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COMPARATIVE EVALUATION OF CONTACT ANGLES OF ROOT CANAL SEALERS TO *GUTTA PERCHA*- AN *IN-VITRO* STUDY

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ABSTRACT: Adhesion of endodontic sealers to Dentine and *Gutta percha* (GP) provides an understanding of the interactions between the root canal wall and the core material. The interaction of Bioceramic sealers has been studied previously but the wetability to *Gutta percha* has rarely been evaluated. Hence, the present in-vitro study was designed to evaluate and compare the wetability of five different root canal sealers with GP by measuring the sealers' static contact angles (SCA). Hundred flat and smooth samples of GP were prepared and randomly divided into five groups (n=20) based on the sealer used to wet the surface of GP. Group 1: AH Plus, Group 2: Gutta Flow, Group3: Calpex, Group 4: MTA Fill apex, Group 5: Endosequence BC Sealer. Controlled (0.1 ml) volume droplets of each sealer were placed onto the flat GP surfaces using a sessile drop method, and static contact angles were measured using a KRUSS Goniometer. The mean values of all the samples were calculated, and the data were statistically analyzed using One-way ANOVA and Post hoc Tukey's test for multiple comparisons. The significance level was set as $P<0.05$. Under the conditions of this *in-vitro* study group 4 showed the least mean CA of 45.14 ± 5.3 followed by group 5 with the mean CA of 46.86 ± 4.2. Lesser CA signifies greater wetting ability and vice-versa. The analysis revealed a statistically significant difference ($p<0.05$). Henceforth, Bioceramic sealers exhibit a superior wetting ability to GP compared with the other sealers tested in the study.

INTRODUCTION: The success of endodontic therapy depends on thorough debridement of root canal space, followed by a three-dimensional obturation [1]. An adequate root canal filling combines solid filling material, such as *Gutta percha,* and a root canal sealer [2].

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The bond between the filling material and the root canal sealer is vital in achieving a fluid-tight seal, thereby sealing the irregularities and complex anatomies of the root canal system. They also act as an intermediary phase between the root canal dentin and the core gutta-percha, the adhesion between these interfaces is critical for the success of endodontic therapy [3, 4, 5].

This adhesion process requires an adequate wetting and optimal flow of the sealers to both the dentin as well as *Gutta percha* (GP), thus resulting in either chemical or micromechanical bond providing greater sealing ability and reducing the risk of root canal microleakage and maintaining a cohesive filling mass [2, 6]. Different types of root canal sealers have been introduced in endodontics and have been consistently used in research to improvise the physical and mechanical properties [7, 8].

These include silicon based sealers, epoxy resin based and bioceramic sealers. Silicon based sealers are biocompatible with low water sorption and potential to form Monoblock, the thus reinforcing the root canal. The Epoxy resin based sealers have a tendency to adhere to dentin, have low water solubility while MTA based sealers have the predilection towards mineralization along with all the viable properties of conventional sealers [9]. Noneugenol-based Calcium hydroxide-containing polymeric root canal sealers have been found to induce biological sealing with calcified tissue deposition over the apical foramina [10]. Bioceramic-based root canal sealers were introduced into endodontics thirty years ago since then, they have evolved to gain popularity owing to their promising results. Bioceramic materials include alumina, zirconia, bioactive glass, glass ceramics, hydroxyapatite, and calcium phosphates [11]. They have excellent physico – chemical and biological properties wherein they interact well with the surrounding tissue to encourage the growth of durable tissues [12-15].

In-vitro testing of the physical properties of root canal sealers is a standard procedure to justify their use and beneficence in clinical endodontic practice [16]. Several studies have investigated the adhesion of different types of root canal sealers to root dentin and *Gutta percha*. Mechanical tests like shear bond tests, push-out bond tests, micro push-out bond tests, and microleakage tests were conducted for evaluation of the adhesion and sealing properties of root canal filling materials. Wettability is the property of a liquid to maintain contact with a solid surface resulting from intermolecular interactions when the two are brought together. This property can be analyzed by measuring the static contact angle (SCA) between the liquid and the solid surface. Static contact angles are the most measured wettability values. They offer a quick, Easy and quantitative measurement of wettability [17]. Contact angle (SCA) is an angle of intersection between a solid and liquid surface which can be measured from the solid surface through the liquid to the liquid/vapor tangent line originating at the terminus of the liquid/solid interface. High contact angle values indicate poor wetting, whereas low contact angle values indicate better wetting [18]. Hence this property can be utilized to evaluate the adhesion potential of the endodontic sealers to *Gutta percha*. The wetting behavior of endodontic sealers such as AH Plus, Gutta flow, Calcium hydroxide, and MTA-based sealers on Gutta percha (CA with GP) have been documented. However, as the wetting characteristics of Bioceramic sealers to GP were rarely reported. As no study has compared the wettability of these five types of endodontic sealers to gutta-percha, the present study was designed to evaluate and compare the wettability of five different types of root canal sealers with GP by measuring the static contact angles (SCA) of the sealers.

