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Comparative Evaluation Of The Apical Sealing Ability Of Three Different Obturating Materials - An In Vitro Study

Saravanapriyan Soundappan[1], Arthanarieswaran Andamuthu Sivakumar[2], T.Dharani[3], Jambai Sampath Kumar Sivakumar[4], M.Chittrarasu[5], B.N. Suresh kumar[6]

[1-6](*Department of Conservative Dentistry & Endodontics, Vivekanandha Dental College for Women, India)*

Abstract:

Background*: The Success Of Endodontic Therapy Depends On Major Factors Like Better Apical Sealing Property Of The Root Canal Sealer And A Highly Efficient Bonding Of The Sealer With Both The Root Canal Wall And The Core Filling Material. To Improve The Sealing Ability Of The Root Canal Sealers They Have Been Formulated To Use In Combination With A Bondable Core Filling Material That Might Fulfill The Ideal Requirements Of The Root Canal Sealers And The Core Filling Material. Since No Previous Studies Compare These Three Types Of Obturating Materials That Helps In Identifying The Material With The Least Microleakage Value By Evaluating Its Apical Sealing Ability.*

Materials And Methods*: 36 Human Mandibular Premolars Were Included And Cleaned. The Samples Were Standardized To A Length Of 12mm. Cleaning And Shaping Were Done Using Hero Shaper Niti Rotary File System. The Canals Were Irrigated With 5.25% Sodium Hypochlorite And 2 Ml Of 17% EDTA Solution During Instrumentation. The Final Rinse Was Done With Distilled Water. The Prepared Samples Were Randomly Divided Into Three Groups And Obturation Was Performed (A- Ceraseal & Bioceramic Gutta-Percha, B- Endorez & Endorez Gutta-Percha, C)- Guttaflow Bioseal& Conventional Gutta Percha). The Samples Were Assigned For A Dye Penetration Test And Evaluated Under A Stereomicroscope.*

Results*: By Comparing The Three Different Obturating Materials This Study Found To Have The Least Microleakage Value And A Higher Bond Strength For Bioceramic Sealer With Bioceramic Impregnated Gutta-Percha Points.*

Key Word*: Apical Seal, Stereomicroscope, Microtome, Methylene Blue.*

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I. Introduction

The main goal of endodontic therapy is the complete debridement of the necrotic debris followed by the 3-dimensional obturation of the root canal system. The 3-dimensional obturation should seal the main canal and all portals of exit from the root canal to the periodontal space to eliminate bacterial penetration [1]. Naidorf reported that inadequate root canal sealing provides a medium for the localization and growth of microorganisms [2].

Endodontically treated teeth restored with bonded materials may improve the strength of the teeth. Bonding between the root canal wall and the sealer occurs through micromechanical bonding and between the sealer and the gutta percha occurs chemical adhesion. Obturated teeth with better bonding of the root canal sealer to both the canal wall and the gutta – percha improve the sealing ability [3].

Various materials are available to produce better sealing and improved bond strength. One such material is the bioceramic root canal sealers (BCS) and bioceramic impregnated/ coated gutta-percha cone (BCC). Bioceramic sealers are stable in humid environments because of the presence of calcium silicates that sets by reacting with tissue fluids. They also have advantages like biocompatibility, osteoinductive capacity, and an excellent seal by the formation of a chemical bond to the canal wall [4]. The newly launched Ceraseal (Meta Biomed Co., Cheongju, Korea) is a premixed endodontic sealer that consists of calcium silicates, zirconium oxide, and thickening agents [4, 5].

EndoREZ (Ultradent Products, Inc., South Jordan, Utah, USA) is a urethane dimethacrylate resin-based sealer that is hydrophilic in nature. It has the advantage of better flow that easily penetrates the accessory canals and shows deep penetration of the particles into the dentinal tubules forming a chemical bond [6].

