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Comparative evaluation of sealing ability of gutta flow and bio ceramic sealer under different moisture control methods and in absence of smear layer. An in vitro study.

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Abstract:
Aim and Objective:
This in vitro study aimed to evaluate the effect of different moisture control methods on apical microleakage in root canals obturated with bioceramic sealer and Gutta flow. The objective was to determine whether moisture control significantly impacts the sealing quality of root canal obturations.
Materials and Method:
Forty extracted single-rooted human teeth with fully developed apices were instrumented using ProTaper rotary files (up to size F4) and irrigated with 5% sodium hypochlorite, saline, and 17% EDTA. Teeth were randomly divided into two groups (n=20) based on moisture control methods: Group A (paper points) and Group B (70% ethanol + paper points). Then these group are subdivided into GroupA1,GroupA2,GroupB1,GroupB2 in which groupA1and groupB1 obturated with bioceramic sealer while group A2 and group B2 are obturated with gutta flow. Specimens were immersed in 2% rhodamine B dye for 24 hours, sectioned longitudinally, and evaluated under a stereo microscope (20× magnification) for linear dye penetration.
Result
Bioceramic sealer shows lesser dye penetration when moisture control method is 70% ethanol in conjunction with paper points
Conclusion
The study concluded that the type of moisture control method—paper point alone or 70% ethanol followed by paper point—did not significantly influence the apical microleakage when
using bioceramic sealers. This suggests bioceramic sealers exhibit reliable sealing ability regardless of minor moisture variations during obturation. While guta percha shows lesser microleakage when mosture control method is 70% ethanol along with paper point.
Keywords: *Bioceramic sealer, gutta percha, root canal obturation, moisture control, microleakage, apical sealing, in vitro study, endodontics, rhodamine B dye penetration*

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I.Introduction

The onset, progression, and persistence of periapical illness and apical periodontitis are largely influenced by endodontic microorganisms. Therefore, the main goal of root canal therapy (RCT) is to stop oral bacteria and debris from entering the root canal system and entering the periapical tissues. The root canal system, including the coronal and apical seals, is fully sealed off to achieve this.[1]

One of the main objectives of root canal therapy is to completely obturate and hermetically close the root canal system. Root filling techniques, moisture management, and the physical and chemical characteristics of the employed sealer are some of the variables that might affect the complex problem of root canal microleakage.[2] Microleakage is defined as the "diffusion of the bacteria, oral fluids, ions and molecules into the tooth and the filling material interface"

OR "defined as the clinically undetectable passageof bacteria, fluids, molecules or ions between tooth a nd therestorative or filling material." Causes of microleakage: Microleakage via the root canal system is one of the main reasons why root canal therapy fails, while there are other reasons as well. Numerous investigations have looked at this problem, pinpointed numerous potential contamination sources, and highlighted the clinician's responsibility to stop microleakage after root canal therapy. Long-term biological reactions within the material and between the substance and its surroundings are what cause microleakage to progress. [3]

It has been shown that the degree of residual moisture in the root canal system influences the sealing performance of both conventional and resin-based sealers. Consequently, the degree of adhesion between root canal dentin and traditional sealers may be impacted by the moisture content of the root canals before obturation procedures. Alcohols such as ethyl alcohol are used to cleanse the root canal before obturation, according to anecdotal reports. The fundamental idea is that alcohol lowers the surface tension of the root canal system, irrigants, and sealants. Reducing a fluid or sealant's surface tension can increase the flow of fluid into the dentinal tubules. [4,5]

The classification of bioceramic materials as either bioactive or bioinert is based on their interactions with the surrounding living tissue. Bioactive materials, such as calcium phosphate and glass, interact with surrounding tissue to encourage the growth of stronger tissues. Bioinert materials, including alumina and zirconia, have no physiological or biological effect because they elicit a very small reaction from the surrounding tissue. Bioactive substances are further divided into degradable and nondegradable categories based on how stable they are. Bioceramics are frequently used to cover metal implants to increase their biocompatibility and for orthopedic procedures including joint or tissue replacements. Porous ceramics, including those based on calcium phosphate, have also been employed as alternatives to bone grafts [6,7].