MATERIALS AND METHODS:

Specimen Preparation: A pilot study was done to determine the sample size, revealing a sample size of 20 per group for statistical significance. Hundred flat GP surface samples were prepared by dispensing the Thermo plasticized gutta-percha on a clean glass plate using Calamus Obturation System (DENTSPLY Tulsa Dental Specialties, Tulsa, Okla, USA). The preset values of temperature (180°C) and flow rate (60%) were used. The gutta-percha cartridge was heated to the desired temperature. On reaching the target temperature, the activation cuff of the handpiece was pressed, and gutta-percha was extruded on the glass slab. It was further pressed by another clean glass slab to prepare gutta-percha flat smooth surfaces. All the samples were immersed in 5.25% Sodium hypochlorite (NaOCl) solution (Sigma-Aldrich, St. Louis, Missouri, United States) for 1 minute and then washed with 1ml of distilled water, followed by drying with nitrogen gas [19].

Sample Grouping: The samples were randomly divided into five study groups (n=20) based on the sealer used for wetting the surface of GP.Group1 (AH Plus, Dentsply DeTrey GmbH, Konstanz, Germany), Group 2 (Gutta Flow, Coltène/ Whale dent AG, Switzerland), Group 3 (Calpex, Prevest Denpro Limited, Bari Brahmana, Jammu, India), Group 4 (MTA Fillapex, Angelus, Londrina, Brazil), Group 5 (Endosequence BC Sealer, Brasseler USA, Savannah, GA, USA).

Measuring the Static Contact Angles of the Samples in the Study Groups: All the root canal sealers were dispensed before the respective contact angle measurements and mixed according to manufacturer's instructions. The SCA's of the sealers were measured with a KRUSS Goniometer (Kruss- GmdH, Germany; model no. –IL4201). The samples were positioned on a flat glass surface on the platform of the measuring device. Controlled (0.1 ml) volume droplets of each sealer were placed onto ten flat GP surfaces using a sessile drop method [20]. Each sample was imaged individually, and each sample's CA was measured using Data Physics Easy Drop software attached to the goniometer. In each sample, one drop of sealer was dispensed, and two measurements, one from the right side and the other from the left side, were recorded. The height (h) and width of the base (b) of each droplet was measured with the device. The measuring units were used to calculate the contact angle with the formula a=2 arc cos 2 h/b [21] (**Fig. 1).**

FIG. 1: IMAGE SHOWING THE MEASURING DEVICE WITH THE ATTACHMENTS - MICROPIPETTE, FLAT GLASS PLATE, *GUTTA-PERCHA* SURFACE, PRESSURE GAUGE, PHOTOGRAPHIC CAMERA, LIGHT SOURCE

Data Presentation and Analysis: The main outcome variable in this study was the static contact angles of the sealers to the surface of *Gutta percha*. The mean values of the two measurements for each drop and mean values of the twenty samples for each sealer were calculated. The data was statistically analyzed using One-way ANOVA and Post hoc Tukey's test for multiple comparisons. The significant level was set as P<0.05.

RESULTS:

Overall Observations: The analysis revealed a statistically significant difference (p<0.05) in the mean CA's of the different groups tested. Group 4 (MTA Fillapex) exhibited least CA amongst all the groups, followed by Group 5 (Endosequence BC Sealer). The CA of Groups 4 and 5 did not exhibit a statistically significant difference.

Group 1 (AH plus) exhibited the highest CA, signifying the least wettability. Comparison of Mean CA's of Groups 1-5 was done using ANOVA (**Table 1)**, and inter-group comparisons were done using Post Hoc Tukey test (**Table 2).** The CA's of the representative sample of Groups 1-5 are depicted in **Fig. 2.**

TABLE 1: COMPARISON OF MEAN CONTACT ANGLE OF GROUPS 1 – 5 USING ANOVA

Comparison of Mean Contact Angle of Groups 1 – 5							
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		ANOVA
					Lower Bound	Upper Bound	
Group 1	20	92.8750	3.15783	.99859	90.6160	95.1340	F = 202.929
Group 2	20	78.1200	3.28907	1.04010	75.7671	80.4729	p = 0.000
Group 3	20	65.4450	5.97022	1.88795	61.1742	69.7158	
Group 4	20	45.1400	5.34934	1.69161	41.3133	48.9667	
Group 5	20	46.8650	4.22332	1.33553	43.8438	49.8862	