GuttaFlow Bioseal (Coltene/Whaledent AG, Altstatten, Switzerland) is a recently developed silicone-based endodontic sealer, a predecessor of GuttaFlow. It contains gutta-percha powder, bioactive glass, polydimethylsiloxane, a platinum catalyst, zirconium dioxide, and silver (preservative). The bioactive particles present in the sealer were claimed to form hydroxyapatite crystals when combined with gutta-percha points [7].

No previous studies are comparing these three different bondable obturating materials. This invitro study aimed to evaluate and compare the apical sealing ability of the three different obturating materials.

II. Material And Methods

A detailed protocol explaining the purpose and procedures of the study was submitted to the Institutional Ethical Committee, Vivekanandha Dental College for Women, and approval for the study was obtained. (VDCW/IEC/215/2121).

METHODOLOGY:

INCLUSION CRITERIA:

Thirty single-rooted mandibular premolars extracted for orthodontic and periodontal reasons with patent root canals were included in this study.

EXCLUSION CRITERIA:

A tooth with an open apex, internal and external resorption, fractures and crack lines, calcifications, and multiple canals were excluded from this study.

REMOVAL OF EXTERNAL RESIDUAL TISSUES:

Seventy-two intact human mandibular single-rooted premolars selected for the study were initially stored at room temperature in deionized water to which 10% formalin was added to prevent dehydration. External residual debris was removed in all the samples using ultrasonic scalers and stored in the same solution after every procedure till the completion of the study which will be replenished at regular intervals.

PROCEDURE:

Diagnostic X-rays (buccal and proximal) were taken to confirm the existence of a single straight canal with intact roots. All the samples were decoronated and standardized to a length of 12mm using a diamond disc with water coolant attached to the straight handpiece. Canal patency was determined using the 10-size K file and the working length was determined 0.5 mm short of the apex using an electronic apex locator. Cleaning and shaping were done using Hero Shaper NiTi rotary file system sequentially with the finishing file 30 size with 6% taper. During instrumentation, the canals were irrigated with 5.25% sodium hypochlorite and 2ml of 17% EDTA solution which was activated ultrasonically to remove the smear layer. The final rinse was done with distilled water. The prepared root canals were dried using paper points [8].

SAMPLE DISTRIBUTION:

The prepared samples were randomly divided into three groups (A, B, C) with each group containing 12 samples. Master cone verified, such that tug back was felt in the apical region, and obturation was performed.

GROUP	SEALER	GUTTA-PERCHA
GROUP A(n=24)	CeraSeal	Bioceramic gutta-percha
GROUP B(n=24)	EndoREZ	EndoREZ gutta-percha
GROUP C(n=24)	GuttaFlow Bioseal	Conventional gutta-percha

All the samples were stored at 100% humid temperature and a temperature of 37°C for 7 days. The samples of each group were assigned for a dye penetration test to evaluate the apical sealing ability.

DYE PENETRATION TEST:

The samples in groups A, B, and C were coated with two layers of nail varnish except for the apical 3mm. the samples were immersed in an aqueous solution of 2% methylene blue dye for 72 hours (Figure 1). Later, the samples were thoroughly rinsed, dried, and mounted horizontally in an acrylic resin block. The sample was sectioned longitudinally with the hard tissue microtome and examined under a stereomicroscope at 30x magnification to measure the dye penetration in millimeters [9].

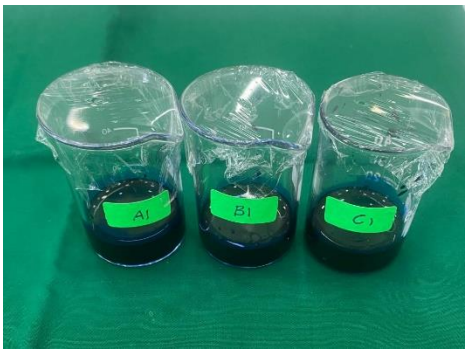


FIGURE 1: DYE IMMERSION

SCORING CRITERIA:

W. P. Saunders's criteria to evaluate the dye leakage was used,

- Score 0= no leakage found,
- Score 1= a leakage of less than 0.5mm,
- Score 2= dye penetration depth between 0.5 mm to 1 mm, and
- Score 3= leakage of more than 1mm respectively.

