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SEALING ABILITY OF TWO DIFFERENT INTRA ORIFICE MATERIAL WITH TWO DIFFERENT ROOT CANAL OBTURATION YECHNIQUES

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ABSTRACT

Purpose: This study was designed to compare the coronal micro-leakage of resin modified glass ionomer (RMGI) and Smart Dentin Replacement (SDR) as intra orifice barrier using two different obturation techniques.

Material and methods: 16 freshly extracted human mandibular premolars were used in this study. They were decapitated to make length in all teeth =16. Teeth were divided into 2 equal groups (n=8) according to the obturation technique: group (L): lateral condensation, group (S): single cone. Rotary files (Mpro system) were used to prepare the root canals, which were then filled with gutta-percha and resin sealer. Three millimeters of the gutta-percha had been removed from the root canals then each group was sub divided into four experimental groups according to intra-orifice materials into SDR and RMGI and two control groups. All teeth were immersed in methylene blue for one week then sectioned longitudinally parallel to their long axis. A stereomicroscope with a 10X magnification was used to examine the samples in order to determine the dye penetration.

Results: The mean dye penetration depth values were significantly different between the materials for lateral condensation technique and single cone technique. Mean dye penetration depth in all the groups were significantly different from each other with the lowest dye penetration depth values in negative control groups followed by SDR and RMGI and the highest in positive control group. Conclusion: SDR and RMGI used as an intra-orifice barriers placement gives accepted coronal seal, prevents micro-leakage, and enhances the durability of post obturation restorations.

KEYWORDS: SDR, Resin Modified glass ionomer, intra orifice barrier, micro-leakage

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INTRODUCTION

One of the most significant contributing factors to endodontic treatment failures is secondary microleakage caused by an impaired coronal seal. Tselnik et al. explained that inadequate coronal seal may occur in a variety of clinical conditions, including tooth structure fracture, absence of temporary filling materials, marginal final restoration leakage, and recurrent caries. Each of these conditions causes coronal microleakage by exposing the root canal system to the oral environment [(1)] .

Clinical investigations showed that a post endodontic coronal seal is also significant as an apical seal to prevent failure of the root canal treatment [(2)]. Compromised filled root canal system occurs due to recontamination with bacterial penetration present in the oral fluids [(3)].

The important objectives of post-endodontic restoration are providing an impermeable hermetic seal and increasing root fracture resistance [(4)]. Intra-orifice barrier is a viable alternative method to reduce coronal leakage in endodontically treated teeth. In this process, additional material is inserted into the orifice of the canal immediately following the removal coronal portion sealer with the gutta-percha [(5)] .

The process entails removing a portion of the coronal gutta-percha and then replacing the empty space with a restorative substance. Since some studies tested various intra-orifice barrier depths, ranging from 1 mm to 4 mm, and found that it typically had a better performance when it was placed at (3 mm) depth, it appears that the depth of the barrier is a key element in reducing micro-leakage [(6)].

The ideal characteristics of intra-orifice barrier materials include the ability to bond to the tooth structure, have easy manipulation, prevent micro-leakage, and can be differentiated from the tooth's natural structure; additionally, they shouldn't adversely affect the final restoration [(7)].

The intra-orifice coronal seal was introduced to promptly restore a portion of the gutta-percha during root canal therapy by Roghanizad and Jones in 1996. They compared replacing 3 mm of gutta-percha with resin-based temporary restorative material (TERM, Dentsply International, USA), Cavit™ (3M, ESPE, Germany) and amalgam with cavity varnish. They showed that amalgam sealed much better than TERM and Cavit when it had two applications of cavity varnish applied. Conversely, amalgam was discovered to discolor teeth and obstruct subsequent bonding agents. Since then, a variety of intra-orifice materials have been made available, such as composite resins, glass ionomer cements, and zinc oxide preparations [(8)] .