Although the exact mechanism by which bioceramic-based sealers adhere to root dentin is uncertain, the following techniques have been proposed for calcium silicate-based sealers:

1. Tubular diffusion: This process forms mechanical interlocking links by allowing the sealer particles to flow into the dentinal tubules.[8,9]. .
2. A mineral infiltration zone is created when the mineral content of a strong alkaline sealer penetrates the intertubular dentin after denaturing the collagen fibers. [10].
3. Along the mineral infiltration zone, calcium silicate hydrogel and calcium hydroxide, which are produced when calcium silicates react with dentin moisture, partially react with phosphate to produce hydroxyapatite.[11].

II.Material And Methods

Total of 40 extracted single-rooted teeth with fully developed apex are collected. Teeth with open apex, severe curvature and with resorption are excluded. The teeth are stored in buffered isotonic saline solution to clean off blood and saliva. The crowns are removed at cemento-enamel junction (CEJ) by a carborandom disc bur under water spray; apical patency is established with a #10 K-file and the length of each canal is determined by placing a #15 K-file into the canal until it became visible at the apical foramen.

The teeth are instrumented with a crown-down technique with Pro taper rotary files (Dentsply) [fig 1 (d)] up to master apical size F4. The canals are irrigated after using each file with 5% sodium hypochlorite (2 mL) and saline. removal of the smear layer [17% EDTA with ultrasonic instrument are used to remove the smear layer]. Every experimental group is devided into two groups(n=20) [group A] & [group B] based on moisture control methods.

In group A the moisture control method is paper point.

In group B the moisture control method will is 70 % ethanol + paper point.

Then these group are subdivided into

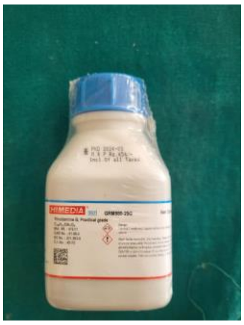
GroupA1 obturated with gutta flow bioceramic sealer.

GroupA2 obturated with gutta flow

GroupB1 obturated with bioceramic sealer.

GroupB2 obturated with gutta flow. [Fig 1a]

Specimens were immersed in 2% rhodamine B dye for 24 hours, sectioned longitudinally, and evaluated under a stereo microscope (20× magnification) for linear dye penetration.



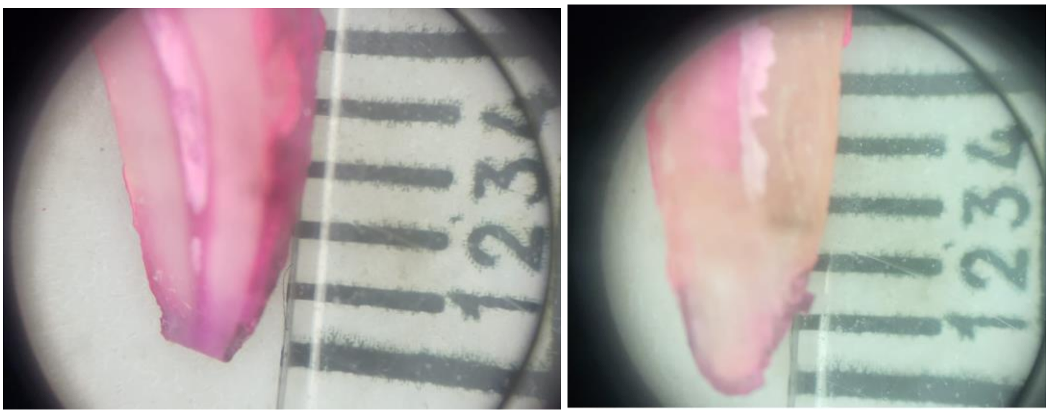
(a) (b)

(c) (d)

Fig 1: a) Bioceramic sealer b) Rhodamine b dye c) Ethanol d)Rotary file, densply protaper

Then in all groups the coronal 3 mm of the obturation material is removed and filled with temporary restoration All teeth is then be stored in an incubator at 37°C at 100% humidity for 2 days. Then, the samples are coated with two layers of nail varnish except for a 2-mm area around the apical foramen. After 1 hour of drying, all the specimens are immersed in a 2% rhodamine B dye for 24hours.

Then, the teeth are washed in water and the nail varnish was removed with a scalpel blade. These samples are longitudinally sectioned and observed under a stereo microscope with 20x magnification for assessing and measuring the linear dye penetration [fig 2]



(A1) **(B1)**

(A2) (B2)

Fig: 2 showing results of group A1) when only paper pionts were used with bioceramic sealer
B1) paper point along with ethenol and bioceramic sealer

A2) paper point with gutta flow
B2) paper point along with ethenol and gutta flow

III.Statistical Analysis

The data was entered into an Excel sheet and analyzed using SPSS (Statistical Package for the Social Sciences) version 30.0, IBM, Chicago. The probability distribution of the data was assessed using the Kolmogorov-Smirnov test. Mean values and standard deviations (SD) were calculated. Student's *t*-test was performed, and a *p*-value of <0.05 was considered statistically significant. The confidence interval was set at 95%.