Whereas scores 0-1 were stated as having a good seal and scores 2-3 had a poor seal [9].

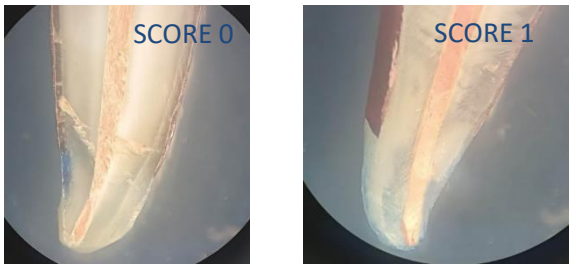


FIGURE 2: STEREOMICROSCOPIC IMAGES OF LONGITUDINAL - SECTION OF GROUP I (APICAL THIRD) WITH DYE PENETRATION SCORING

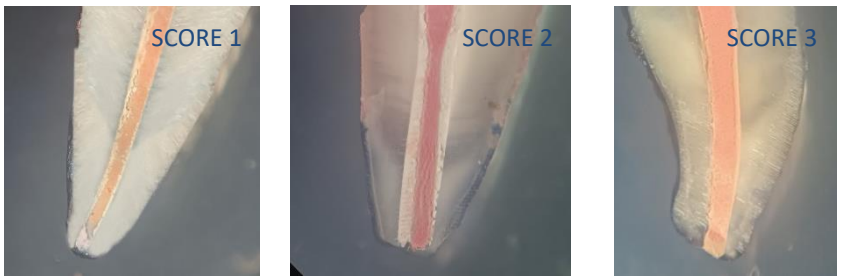


FIGURE 3: STEREOMICROSCOPIC IMAGES OF LONGITUDINAL - SECTION OF GROUP II (APICAL THIRD) WITH DYE PENETRATION SCORING

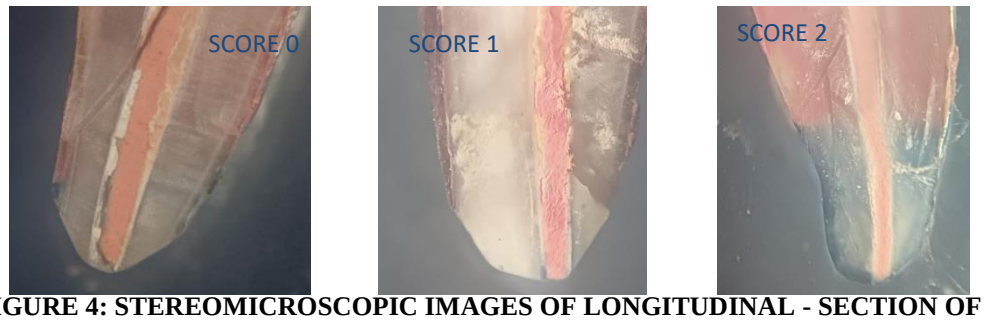


FIGURE 4: STEREOMICROSCOPIC IMAGES OF LONGITUDINAL - SECTION OF GROUP III (APICAL THIRD) WITH DYE PENETRATION SCORING.

Statistical analysis:

The statistical analysis was performed using IBM SPSS version 26 (IBM, Armonk, USA). The normality of the data was tested using the Shapiro-Wilk test. Intergroup comparison was performed for "push out bond strength" using one-way ANOVA followed by post hoc Tukey HSD test. Intergroup comparison was performed for "microleakage" using the chi-square test. For all comparisons, $p<0.05$ was statistically significant.

III. Result

Descriptive statistics such as mean, standard deviation, standard error, 95% confidence interval, and minimum and maximum values for "microleakage" with respect to the different groups are represented in Table 1. The intergroup comparison performed using one-way ANOVA showed a statistically significant difference for "microleakage (p=0.006) (Table The intergroup comparison performed using a chi-square test revealed that there was a statistically significant difference between the groups for different scores of microleakage (p=0.044) (Table 3 & 4) with the least microleakage scores (0 and 1) shown by group A followed by group C. More number of teeth with greater microleakage scores (2 and 3) are shown by group B (Table 4). The mean "microleakage" are illustrated using Figure 5.

