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EVALUATION OF MARGINAL ADAPTIBILITY OF NT BIOCERA FLOW, ANGELUS BIO-C SEALER AND BIOACTIVE RCS- AN IN VITRO STUDY

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Abstract
Objective: This study aims to assess and compare the penetrability and gap formation of root canal sealers in root dentin, evaluating NT BioCera Flow, Angelus Bio-C Sealer, and Bio-Active RCS.
Materials and Methods: Eighteen maxillary and mandibular posterior teeth were selected, radio graphed from two angles, and stored in saline-filled labeled vials. The teeth were randomly divided into three groups: Group I—NT Bio Cera Flow (n = 6), Group II—Angelus Bio-C Sealer (n = 6), and Group III—Bio-Active RCS (n = 6). After decoronating, root canal therapy was performed using fifth-generation rotary files. The root canals were then filled using the single-cone technique with the assigned sealer. Apical, middle, and cervical third sections of 1 mm were prepared using a water-cooled low-speed saw and analyzed under a scanning electron microscope.
Clinical Relevance: Effective root canal obturation aims to achieve a complete three-dimensional seal to prevent reinfection and maintain periapical health. Traditional gutta-percha, being hydrophobic, can result in sealer detachment. Newer sealer systems have been developed to improve sealing capabilities. Bioceramic sealers are increasingly preferred for their superior flowability, extended setting time, and long-term stability, leading to better penetration into dentinal tubules.
Results: The BioActive RCS group exhibited the least gap formation among the sealers evaluated in this study.
Conclusion: BioActive RCS demonstrated superior sealer penetrability and minimal gap formation in the apical third compared to the other sealers tested.
Keywords: Bioceramic sealer, Gap formation, Marginal adaptation, Scanning electron microscopy.

INTRODUCTION

Bioceramic cements are advanced materials used in both medicine and dentistry, known for their biocompatibility and enhanced sealing capabilities, along with their antibacterial and antimicrobial properties. These cements are similar in composition to biological hydroxyapatite, which contributes to their excellent biocompatibility and osteo-inductive properties. They can absorb osteo-inductive substances, supporting bone healing processes. Bioceramics distinguish themselves from other sealers by their ability to create an airtight seal, chemically bond with tooth structure, and exhibit good radiopacity. Additionally, these materials act as resorbable regenerative scaffolds, gradually dissolving as tissue regeneration occurs.
Bioceramics encompass a variety of materials, including alumina, zirconia, bioactive glass, glass ceramics, calcium silicates, hydroxyapatite, and resorbable calcium phosphates. Methods such as stereomicroscopy, scanning electron microscopy (SEM), and leakage tests are commonly employed to evaluate the adaptability of sealers to dentin. Various bioceramic sealers have been developed and classified based on their chemical composition and structural properties.
This study focuses on three specific bioceramic sealers: NT BioCera Flow, Angelus Bio-C, and BioActive RCS. NT BioCera Flow is a pre-mixed, injectable system known for its high hydrophilicity, excellent hydroxyapatite formation, chemical bonding properties, absence of setting shrinkage, and high radiopacity. Angelus Bio-C sealer has demonstrated effectiveness in endodontic procedures by expanding to provide a physical seal and promoting biological sealing through mineralization. Its high pH helps neutralize acidic environments, preventing further resorption in cases of internal resorptions. BioActive RCS utilizes innovative "Active Biosilicate Technology," which enables the material to crystallize within dentinal tubules, forming a tight seal and allowing for easy removal from the root canal.

Materials and Method

Sample Collection:

A total of eighteen posterior teeth from the maxillary and mandibular regions, extracted for various clinical reasons, were utilized for the study. Teeth were selected based on radiographic criteria, including the absence of calcified root canals, signs of internal or external root resorption, cracks or fractures, existing root fillings, and poorly formed apices.

Root Canal Preparation:

Access cavities were prepared using an Endo access bur (Dentsply). The canals were irrigated with 5 mL of 5.25% sodium hypochlorite (NaOCl). A working length was set at 0.5 mm short of the apical foramen. Protaper Gold instruments (Dentsply) were used in a pecking motion with an X-MART endodontic handpiece (Dentsply).

The instruments were advanced apically using a light, in-and-out pecking motion, with cleaning performed after every three pecking movements. The canals were irrigated with 5.25% NaOCl between each preparation step, and the enlargement continued to file sizes F1 and F2.

Upon completion of the preparation, the canals were treated with 17% EDTA, followed by additional irrigation with 5.25% NaOCl, and then rinsed with saline.