TABLE 2: POST HOC TUKEY TEST FOR INTERGROUP COMPARISON

Post Hoc Tukey HSD					
(I) Group	(J) Group	Mean Difference (I-J)	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
Group 1	Group 2	14.75500*	.000	8.9907	20.5193
	Group 3	27.43000*	.000	21.6657	33.1943
	Group 4	47.73500*	.000	41.9707	53.4993
	Group 5	46.01000*	.000	40.2457	51.7743
Group 2	Group 1	-14.75500*	.000	-20.5193	-8.9907
	Group 3	12.67500*	.000	6.9107	18.4393
	Group 4	32.98000*	.000	27.2157	38.7443
	Group 5	31.25500*	.000	25.4907	37.0193
Group 3	Group 1	-27.43000*	.000	-33.1943	-21.6657
	Group 2	-12.67500*	.000	-18.4393	-6.9107
	Group 4	20.30500*	.000	14.5407	26.0693
	Group 5	18.58000*	.000	12.8157	24.3443
Group 4	Group 1	-47.73500*	.000	-53.4993	-41.9707
	Group 2	-32.98000*	.000	-38.7443	-27.2157
	Group 3	-20.30500*	.000	-26.0693	-14.5407
	Group 5	-1.72500	.913	-7.4893	4.0393
Group 5	Group 1	-46.01000*	.000	-51.7743	-40.2457
	Group 2	-31.25500*	.000	-37.0193	-25.4907
	Group 3	-18.58000*	.000	-24.3443	-12.8157
	Group 4	1.72500	.913	-4.0393	7.4893

*. The mean difference is significant at the 0.05 level.

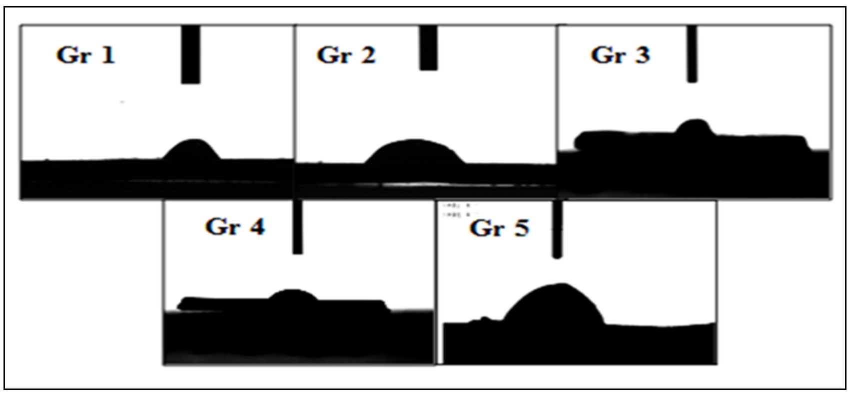
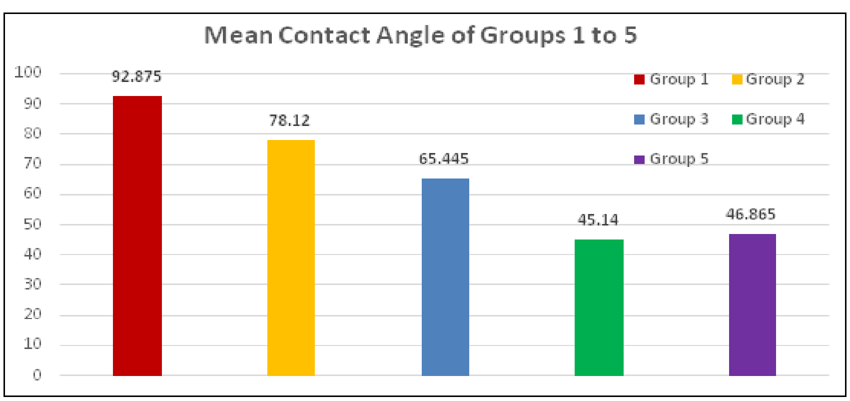


FIG. 2: REPRESENTATIVE IMAGES OF THE DROPLET MENISCUS OF EACH SEALER ON GUTTA-PERCHA (GROUP1-5)

Specific Observations: Table 1 and Graph 1 represent the mean CA of Groups 1 to 5. Group 4 exhibited a mean CA of 45.14 ± 5.3, which was the least amongst all the groups followed by Group 5 with CA of 46.86±4.2, Group 3 with 65.44±5.9, Group 2 with 78.12±3.28 and the highest CA was exhibited by Group 1 with a mean CA of 92.87±3.1.



