of the two sealers were detected and considered as the flow of each sealer.

**Setting time**

Split molds were fabricated; having an internal diameter of ten millimeters and a uniform thickness of two millimeters. Molds were adjusted on top of two glass plates, each material of the two tested sealers was loaded into them using a stainless steel spatula. The whole assemblies were then transferred to an incubator at 37 °C. After 120 seconds from the beginning of the mixing, 100 gm cylindrically shaped needle having a flat end indenters with dimensions two millimeters in diameter and five millimeter in length were vertically adjusted on the surface of each sample for 5 seconds. Any indentation on the surface would indicate that the material was not set yet. The procedure was repeated at frequent intervals (60 seconds), until no new marks were detected.

Setting time was measured as the time interval from the start of mixing and the instant at which new no marks were observed on the surface of the sealers.

Seven values not differing by more than  $\pm 5$  percent were obtained for each tested sealer. The mean of these seven values was considered to be the setting time.

**Working time**

Directly after mixing, using a 3 ml graduated disposable syringe, a volume of 'zero point zero five milliliter'  $\pm 0.005$  ml of the mixed sealer was aspirated on the top of a glass slab having dimensions of 40 x 40 millimeter and a uniform thickness of 5 millimeter. After three minutes, a second glass slab weighed 20 gm was adjusted on top of the sealer then a 100 gm custom made weight was adjusted on the two slabs. Ten minutes from the beginning of the mixing, the minor and major diameters of the disc were measured. The previous procedure was repeated with freshly mixed sealers at escalating time intervals from the start of the mixing procedure until the diameter had decreased by ten percent of the value obtained from the flow test. The mean of seven values was detected and considered the working time of each sealer.

**Film thickness**

2 transparent, rectangular glass slabs with dimensions 10x20 millimeters and a uniform thickness of 6 millimeters were used.

A specially designed loading device was constructed; it consisted of a tray connected to a base by two rods 7 cm each, a movable piston having a circular upper end that can accept loads and a rectangular lower end of 10 x 20 mm that passes through the tray. A load of 14.6 kg was placed on the upper end of the piston which weighed 402 gm so that the total force applied by the assembly would be 147.3 N.

A metallic base was constructed with a groove of dimensions 10.8 mm width, 20.6 mm length and 8.0 mm depth to accommodate the two glass plates when assembled together, protruding outside the groove by at least 4 mm.

The piston, carrying the load, fits the groove within the metallic base. One glass slab was adjusted at the depth of the groove and a zero point five milliliters of the newly mixed sealer was aspirated

on the middle using a plastic syringe, immediately the sealer was covered by the second glass plate. 3 minutes from the beginning of mixing, the load was vertically adjusted on the glass slab. The load was removed after 7 minutes and the thickness of the two glass slabs and the sealer between them was detected by the use of a digital caliper. The film thickness was calculated as the difference of thickness between the two glass slabs with and without the sealer. The mean of seven values was detected and considered the film thickness of each sealer.

### Dimensional Changes

Cylindrical Teflon molds with dimensions of 12 mm height and 6 mm internal diameter were adjusted on a glass slab enclosed by a cellophane sheet. The molds were loaded with the mixed sealers until a slight excess of the sealers were observed at the top, then another glass slab wrapped in cellophane sheet was adjusted on the sealers. The mold and the plates were held together tightly using a C-clamp. All samples were stored in chamber at 37°C for three times more than the previously detected setting time of the sealer. Smooth surfaces were obtained by grinding the flat ends of the molds using six hundreds grit wet sandpaper and then discs were removed from the molds. The distance between the two flat ends of each sample was detected using a digital caliper. The samples were stored in distilled water at thirty seven °C for thirty days. They were then dried and their lengths were detected again.

The difference in length was obtained as a percentage of the original length. Mean of seven values was calculated and considered as the dimensional changes of each sealer.

### Statistical analysis

Statistical analysis was then performed using a commercially available software program (SPSS 18; SPSS, Chicago, IL, USA). Data were then expressed as means, standard deviation and standard error of means. Significance of the difference between both groups was compared using the independent t-test.

The level of significance was set at  $P < 0.05$ .

## RESULTS

### Flow

According to the flow test higher mean values were demonstrated with ZnO/E than that of GuttaFlow bioseal, with an extremely significant difference ( $p=0.00$ ) (Table 2).

### Setting time

According to the setting time test higher mean values were recorded with ZnO/E, with an extremely significant difference ( $p=0.00$ ) (Table 2).

### Working time

According to the working time test higher mean values were recorded with ZnO/E, with an extremely significant difference ( $p=0.00$ ) (Table 3).

TABLE (2) Mean values of flow (mm) and setting time (min) of GuttaFlow bioseal and ZnO/E using independent t test.

	Flow			Setting Time		
	Mean	Stand. Deviation	P	Mean	Stand. Deviation	P
GuttaFlow bioseal	18.88	.89	0.000*	61.7686	2.8275	0.000*
ZnO/E	24.09	.96		1226.2857	1.7043	

CI=95% confidence interval, Significance level  $P < 0.05$ , \*significant

TABLE (3) Mean values of working time (min) and film thickness (mm) of GuttaFlow bioseal and ZnO/E using independent t test.

	Working Time			Film Thickness		
	Mean	Stand. Deviation	P	Mean	Stand. Deviation	P
GuttaFlow bioseal	18.29	1.38	0.000*	0.0580	0.0121	0.000*
ZnO/E	31.83	2.39		1226.2857	.0007	

CI=95% confidence interval, Significance level  $P < 0.05$ , \*significant

**Film thickness**

According to the film thickness test GuttaFlow bioseal recorded higher mean values than ZnO/E with an extremely significant difference ( $p=0.00$ ) (Table 3)

**Dimensional changes**

Regarding difference, a positive mean value was recorded with GuttaFlow bioseal, while ZnO/E recorded a negative mean value, with a significant difference ( $p=0.000$ ). A greater percent change was recorded in GuttaFlow bioseal, with a statistically significant difference ( $p=0.000$ ) (Table 4).