Filling Materials and Techniques:

The prepared canals were divided into three groups, with each group consisting of six teeth. Each group was filled using the single-cone technique with one of the following materials:

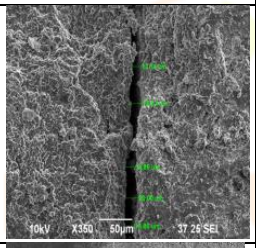
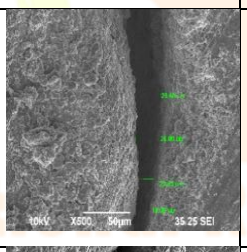
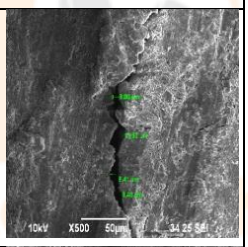
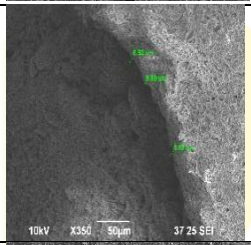
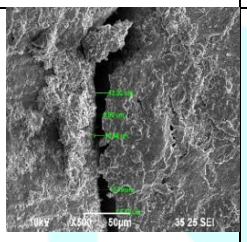
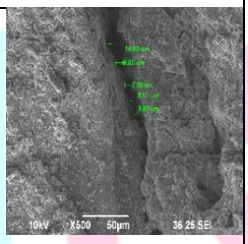
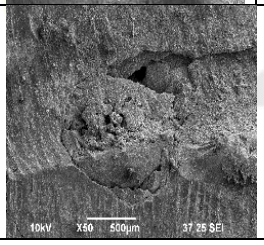
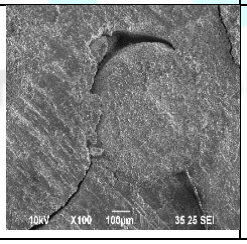
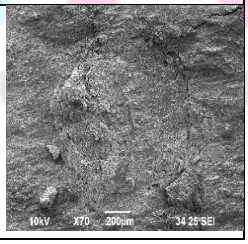
- NT Bioceraflo
- Angelus Bio-C Sealer
- Bio-Active RCS

Sectioning and Evaluation:

The teeth were mounted on acrylic stumps, and 1-mm thick serial sections were prepared using a water-cooled low-speed saw (Buehler Isomet 1000). For evaluating marginal adaptation, the sections were dehydrated through a series of ascending ethanol concentrations. The specimens were then sputter-coated with gold-palladium and examined using a scanning electron microscope (SEM).

SEM images of the apical, middle, and cervical sections were captured to assess the marginal adaptation of the sealer materials in each group.

To evaluate the marginal adaptation, measurements of the distance between the sealer and gutta-percha interface were recorded in micrometers (µm).

Region	NT Biocera flo	A	BioActive RCS
CORONAL			
MIDDLE THIRD			
APICAL			

DATA ANALYSIS

Table – 1 : Description of Study Groups

Group	Material
Group I	NT Endo Biocera flo
Group II	Angelus Bio-C sealer
Group III	BioActive RCS bioceramic sealer

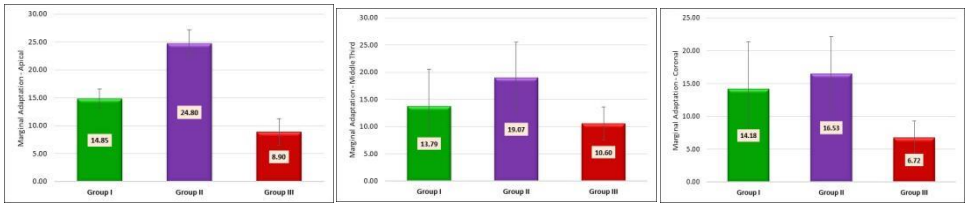
The study categorized the materials into three groups for the evaluation of marginal adaptation. Group I utilized NT Endo Biocera flo, Group II employed Angelus Bio-C sealer, and Group III utilized BioActive RCS bioceramic sealer.