GRAPH: 1 MEAN CONTACT ANGLES OF GROUPS 1 TO 5

Post hoc analysis represented in (**Table 2)** revealed that Group 4 had the least CA compared to Groups 1, 2 3, which was statistically significant. (p=0.000). The CA's of Group 4 and Group 5 were similar and did not exhibit a statistically significant difference (p=0.913). Group 3 demonstrated lower CA values compared to Group 1 (p=0.000) & Group 2 (p=0.000) and higher CA when compared to Group 4 (p=0.000) & Group 5 (p=0.000). The CA of Group 2 was lesser than Group 1 (p=0.000), but significantly greater compared to groups 3, 4 &5 (p = 0.000). Group 1 exhibited the highest CA of all the sealers tested. The order of the mean CA of the root canal sealers tested was in the order as Group 4<Group 5<Group 3<Group 2< Group 1. As lesser CA signifies greater wetting ability and vice-versa, the wetting abilities of sealers tested were in the order Group 4 > Group 5 > Group 3 > Group 2> Group1.

DISCUSSION: A good adhesive seal between the root canal sealer and the core material is of foremost importance for the success of endodontic therapy. The interaction between sealer and GP is as important as that between sealer and the root canal wall (dentin) to achieve a fluid impervious seal [22]. Recent studies evaluated the wetting ability of root canal sealers to dentin by different surface treatment methods like lasers [23], chelating agents [24], and irrigant activation techniques [25], nevertheless as there is a lacuna of research on the wetting ability of Sealers to GP the present study was designed.

In the present study, Static Contact angles (SCA) of the sealers to GP surface were evaluated to determine the wettability of five different types of sealers. Wetting is an important phenomenon that determines the bond between a solid surface and a liquid [26]. The wetting behavior of root canal sealer can be determined by measuring the contact angle between the sealer droplet and the dentin or *Gutta percha* surface [6]. Kontakiotis *et al.* [5] and Prado *et al.* [27] have stated that contact angle is a practical method of determining the wettability that characterizes the clinical behavior of a sealer. The methodology adopted in the present study was tested in the previous studies and is proven to be highly effective. The advantage being the measurements can be carried out using small quantities of liquid i.e 0.1 ml of each sealer, as any volumetric change could affect the value of the contact angle. To measure the contact angle of a liquid on a solid, the solid surface has to be flat and smooth, Hence flat GP surfaces were prepared using sterile heated glass plates following the previous studies [21]. The samples were immersed in 5.25% NaOCl for 1 min [28] and then washed with distilled water followed by drying with nitrogen gas to simulate the sterilization procedure of GP before sealer application [14]. Standard environmental conditions were maintained during the entire procedure because the surface tension coefficient of liquids is influenced by temperature change and humidity. Any liquid tested wetting behavior is formed at three-phase boundaries where a liquid, gas, and a solid intersect.

Low contact angle values (<90º) indicate that the liquid (such as the sealer in this case) wets well, whereas high values (>90º) indicate poor wetting. A zero-contact angle represents complete wetting [29]. In the present study, the bioceramic sealers MTA fillapex and Endosequence BC were found to wet the *Gutta percha* surface better than the other sealers. On the contrary AH plus sealer, which was proven to have low solubility, adequate dimensional stability, and better adhesion to dentin due to its expansion over time [2] did not exhibit superior adhesion to GP as asserted in similar studies. This adhesion of AHPlus to GP thus needs further research under different parameters and conditions.

On the other hand, Calpex on setting forms an amorphous calcium disalicylate which is viscous and thereby does not wet the surface satisfactorily. Guttaflow also showed results similar to Calapex and AH plus, unlike MTA Fillapex and Endosequence BC sealer, which may be due to the particle size of the sealer coupled with hydrophobicity the resinous component of GP he results of the present study are in accordance with the study conducted by Ha JH *et al.* suggesting that Bioceramic sealers MTA Fillapex and Endosequence BC revealed better wetting ability which was statistically significant in comparison to the other Groups *i.e* AH plus, Gutta flow, and Calapex. The wettability of MTA Fillapex was better than Endosequence BC sealer though not statistically significant.

The superior wettability of Bioceramic sealers can be attributed to their more excellent hydrophilicity, and low viscosity [22] and poor wettability of AH plus may be due to the resin-based sealer's composition. Thus, within the limitations of the present study all the sealers had an optimal wetting to GP with Bioceramic sealers showing superior wetting ability. Nevertheless, there were certain limitations in the study.

The present study evaluated and compared the wetting ability of five commercial root canal sealers to GP by measuring the CA‘s. The other factors like surface tension, surface energy, hydrophilicity/hydrophobicity of sealers to GP could also be considered for a more comprehensive comparison in further studies.

Moreover, in the present study, only static contact angles were measured for a single period, and the sealers were not tested under any load as there might be a change in their behavior under lateral or vertical compaction. Hence it would be appropriate to test the sealers under a certain amount of pressure to simulate a clinical situation.

CONCLUSION: The results of the present study indicate that Bioceramic sealers exhibit the superior wetting ability to GP when compared with the other sealers tested. The results suggest that hydrophilic sealers - MTA fillapex and Endosequence BC, Calpex have better wettability in comparison to hydrophobic sealers – Gutta flow and AHplus.

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