TABLE (4) Mean values of dimensional changes (difference and percent) of GuttaFlow bioseal and ZnO/E using independent t test.

Time	Groups	Mean	Stand. Deviation	P
Difference	GuttaFlow bioseal	0.2119	0.0048	0.000*
	ZnO/E	-0.0611	0.0025	
Percent	GuttaFlow bioseal	2.6377	0.0530	0.000*
	ZnO/E	0.7480	0.0315	

CI=95% confidence interval, Significance level  $P < 0.05$ , \*significant

**DISCUSSION**

Nowadays, with the development of new endodontic sealers that are commercialized by manufacturers, it is essential for the clinicians to realize their physicochemical properties. Therefore, laboratory studies on these properties are conducted for better perception of their handling characteristics and clinical behavior. A newly introduced poly-di-methyl-siloxane gutta-percha calcium-silicate containing sealer (GuttaFlow bioseal) has been introduced which combines the properties of both sealer and gutta-percha.

A commercially available zinc oxide and eugenol (ZnO/E) root canal sealer was used, as these sealers still represent the golden standard in endodontics<sup>(7,8)</sup>.

Flow is influenced by particles size, temperature, rate of insertion, film thickness, internal diameter of the canal, powder/liquid ratio and shear rate<sup>(14)</sup>.

ZnO/E demonstrated flow mean value greater than that of GuttaFlow bioseal. The lower flow mean value of GuttaFlow bioseal might be due to the reaction between the poly-di-methyl-siloxane, silicone oil and paraffin present in their composition<sup>(2)</sup>, this was in accordance with Camargo et al in 2017<sup>(2)</sup>. Also, Saygili et al in 2017<sup>(12)</sup> and Yigit et al in 2012<sup>(14)</sup>, stated that thixotropic materials exhibit low viscosity when moved at a high speed and high viscosity when moved at a slow speed. This might also explain the decreased flow of GuttaFlow bioseal.

Setting time is considered as the time needed for the sealer to attain its ultimate properties. It is affected by composition of the sealer, the particles size, the temperature and the relative humidity <sup>(2, 15)</sup>.

In the present study, higher mean value of setting time was recorded with ZnO/E, which might have been due to the influence of humidity conditions, this was in agreement with Saygili et al in 2017 <sup>(12)</sup>.

In addition, Marín-Bauza et al in 2012 <sup>(16)</sup>, stated that the radiopacifying agents incorporated to promote the radiopacity of zinc oxide and eugenol can be in charge for the longer setting time, since these radiopacifying agents exhibit low solubility in water.

While GuttaFlow bioseal showed lower mean value of setting time than that of ZnO/E, this can be attributed to the polydimethylsiloxane polymers, which encourage the polymerization reaction between the silicone oils, polydimethylsiloxane and paraffin catalyzed by platinum. It also comprises gutta-percha, silver nanoparticles and calcium silicate in its composition, they all act as fillers instead of participating in the polymerization reaction, this might result in reduced setting time, this was in accordance with Camargo et al in 2017 <sup>(2)</sup>.

Working time is considered to be the time during which the sealers can be easily manipulated without negatively affecting their properties.

ZnO/E showed higher mean value of working time than that of GuttaFlow bioseal, there is no set working time for sealers, however clinically it should be sufficient to allow complete obturation of the root canals <sup>(17)</sup>.

The size and shape of the fillers, the viscosity of the unset material and its rate of setting are factors that influence the film thickness of root canal sealers<sup>(18)</sup>.

GuttaFlow bioseal demonstrated higher mean value of film thickness than that of ZnO/E, which might be attributed to the thixotropic property of

GuttaFlow bioseal, which was discussed before <sup>(12)</sup>.

Dimensional changes studies are important to show the potential of the sealers to provide the desired hermetic sealing and the bonding of the core materials to the dentinal walls <sup>(14)</sup>.

Results showed that negative mean value was recorded with ZnO/E, which can be explained by Versiani et al in 2016<sup>(19)</sup>, who stated that the amount of degradation of zinc oxide and eugenol based root canal sealers exceeds the amount of water absorption after its setting as a result of the leach out process of the unreacted and excess eugenol, in addition to the hydrolysis of set zinc eugenolate matrix, which might had affected its dimensional stability.

While positive mean value was recorded with GuttaFlow bioseal, this might be explained by the water adsorbed to the close and rigid hydrogen bonded structure resulted from the chemical reaction occurred between bisphenol A and resins. This was in agreement with Camargo et al in 2017 <sup>(2)</sup>.

Also Camargo et a. in 2017 <sup>(2)</sup>,stated that large size pores results in a more opened molecular structure, consequently more water absorption. Since, gutta percha is one of the constituents of silicone-based sealers, which might increase the size of the polymer pores. The hygroscopic capability of the calcium silicate present in GuttaFlow bioseal might result in the high amount of water retained between the chains of this polymer.

## CONCLUSIONS

According to the implied methodology and the results conducted in the present study, it might be concluded that; GuttaFlow bioseal can be considered an acceptable substitute to zinc oxide and eugenol sealer. New researches should be postulated for more precise analysis of the properties of marketed endodontic sealers and to give more support and knowledge to researchers and clinicians attempting to develop an ideal sealer.

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