Region	**NT Endo Biocera flo**	**Angelus Bio-C sealer**	**BioActive RCS**
APICAL	13.14 16.57 14.85	26.40 26 22	6.80 11.50 8.41
MIDDLE THIRD	20.00 14.86 6.52	26.00 18 13.2	11.60 13.00 7.20
CORONAL	14.86 6.69 21.00	22.40 11.20 16.00	8.46 3.69 8.00

Fig- Marginal gap calculated in Apical, Middle third and Coronal region

Region	**Material Group**	**Marginal Adaptation**	
		Mean	SD
APICAL	Group I	14.85	1.72
	Group II	24.80	2.43
	Group III	8.90	2.39
	ANOVA	F=39.9, **p<0.001**	
		Mean	SD
MIDDLE THIRD	Group I	13.79	6.80
	Group II	19.07	6.47
	Group III	10.60	3.03
	ANOVA	F=1.7,p=0.261	
		Mean	SD
CORONAL	Group I	14.18	7.18
	Group II	16.53	5.62
	Group III	6.72	2.63
	ANOVA	F=2.6, p=0.152	

n Group I, the mean marginal adaptation is 14.85 with a standard deviation of 1.72. Group II exhibits a significantly higher mean of 24.80, accompanied by a standard deviation of 2.43. On the other hand, Group III demonstrates a lower mean marginal adaptation of 8.90, with a standard deviation of 2.39. The analysis of variance (ANOVA) indicates a statistically significant difference among the material groups for apical region marginal adaptation, with an F-value of 39.9 and a p-value less than 0.001.



Group I exhibited a mean difference of -9.95 compared to Group II, with a p-value of 0.004, signifying significant disparities in marginal adaptation. Similarly, Group I and Group III displayed a mean difference of 5.95 (p-value: 0.037), indicating notable distinctions. The most pronounced variation was observed between Group II and Group III, with a mean difference of 15.90 and a highly significant p-value of less than 0.001.

The mean values for marginal adaptation in the middle third region were observed to be 13.79 (SD=6.80) for Group I, 19.07 (SD=6.47) for Group II, and 10.60 (SD=3.03) for Group III.

RESULT

Based on SEM images, the Angelus Bio-C sealer shows good marginal adaptation compared to NT endo Bioceraflo, BioActive RCS groups.

DISCUSSION

The bonding mechanism of bioceramic-based sealers to root dentin is not fully understood, but several theories for calcium silicate-based sealers include:

1. Tubular Diffusion: Sealer particles may enter dentinal tubules, creating mechanical bonds.
2. Mineral Infiltration: The sealer's minerals can penetrate intertubular dentin, forming a mineral infiltration zone after collagen fibers are altered by the alkaline sealer.
3. Hydroxyapatite Formation: Phosphate partially reacts with calcium silicate hydrogel and calcium hydroxide, produced from calcium silicates interacting with dentin moisture, leading to hydroxyapatite formation in the mineral infiltration zone.

Many bioceramic sealers are commercially available, though others are still experimental and need further testing. These sealers are categorized based on their main components, and their properties are evaluated relative to ideal sealer characteristic**s.**

Bioceramic sealers are known for their biocompatibility and potential to aid bone regeneration if extruded through the apical foramen or used in root perforation repairs. The setting times for various bioceramic sealers are as follows: Angelus Bio-C takes up to 240 minutes, Bio Root RCS takes 270 minutes, and NT Bioceraflo takes 210 minutes, with moisture in the dentinal tubules catalyzing the setting reaction. Flow is crucial for these sealers as it allows them to reach and fill complex root canal spaces. Among these, BioActive RCS shows good flow properties.

The retreatability of root filling materials is important for isolating necrotic tissue and bacteria, preventing persistent periapical inflammation. Solubility, which refers to mass loss in water, should not exceed 3% by ANSI/ADA standards to avoid gaps and leakage. Aesthetic considerations also require that sealers do not stain teeth, with chromogenic effects increasing if excess sealer is left on coronal dentin.

BioActive RCS is noted for its high alkalinity (pH 12.5), high radiopacity (≥8 mm on an aluminum scale), and significant antibacterial properties due to its high pH and calcium ion release, which aids in mineralized tissue repair. It features zirconium oxide as a radiopacifier, preventing tooth staining. The sealer has a particle size of <2 µm, enhancing flow and reactivity, which supports the healing process. Antibacterial activity is commonly assessed using the agar diffusion test or direct contact testing, with BioActive RCS showing superior penetrability and minimal gap formation. The adhesion of sealers to dentin and filling cones is crucial, with some experts suggesting that "bonding" is a more accurate term than "adhesion" due to the mechanical interlocking forces involved. Overall, the sealing ability of bioceramic sealers relates to their solubility, bonding strength, and flow characteristics, which have been evaluated in various studies.

CONCLUSION

Bioceramic-based root canal sealers show promising results as root canal sealers. However, discrepancies in the results of these studies reveal that these sealers do not fulfil all of the requirements demanded of the ideal root sealer. The biocompatibility and biomineralization effect of these sealers might avail them for alternative uses in direct pulp capping and root end filling. Further studies are required to clarify the clinical outcomes associated with the use of these sealers.

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