Table 1: Mean value of microleakage and push-out bond strength values

		N	Mean	Std Deviation	Std Error
Microleakage	Group A	12	.58	.669	.193
	Group B	12	1.67	.651	.188
	Group C	12	1.17	.937	.271
	Total	36	1.14	.867	.144

Table 2: Intergroup comparison performed using a one-way test

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Microleakage	Between Groups	7.056	2	3.528	6.048	.006*
	Within Groups	19.250	33	.583		
	Total	26.306	35			

*p<0.05 is statistically significant
**p<0.001 is statistically highly significant

Table 3: Intergroup comparison performed using Post hoc Tukey HSD test

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
microleakage	Group A	Group B	-1.083	.312	.004*
		Group C	-.583	.312	.163
	Group B	Group C	.500	.312	.258

*p<0.05 is statistically significant
**p<0.001 is statistically highly significant

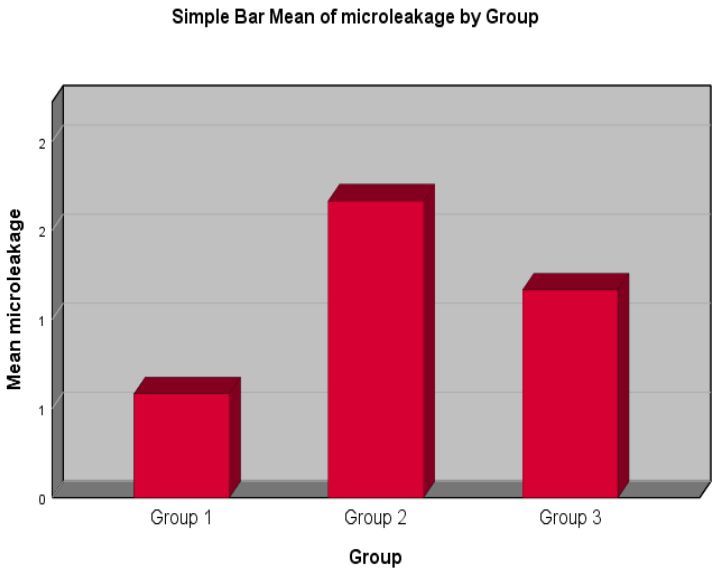
Table 4: Intergroup comparison performed using chi-square test

			Microleakage scores				Total	Chi-square statistic	P value
			0	1	2	3			
Group	Group 1	Count	6	5	1	0	12	12.946	0.044*
		% within Group	50.0%	41.7%	8.3%	0.0%	100.0 %		
	Group 2	Count	0	5	6	1	12		
		% within Group	0.0%	41.7%	50.0%	8.3%	100.0 %		
	Group 3	Count	4	2	6	0	12		
		% within Group	33.3%	16.7%	50.0%	0.0%	100.0 %		
Total		Count	10	12	13	1	36		

	% within Group	27.8%	33.3%	36.1%	2.8%	100.0 %		

*p<0.05 is statistically significant
**p<0.001 is statistically highly significant

FIGURE 5:



IV. Discussion

The rationale for a well-obturated root canal system is, to prevent coronal leakage, provide an adequate apical seal, and entomb the residual debris that has sustained the canal disinfection steps [10]. Schilder et al (2006) stated that an ideal obturating material should provide a better adaption with the canal wall without any voids and irregularities and the complete root canal should be uniformly compacted with a homogenous mass of gutta-percha [11, 12]. An inadequate apical seal will allow the entry of bacteria, apical fluids, and proteins into the root canal that causes failure. Strindberg in 1956 stated that 60% of endodontic failure occurs due to inadequate apical seal [13].