A systematic review in 2022 suggested that resin based composite was an accepted intraorifice material due to the wide range of color availability and the excellent properties. [(8)] The flowable resin composites are regarded as a proper choice for an intraorifice barrier material for advantageous property of low viscosity penetrating into the difficult areas such as orifices. The main drawback was the polymerization shrinkage that could interrupt the orifice seal. Smart dentin replacement (SDR) is a bulk fill flowable composite resin with the following characteristics: low shrinkage, good cavity adaptation, can attach to the tooth structure, and has minimal leakage [(9)]. So far, Smart Dentin Replacement materials have been used as a replacement of dentin structure in teeth restorations. Resin modified glass ionomer cement (RMGI) had been recommended for use as an intra-canal barrier when micro-leakage or recurrent caries because of its cariostatic and adhesive characteristics. It has a high bond strength to dentin as well as significant fluoride release [(10,11)].

Based on this problem, the hypothesis of this study was; the RMGI would be more resistant to micro-leakage compared to the SDR as an intra-orifice material in endodontically treated teeth.

MATERIAL AND METHODS

Material	Composition	Manufacturer	Lot Number
SDR (Smart Dentin Replacement) Resin Composite Material	SDR patented urethane dimethacrylate (UDMA) resin, Dimethacrylate resin, Difunctional diluent, Barium and Strontium alumino fluoro-silicate glasses, Photoinitiating System, Colorant	Dentsply; Germany	8521
Universal Adhesive	Bisphenol A Diglycidylmethacrylate (20–50%), Ethanol (30–50%), Methacryloyloxydecyl dihydrogen Phosphate (5–25%), 2-Hydroxyethyl Methacrylate (2–25%), water, Initiators	Bisco Inc, Schaumburg ,USA	220000389
Riva LC (Resin Modified Glass Ionomer)	Acrylic acid homopolymer (15–25%), 2-hydroxyethyl methacrylate (15–25%), dimethacrylate cross-linker (10–25%), Acid monomer (10–20%), tartaric acid (5–10%) Glass powder (93–100%) of Bioactive hybrid glass filler	SDI Limited. Bayswater Victoria, Australia	1230316

Methods

1- Ethical Approval

The study had been approved by the Research Ethics Committee, faculty of Dentistry, Ahram Canadian University; Research number: IRB00012891#101

2- Sample size Calculations:

Sample size calculated depending on a previous study (Bhullar, et al.) [12] as reference. According to this study, the minimally accepted sample size was 6 per group, when mean ± standard deviation of linear leakage in Fuji II at depth 3 mm was 2.56 ± 0.041 while estimated difference with other group was 0.07, when the power was 80 % & type I error probability was 0.05. The t test was performed by using P.S.Power 3.1.6.

3- Selection of samples

Sixteen single-rooted freshly extracted human mandibular premolars with mature apices were used in this study. Before use, each tooth was placed in (5.25%) NaOCl for surface disinfection and periodontal ligament removal followed by storage in distilled water until use.

4- Preparation of samples

Initial radiographs were taken to confirm root canal patency. All teeth were mechanically scaled by means of an ultrasonic scaler to remove any remaining bone, calculus, or soft tissue. Teeth were decoronated to the cemento-enamel junction with average root length 16mm (±1 mm) using low speed diamond stone.

5- Root canal treatment of the teeth

Root canal treatment was done using crown down technique utilizing rotary M-Pro nickel titanium instruments (IMD Company) following the manufacturer's instructions up to #40 instrument. The M-Pro system was connected to an endodontic micro-motor X-Smart (X-Smart, Dentsply-Maillefer, Ballaigues, Switzerland). Each root canal was irrigated with 2 ml of 5.25% sodium hypochlorite (NaOCl) at each file size by means of a 27-gauge needle. After finishing root canal preparation, irrigation of each canal was performed with 5ml of 17% ethylenediaminetetraacetic acid (EDTA) for 60 seconds.