IV.Result

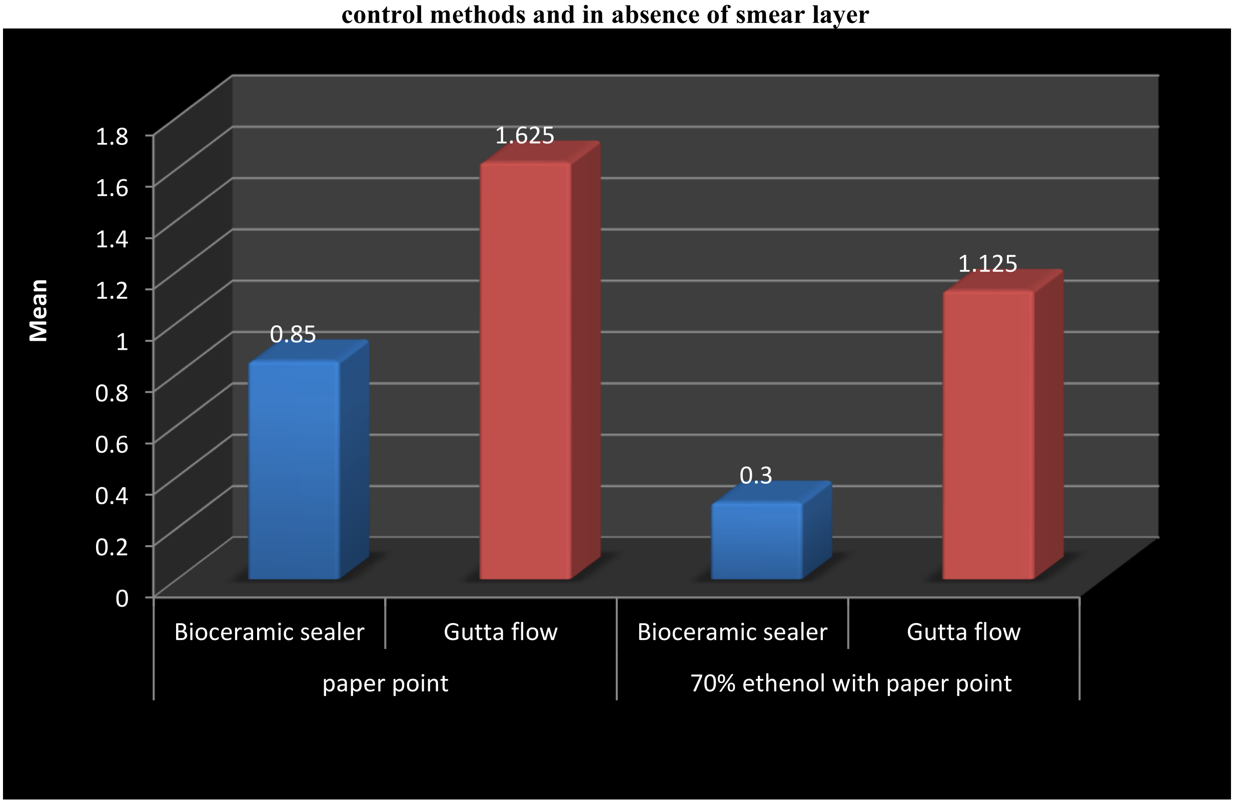
SEALING ABILITY

Table 1- Comparison of sealing ability of gutta flow and bio ceramic sealer under different moisture control methods and in absence of smear layer

Moisture control	Sealer used	n	Mean	SD	Mean Difference	95% CI Lower	95% CI Upper	t-value	p-value
Group A1- Moisture controlled by paper point	Group A1- Bioceramic sealer	4	0.850	0.50	-0.775	-1.627	0.077	-2.224	0.068
	Group A(2)- Gutta flow	4	1.625	0.47		-1.628	0.078		
Group B2- Moisture controlled by 70% ethenol with paper point	Group B1- Bioceramic sealer	4	0.300	0.24	-0.825	-1.25321	-0.396	-4.714	0.003*
	Group B2- Gutta flow	4	1.125	0.25		-1.25325	-0.396		

