Sains Malaysiana 54(2)(2025): 547-555
http://doi.org/10.17576/jsm-2025-5402-19

Impact of Light Curing Modes on Microleakage in Alkasite and High Viscosity Glass Ionomer Cement Restorations

(Kesan Mod Pengawetan Cahaya Ringan terhadap Kebocoran Mikro dalam Alkasit dan Pemulihan Simen Ionomer Kaca Kelikatan Tinggi)

JIAN SHENG LEE & NOOR AZLIN YAHYA*

Department of Restorative Dentistry, Faculty of Dentistry, Universiti Malaya, 50603 Kuala Lumpur, Malaysia

Received: 30 June 2024/Accepted: 12 November 2024

ABSTRACT

Light curing modes influence the polymerisation shrinkage of dental materials, and subsequently affect the degree of microleakage generated from the resultant contraction stress. Alkasite and high viscosity glass ionomer cement (HVGIC) are newer light-cured tooth-coloured restorative materials for restoring posterior proximal or Class II cavities. This study investigated the impact of light curing modes and test materials on the microleakage of alkasite Cention N (CN) and Riva Light Cure HVGIC (RV). Twenty sound premolars were randomly segregated into two groups, i.e., Group CN and Group RV. Class II slot cavities of standard dimension (3 mm bucco-lingually, 2 mm mesio-distally and 5 mm occluso-gingivally) were prepared on both proximal surfaces of all teeth, resulting in twenty cavities in each group. Within groups, ten cavities were cured under high power, while the others were cured under soft-start polymerisation. The samples were then thermocycled at 5 °C and 55 °C for 500 cycles before immersion in 0.5% methylene blue dye for 24 h. The samples were sectioned mesio-distally into buccal and lingual halves. Occlusal and cervical microleakage scores were obtained under a stereomicroscope at 100× magnification. Data were analysed using the Mann-Whitney U Test and multinomial logistic regression ($p < 0.05$). Results showed that the impact of light curing mode on microleakage was insignificant. The majority of CN samples (67.5%) presented no occlusal microleakage (score 0), while RV samples (90%) presented occlusal microleakage up to enamel (score 1). Cervical microleakage was significantly higher than occlusal microleakage for both groups.

Keywords: Alkasite; high viscosity glass ionomer cement; light curing mode; microleakage; polymerisation shrinkage

ABSTRAK

Mod penyinaran lampu mempengaruhi penyusutan polimerisasi bahan pergigian dan seterusnya mempengaruhi tahap kebocoran mikro yang dihasilkan daripada tekanan susutan tersebut. Alkasit dan simen ionomer kaca bertekstur tinggi (HVGIC) adalah bahan pergigian berwarna yang dipekakan dengan cahaya yang baharu, digunakan untuk restorasi kaviti kelas II. Penyelidikan ini menganalisis kesan mod penyinaran lampu dan bahan ujian terhadap kebocoran mikro alkasit Cention N (CN) dan Riva Light Cure HVGIC (RV). Dua puluh gigi premolar yang sihat dibahagikan secara rawak kepada dua kumpulan, iaitu Kumpulan CN dan Kumpulan RV. Kaviti slot kelas II dengan dimensi piawai (3 mm buko-lingual, 2 mm mesio-distal dan 5 mm okluso-gingival) disediakan pada kedua-dua permukaan proximal semua gigi, menghasilkan dua puluh kaviti dalam setiap kumpulan. Dalam kumpulan, sepuluh kaviti dirawat di bawah kuasa tinggi, manakala sepuluh yang lain di bawah polimerisasi bermula rendah. Sampel kemudian dikitar termos pada suhu 5 °C dan 55 °C selama 500 kitaran sebelum direndam dalam pewarna metilena biru 0.5% selama 24 jam. Sampel dipotong menjadi separuh bukal dan lingual secara mesio-distal. Skor kebocoran mikro oklusal dan servikal diperoleh di bawah stereomikroskop pada pembesaran 100×. Data dianalisis menggunakan Ujian Mann-Whitney dan regresi logistik multinomial ($p < 0.05$). Keputusan menunjukkan bahawa kesan mod penyinaran lampu terhadap kebocoran mikro adalah tidak signifikan. Kebanyakan sampel CN (67.5%) tidak menunjukkan kebocoran mikro oklusal (skor 0), manakala sampel RV (90%) menunjukkan kebocoran mikro oklusal sehingga ke enamel (skor 1). Kebocoran mikro di servikal adalah signifikan lebih tinggi daripada kebocoran mikro oklusal untuk kedua-dua kumpulan.