6-Samples Grouping:

Samples were randomly grouped according to obturation techniques used (n=8) **Group (L)**: lateral condensation and **Group (S)**: Single cone technique. Obturation was carried out using greater taper gutta-percha 40 master cone along with resin sealer (ADSEAL, Meta Biomed Co., Korea), following the manufacturer instructions for each technique. Gutta-percha was removed 3 mm from the coronal orifice (cement dentinal junction) in all the roots using Gates Glidden Drills in all the roots except negative group (Gutta percha used as intra-orifice material) and vertically condensed the remaining gutta-percha. To control the depth of intra-orifice cavity a periodontal probe was used and a cotton dipped in alcohol was used to remove the residual sealer on dentinal walls .Each group was subdivided into four experimental subgroups according to the intra-orifice material used:

- For Lateral Condensation Group; **Gp SL**: for SDR restorative material**, Gp RL**: for RMGI restorative material, **Gp PL**: for Positive group and **Gp NL**: Negative group.
- While Single Cone Technique group was subdivided into **Gp SS**: for SDR restorative material, **Gp RS**: for RMGI restorative material, **Gp PS:** Positive group and **Gp NS:** Negative group.

7- Restorative Material Application:

Coronal part of the orifice of the tested groups was filled with the sealing materials in 3 mm depth as the following:

- Riva LC:

25–30% polyacrylic acid (Riva Conditioner, SDI Bayswater, Victoria, Australia) was applied for 10 seconds, rinsed, and then gently dried. Application of the material was done , and light cured for 20 seconds[13]

- Smart Dentin Replacement (SDR):

Universal adhesive resin bond was applied to the space created and excess was removed using clean bond brush and cured then the bulk fill material was applied and cured following the manufacturer instructions. [9] All samples were stored in one hundred percentage of humidity inside an incubator (37°C) for 48 hr.

8- Dye leakage:

Dye leakage was applied to the teeth in order to assess the coronal seal's quality. Nail varnish was applied in two coats to all three experimental groups and one positive control group, with the exception of a 2-millimeter region surrounding the access restoration. The negative control group's teeth were completely encased in nail polish. After that, samples were immersed in Methylene Blue dye for 7 days. [12]. The samples were then washed under with running water to get the dye off their outside surfaces . The samples were then sectioned longitudinally using a diamond disc and examined under a stereomicroscope. The leakage was evaluated using a ×10 stereomicroscope (Olympus SZX16) by measuring the distance from the coronal extent of the orifice material to the greatest depth of penetration of the dye. An ANOVA and a post hoc Tukey's test were used to examine the dye penetration in the teeth.

RESULTS

Comparison between lateral condensation and single cone techniques:

Mean and standard deviation of dye penetration depth in SDR (SL), RMGI (RL), Positive (PL), and Negative (NL) regarding both lateral condensation and single cone techniques were presented in **table (1)** and **figure (1).** Comparison between lateral condensation and single cone revealed that:

- In SDR (SL) material, single cone technique (4.40 ± 0.71) was significantly higher than lateral condensation technique (3.01 ± 0.30). The mean difference is 1.39, with a 95% CI of 0.68 to 2.09, and the difference is statistically significant (p = 0.001).

- In the RMGI (RL) material, the single cone technique (4.04 ± 0.01) was significantly higher than the lateral condensation technique (3.06 ± 0.06). The mean difference is 0.98, with a 95% CI of 0.92 to 1.03, and the difference is statistically significant (p = 0.0001).
- For the Positive (PL) material, the single cone technique (7.22 ± 0.05) was significantly higher than lateral condensation technique (4.6 ± 0.95). The mean difference is 2.62, with a 95% CI of 1.75 to 3.48, and the difference is statistically significant (p = 0.0001).
- For the Negative (NL) material, the single cone technique (1.58 ± 0.13) was significantly higher than lateral condensation technique (0.00 ± 0.00). The mean difference is 1.58, with a 95% CI of 1.46 to 1.69, and the difference is statistically significant (p = 0.0001).

Comparison between SDR (SL), RMGI (RL), Positive (PL), and Negative (NL):

Mean and standard deviation of dye penetration depth in SDR (SL), RMGI (RL), Positive (PL), and Negative (NL) regarding lateral condensation and single cone were presented in table (2) and figure (2).

For the lateral condensation technique (Figure 3), the mean dye penetration depth values are significantly different (P < 0.05) between the materials. Specifically, Positive (PL) exhibits the highest mean dye penetration depth (4.60 ±0.95), followed by SDR (SL) (3.01± 0.30) and RMGI (RL) (3.06 ± 0.06), while Negative (NL) has the lowest mean penetration depth (0.00 ± 0.00).