***Statistically significant**

Figure 3- Comparison of sealing ability of gutta flow and bio ceramic sealer under different moisture control methods and in absence of smear layer



In this evaluation, the sealing ability of two sealers—bioceramic sealer and GuttaFlow—was compared under two moisture control methods (using paper points alone and using 70% ethanol with paper points), all in the absence of a smear layer. In Group A1, where moisture was controlled by paper points alone, the mean leakage value for the bioceramic sealer was 0.850 (±0.50), while it was higher at 1.625 (±0.47) for GuttaFlow. Although the bioceramic sealer showed better sealing ability (indicated by lower mean leakage), the difference was not statistically significant (*p* = 0.068), with a mean difference of -0.775 and a 95% confidence interval ranging from -1.627 to 0.077, which includes zero.

However, in Group A2, where moisture control was achieved using 70% ethanol along with paper points, the bioceramic sealer again outperformed GuttaFlow, with mean leakage values of 0.300 (±0.24) and 1.125 (±0.25) respectively. In this case, the difference was statistically significant (*p* = 0.003), with a mean difference of -0.825 and a 95% confidence interval from -1.253 to -0.396, clearly excluding zero. These findings suggest that the bioceramic sealer provides superior sealing ability compared to GuttaFlow, especially when optimal moisture control is achieved using ethanol, and that proper moisture control can enhance the performance of certain sealers. **(Table 1, Figure 3)**

In this analysis, the sealing abilities of bioceramic sealer and GuttaFlow were assessed under two moisture control techniques in the presence of the smear layer. In Group B1, where moisture control was achieved using paper points alone, the mean leakage for the bioceramic sealer was 1.375 (±0.47), compared to a higher mean leakage of 2.000 (±0.40) for GuttaFlow. Although the bioceramic sealer showed better sealing ability, the difference was not statistically significant (*p* = 0.094), with a mean difference of -0.625 and a 95% confidence interval from -1.395 to 0.145, which includes zero.

In contrast, Group B2, where moisture control was performed using 70% ethanol along with paper points, demonstrated a statistically significant difference between the two sealers. The bioceramic sealer again showed a lower mean leakage of 1.375 (±0.47), while GuttaFlow exhibited a higher leakage of 2.375 (±0.47). The mean difference was -1.000, and the 95% confidence interval ranged from -1.828 to -0.172, excluding zero. The difference was statistically significant with a *p*-value of 0.025.

These findings indicate that while bioceramic sealer consistently provides better sealing ability than GuttaFlow in the absence of the smear layer, the advantage becomes statistically significant only when effective moisture control is achieved using 70% ethanol. This suggests that both the type of sealer and the method of moisture control influence the sealing effectiveness, even in the absence of smear layer. **(Table 1, Figure 3)**

V.Discussion

Achieving a hermetic apical seal is a cornerstone of successful endodontic treatment, as it prevents microbial ingress and subsequent periapical inflammation or reinfection. Root canal sealers play a pivotal role in this process by filling voids and ensuring adaptation between the core material and canal walls. In this study, the sealing ability of two sealers—bioceramic sealer and GuttaFlow—was evaluated under different moisture control methods (paper point drying alone vs. 70% ethanol followed by paper points) and in the absence of the smear layer. The findings offer critical insights into the influence of both material composition and moisture control strategy on sealing efficacy.

Influence of Sealer Composition

Bioceramic sealers, primarily composed of calcium silicates, are known for their hydrophilic nature, bioactivity, and ability to chemically bond with dentin. These sealers undergo a hydration-based setting reaction, forming calcium hydroxide and subsequently hydroxyapatite [12,13]. This property is essential in wet environments, where moisture activates their setting reaction and promotes micromechanical and chemical adhesion to dentin [14]. On the other hand, GuttaFlow, a polydimethylsiloxane-based sealer with gutta-percha and silver particles, is hydrophobic and relies primarily on mechanical retention and flowability rather than chemical bonding [15].

The results of the present study affirm this distinction. In both moisture conditions, the bioceramic sealer consistently exhibited lower leakage values than GuttaFlow, indicating superior sealing ability. However, the extent of this advantage varied depending on the moisture control technique.