Bonding of the root canal sealer to the gutta-percha and the dentinal walls plays an important role in successful endodontic therapy [14]. The inability of the sealers to adhere to the canal walls has led to the advent of various newer materials and the development of a newer concept that help in better adhesion and an adequate seal. The term monoblock refers to a single unit. Franklin R Tay first demonstrated the concept of monoblock in endodontics. Achieving a monoblock obturation in the root canal helps in the even distribution of the stresses that occur within the remaining tooth structure [15].

The results of our study showed the highest mean value for group A (CeraSeal), followed by group C (Guttaflow bioseal), and the lowest mean value for group B (EndoREZ). In our study, the apical sealing ability of CeraSeal is higher than all the other tested groups, this could be due to the formation of the mineral infiltration zone (bioactivity) of CeraSeal, its hydrophilic nature, and the low contact angle (better wettability) that enables the sealer to flow easily along the entire canal wall providing a better adaptation with the canal wall and the bioceramic obturating core material providing a good hermetic seal in the apical region of the root.

Jeong et al (2017) reported the ability of calcium silicate-based sealers to penetrate the dentinal tubules to be high without compaction forces applied with different obturation techniques [16]. A recent study by Eltair et al (2018) demonstrated that bioceramic sealer has enhanced adaptability to the canal walls than AH plus sealer when viewed under the scanning electron microscope [9].

A study by Abdelrahman et al (2021) compared the apical sealing ability and bond strength of Adseal, Wellroot, and CeraSeal and concluded that CeraSeal has a better sealing ability than the other two sealers, because of their physical properties like flow, low film thickness, and dimensional stability. The alkaline nature of the by-products produced by calcium silicate-based sealers might have denaturized the dentin collagen fibers thus facilitating the penetration of the sealer into the denatured collagen network [17]. Zhang et al (2009) also stated that bioceramic sealers can easily diffuse into the dentinal tubules which results in better adaptation and hermetic seal [18].

A comparative study by Akcay et al (2016) between Guttaflow bioseal and MTA Fillapex to determine the penetration of the sealers into the dentinal tubules showed similar results for both sealers [9]. Guttaflow bioseal

shows the ability to nucleate deposits of hydroxyapatite which enhances its biomineralization properties. It also shows low solubility [19]. Alalaf et al (2022) demonstrated the better penetration of the Guttaflow bioseal root canal sealer into the simulated lateral canals, this may be due to the Nano-sized gutta-percha particles, which were similar to the core base material (gutta-percha) along with thixotropic property; and mild setting expansion that increases the ability to penetrate in dentinal tubules [20].

A Scanning electron microscopic study conducted by Ersahan et al (2010) stated that EndoREZ showed the lowest bond strength due to more amount of gap present between the sealer and the canal wall which may be due to the polymerization shrinkage [21]. Similar results were obtained for EndoREZ in a study done by Sevimay et al (2005) showing the lower value of apical sealing ability and adaptation of sealer to dentin for EndoREZ sealer compared with AH plus sealer [22]. The inhibition of free radicals reduces the transformation of monomers to polymers on exposure to oxygen in the air which results in the poor sealing ability of EndoREZ root canal sealer [3].

Bioceramic sealers have better properties like alkaline pH, antibacterial activity, radiopacity, biocompatibility, non-toxic, and dimensional stability, and are chemically stable within the biological environment. An ideal advantage of bioceramic sealer is it promotes the formation of hydroxyapatite crystals, facilitating a bond between dentin and the filling material during the setting process [23]. Bioceramic sealer also has a better healing property compared to other commercial obturating materials because of its presence of di- and tricalcium silicate particles which leads to the precipitation of calcium phosphate or calcium carbonate [4].

Within the limitations of the study, the bioceramic sealer combined with bioceramic-coated gutta-percha points had a better sealing ability and push-out bond strength than that of the GuttaFlow bioseal sealer with convention gutta-percha and the EndoREZ sealer and EndoREZ gutta-percha points.

V. Conclusion

It was observed that the bioceramic sealer with the bioceramic-coated gutta-percha points showed the least microleakage value. Thus, an ideal root canal sealer along with dedicated gutta-percha points aids in a better sealing ability and a higher bond strength for long-term successful endodontic treatment.

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