The single cone technique (Figure 4), the mean dye penetration depth values are significantly different (P < 0.05) between the materials. Positive (PL) shows the highest mean dye penetration depth (7.22 ± 0.05), followed by RMGI (RL) (4.04 ± 0.01) and SDR (SL) (4.40 ± 0.71) , while negative (NL) (1.58 ± 0.13) have relatively lower mean values.

TABLE (1) Mean and standard deviation of dye penetration depth in SDR (SL), RMGI (RL), Positive (PL), and Negative (NL) regarding both lateral condensation and single cone techniques:

	L: lateral condensation		**S: Single cone**		**MD**	**SEM**	**95% CI**		**P value**
	M	SD	M	SD			L	U	
SDR (SL)	3.01	0.30	4.40	0.71	1.39	0.31	0.68	2.09	0.001*
RMGI (RL)	3.06	0.06	4.04	0.01	0.98	0.02	0.92	1.03	0.0001*
Positive(PL)	4.60	0.95	7.22	0.05	2.62	0.38	1.75	3.48	0.0001*
Negative(NL)	0.00	0.00	1.58	0.13	1.58	0.05	1.46	1.69	0.0001*

M: mean ***SD: standard deviation*** ***MD: mean difference*** ***SEM: standard error mean***

L: lower arm ***U: upper arm*** ***CI: confidence interval***

****Significant difference as P<0.05.***

TABLE (2) Comparison between SDR (SL), RMGI (RL), Positive (PL), and Negative (NL) regarding lateral condensation and single cone techniques:

	SDR (SL)		RMGI (RL)		POSITIVE(PL)		NEGATIVE(NL)		P VALUE
	M	SD	M	SD	M	SD	M	SD	
LATERAL CONDENSATION	3.01 a	0.30	3.06 a	0.06	4.6 b	0.95	0.00 c	0.00	0.0001*
SINGLE CONE	4.40 a	0.71	4.04 a	0.01	7.22 b	0.05	1.58 c	0.13	0.0001*

M :mean *SD :standard deviation* **Significant difference as P.0.05>*

Mean with different superscript letters were significantly different as P<0.05.

Mean with the same superscript letters were insignificantly different as P>0.05.

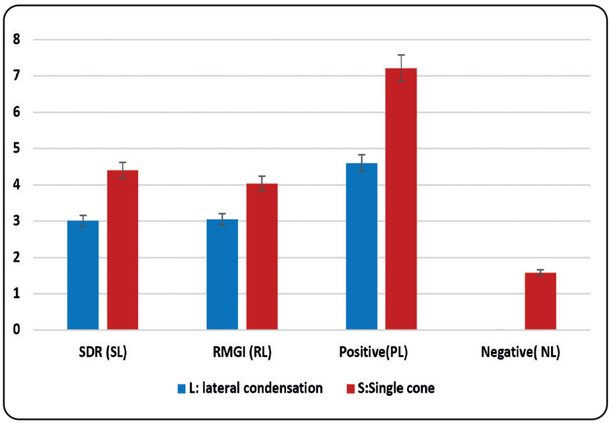


Fig. (1) Bar chart representing comparison between lateral condensation and single cone techniques.