Effect of Moisture Control: Paper Points vs. Ethanol

Paper Point Drying Alone (Group A1):
In the absence of smear layer, when canals were dried only with paper points, the bioceramic sealer had a mean leakage of 0.850 (±0.50) compared to GuttaFlow's 1.625 (±0.47). Although the bioceramic sealer performed better, the difference was not statistically significant (p = 0.068). This result is similar to that of studies by Zhou et al. [12] and Viapiana et al. [16], who found that bioceramic sealers can maintain better adaptation under moist conditions due to their hydrophilic nature, whereas GuttaFlow's sealing is compromised when moisture is uneven or excessive.
Ethanol with Paper Point Drying (Group A2):
When canals were dried with 70% ethanol followed by paper points, a statistically significant difference was observed. Bioceramic sealer demonstrated a mean leakage of 0.300 (±0.24), while GuttaFlow had 1.125 (±0.25) (p = 0.003). This improvement in sealing can be attributed to ethanol's hygroscopic nature, which removes

residual moisture effectively without desiccating the dentin, thus providing an optimal substrate for hydrophilic sealers to bond [17].
Nagas et al. demonstrated that ethanol-dried canals improved the bond strength of epoxy resin-based sealers [18]. Although bioceramics and epoxies differ in setting mechanisms, this effect can be extrapolated to suggest that ethanol aids in exposing collagen and increasing surface energy—both favorable for sealer adaptation [19]. Ethanol also reduces the contact angle of the sealer to the dentin, improving wettability [20].
The chemical interaction between calcium silicate-based sealers and dentin enhances their sealing performance. Bioceramic sealers form tag-like extensions into dentinal tubules and generate an interfacial layer of hydroxyapatite, which reduces microleakage and improves long-term dimensional stability [21,22]. Additionally, they exhibit slight expansion upon setting (up to 0.2%), which contrasts with the shrinkage seen in traditional resin or silicone-based sealers like GuttaFlow [23].
Another important factor is their bioactivity, which allows for dentin remineralization. The calcium ions released during setting react with phosphate ions from the surrounding tissue or saline to form hydroxyapatite, effectively "sealing" the dentin from within [24]. This is not seen with GuttaFlow, which does not form chemical bonds or promote mineral deposition.

Presence or Absence of Smear Layer

While this study focused primarily on conditions without a smear layer, it's important to recognize that smear layer removal enhances sealer penetration, especially for hydrophilic materials. Studies by Gopikrishna et al. and Shokouhinejad et al. report that bioceramic sealers penetrate deeper into dentinal tubules when the smear layer is removed, creating more effective seals and entombing residual bacteria [25,26].

However, in the presence of a smear layer (as in your second scenario), both sealers exhibited higher leakage values, though the trend remained similar—bioceramic sealers outperformed GuttaFlow. The significance was reached only with ethanol drying, again emphasizing the synergistic effect between proper moisture control and smear layer removal.

Comparative Studies

Several studies corroborate these findings. In a microleakage evaluation by Eymirli et al., calcium silicate sealers showed significantly lower leakage than GuttaFlow under both dry and moist conditions [27]. Similarly, a study by Al-Haddad and Che Ab Aziz concluded that bioceramic sealers outperformed GuttaFlow in sealing ability and marginal adaptation [28].

In contrast, some earlier studies reported comparable outcomes between GuttaFlow and other sealers, but these studies did not control for moisture variability or smear layer presence [29]. The current study's robust design, focusing on these variables, likely accounts for the more pronounced differences observed.

Clinical Implications

The findings have substantial implications for clinical practice. First, moisture control should not be underestimated. The use of 70% ethanol prior to obturation can substantially enhance the sealing efficacy of bioceramic sealers and should be considered as a clinical adjunct, especially in challenging cases with excessive canal moisture.

Second, the choice of sealer is critical. Bioceramic sealers offer multiple advantages: superior sealing, biocompatibility, bioactivity, and ease of handling. They are especially beneficial in cases where complete drying is difficult, such as in wide, curved, or infected canals.

Finally, smear layer removal, in combination with ethanol drying, appears to maximize the performance of bioceramic sealers, reinforcing the need for a meticulous irrigation protocol using EDTA and final rinse with ethanol before obturation.

VI.Conclusion

This study reinforces the superior sealing ability of bioceramic sealers over GuttaFlow, especially under optimized moisture control conditions using 70% ethanol. The combination of hydrophilicity, chemical bonding, and bioactivity renders bioceramic sealers particularly effective in achieving a hermetic seal. Clinicians should consider integrating ethanol-assisted drying and smear layer removal protocols to fully exploit the advantages offered by bioceramic-based sealers in contemporary endodontic practice.

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