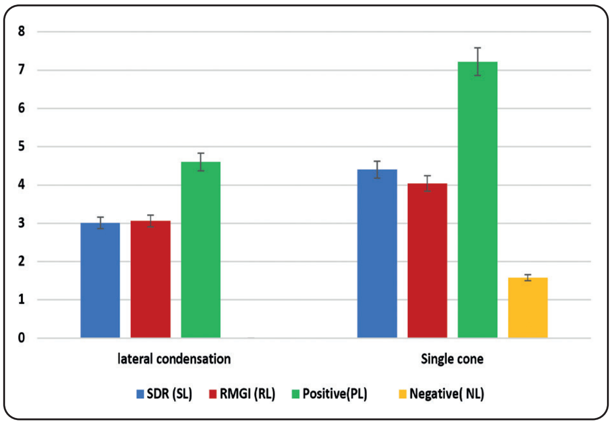
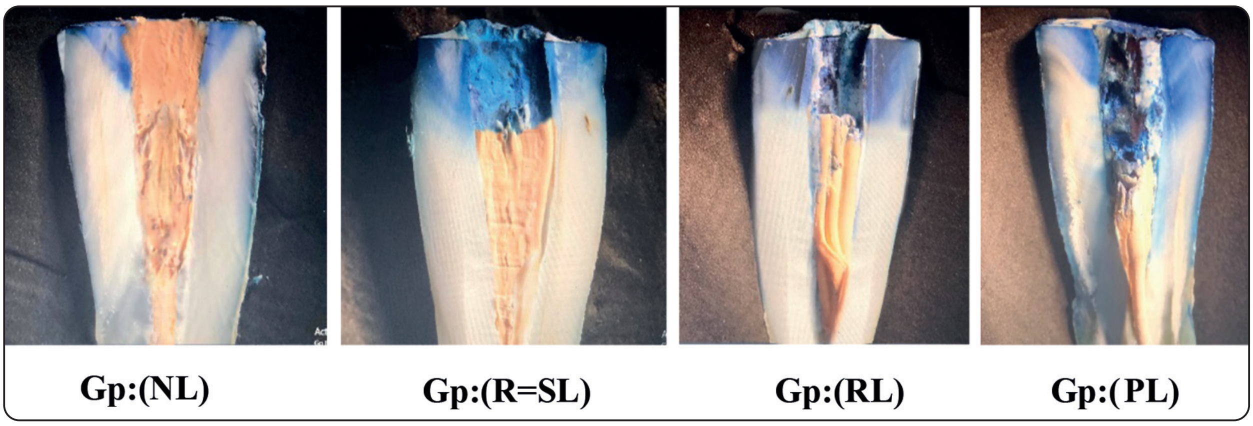


Fig. (2) Bar chart representing comparison between SDR (SL), RMGI (RL), Positive(PL), and Negative (NL).



Fig, (3) Lateral condensation technique m groups

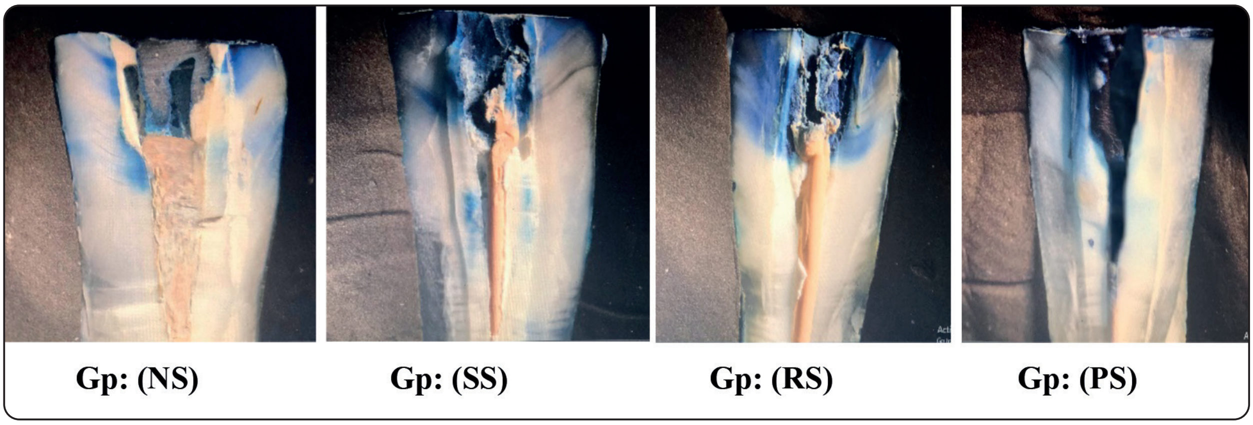


Fig. (4) Single cone technique groups

DISCUSSION

Three-dimensional obturation of the canal spaces and thorough cleaning are prerequisites for successful endodontic therapy. A compromised seal, which permitted germs to re-contaminate the canals and restart the endodontic failures, has been linked to long-term failures. Most scientific effort has been focused on creating instruments and strategies that strengthen the apical seal. Recent researches have demonstrated that because bacteria from the oral environment could penetrate, an inadequate coronal seal increases the risk of reinfection. It has been shown that current techniques for root canal obturation and post-endodontic restorations are insufficient to produce a full coronal seal [14].

Efficacy of restorative materials could be evaluated by one of the most significant parameter; is the microleakage. Minor leaks could be caused by poor fit or shrinkage between the restorative material and the cavity walls. This micro-leakage in vital teeth causes pulpal disease and recurring caries [15].

Establishing an impermeable barrier between the oral environment and the root canal system is one of the contemporary methods for decreasing contamination in endodontically treated root canals. After endodontic therapy, the intra-orifice barrier is a useful standing technique for reducing coronal leakage in teeth. This technique includes removal of the gutta-percha cones and sealant and then injecting more material containing various restorative elements into the canal orifices, this approach allows for the completion of the final healing [12].

The following criteria have been proposed for the ideal intra-orifice seal: (i) it should be easy to place; (ii) it should bond to the tooth structure; (iii) it should effectively seal against coronal micro-leakage; (iv) It should be readily identifiable from the normal tooth structure; and (v) it shouldn't obstruct the final restoration placed after access preparation [16, 17]. The two most crucial requirements are bonding to the tooth structure and sealing against coronal micro-leakage.

According to Olmez et al., compared the coronal leakage of MTA as an intra-orifice barrier with different thickness of one, two, three and four millimeters, the researcher assumed that the thicker the material, the better sealing and lesser the micro-leakage. In this investigation, the thickness of the material was 3 mm [18]. Conversely, Ghulman and Gomma found a different outcome, stating that if retreatment is necessary, the 4 mm thickness of the orifice barrier makes it difficult to retrieve the material; as a result, 2-3 mm is the recommended material thickness. [19]

This study evaluated the viability of two materials to be used as intra-orifices for endodontic teeth in order to reduce coronal micro-leakage by the use of leakage of methylene blue dye. This approach was chosen due to its simplicity and reliable findings [20].

The single-cone method uses a single gutta-percha cone that is filled to room temperature with varying sealer layer thicknesses based on the degree the single cone adapts the canal. [21] In this investigation, dye penetration was higher in groups using the single cone technique than in groups using the lateral condensation technique. This could be because the technique's principal drawbacks—setting contraction, sealer dissolving, and vast volumes of porosities caused by the sealer—were caused by the excessive amounts of sealer utilized [22].

Comparing between different materials in each technique group, there was no significant differences in dye penetration between SDR and RMGI materials. RMGI has superior chemical bonding to dentin, it expands on setting due to water sorption improving its sealing ability [23]. Shafiei et al. also came to the conclusion that the poly-acrylic acid in RMGI functions as an ultra-mild self-etch when it is applied to cavity surfaces without any prior preparation [24]. It is suggested that this acid produces a nanometer sized hybrid layer with chemical bonded link with the calcium ions found in the smear layer [25]. Presence of Urethane Dimethacrylate in SDR reduces polymerization shrinkage, so that this material experiences less micro-leakage. [26]. Moreover, SDR has high adaptation to the tooth structure owing to self-leveling property [27].

A study in 2023 agreed that both materials are acceptable in micro-leakage findings [28] On the other hand, few studies dis-agreed with our results, Bilgrami et al. stated that RMGI showed unsatisfactory sealing even the chemical adhesion property. They explained the cause of its brittle nature forming cracks with thermal changes related to distress.[29] Sofiani and Sari explained the greatest micro-leakage of the RMGI was related to their dismiss to use the dentin conditioner lead to the presence of the smear layer which interfered with the bonding of the ionic material to the tooth structure[9].

With limitation of this study, our hypothesis is rejected. It was concluded that both SDR and RMGI are recommended as intra-orifice barrier material. Those materials have the credibility to complete the check list of the criteria, including easily placed, ability to attach to the tooth structure, and high density to prevent micro-leakage .On the other hand, micro-orifice barrier leakage can expose saliva and bacteria in to the gutta-percha and sealer disturbing the restorative system. Also, it is necessary to select the proper obturation technique to obtain good adhesion to tooth structure.

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