Kata kunci: Alkasit; kebocoran mikro; mod penyinaran lampu; penyusutan polimerisasi; simen ionomer kaca bertekstur tinggi

INTRODUCTION

Dental amalgam has a long history of being the restorative material of choice, especially in the posterior stress-bearing region of the oral cavity. Following the phase-down of dental amalgam usage in 2013 (Fisher et al. 2018), researchers and clinicians pursued an alternative which has comparable or better properties than amalgam. Tooth-coloured restorative materials gained popularity by having better aesthetics and a more conservative approach to restorative treatment. Among others, composite resin (CR) is the most popular in clinical applications. However, the frequently discussed drawback of CR was polymerisation shrinkage which occurred as the distance between monomer chains shortened when weak Van der Waals forces were converted into covalent bonds during the polymerisation process. The shrinkage stress generated is attributed to interfacial gap formation and, subsequently complications such as adhesion failure and microleakage (Soares et al. 2017). According to Kidd (1976), microleakage was defined as the passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative material applied to it. Consequently, poor marginal seal led to secondary caries, pulpitis, post-operative sensitivity and ultimately failure of restorations (Mariani, Sutrisno & Usman 2018).

Malhotra and Acharya (2010) explained that the amount of polymerisation shrinkage was dependent on material placement methods and light curing protocol, along with cavity configuration factor (C-factor) and material compositions. A maximum placement of 2 mm for each increment of CR was widely accepted to be one of the strategies for the reduction of contraction stress generated by curing conventional CR, in addition to allowing complete light penetration throughout the entire thickness (Malhotra & Acharya 2010; Soares et al. 2017). However, the incremental technique could sometimes be time-consuming and technique-sensitive (Malhotra & Acharya 2010). Bicalho et al. (2014) found that higher numbers of oblique increments resulted in larger cumulative cuspal deformation than bulk-filling.

Bulk-fill restorative materials were proposed by manufacturers to have better depth of cure, thus, negating the necessity of incremental filling techniques by allowing for up to 4-5 mm of incremental thickness. The depth of cure of bulk-fill materials was increased, having higher translucency by matching the refractive indices of matrix and filler, changing the filler size and shape (Van Ende et al. 2017). Bulk-fill composite was also found to have reduced polymerisation shrinkage stress with the incorporation of higher molecular weight monomers as polymerisation modulators (Soares et al. 2017; Tiba et al. 2013).

Cention N (Ivoclar Vivadent, Schaan, Liechtenstein) is an alkasite tooth-coloured restorative material. The manufacturer claimed that Cention N (CN) had combined both the longevity and strength of amalgam restorations and caries inhibition properties from glass ionomer cement. It is a bulk-fill restorative material that has both the ability for auto-polymerisation and light polymerisation. The formulation of CN contained Isofiller, a shrinkage stress reliever that lowers polymerisation shrinkage and microleakage. A study by Kini et al. (2019) showed that CN demonstrated the least microleakage when compared to incremental placement of CR and bulk placement of GIC.

High viscosity glass ionomer cement (HVGIC) was developed for atraumatic restorative technique and paediatric dentistry (Berg & Croll 2015). HVGIC was said to combine both the advantages of higher mechanical and aesthetic properties from CR and cariostatic properties from GIC (Friedl, Hiller & Friedl 2011; Hesse et al. 2018). Besides, having light curing and high viscosity provided superior handling properties as compared to conventional self-cure GIC (Hesse et al. 2018). Microleakage comparison between light-cured HVGIC and flowable CR had also shown superior results for the former according to the manufacturer (SDI 2005). However, HVGIC has a depth of cure of only 2 mm and hence requires incremental placement for deeper cavities (SDI 2017).

As mentioned earlier, light curing protocol influences polymerisation shrinkage stress and resultant microleakage. The conventional light curing protocol involves constant and stable high intensity which accelerates curing and shortened exposure time. The soft-start technique was a protocol developed later, in which the polymerisation process is initiated with the use of low-intensity light polymerisation during the pre-gel phase, followed by high-intensity light in the post-gel phase (Dall'Magro et al. 2007). This technique was further divided into staged, ramped and pulse-delay. In staged curing, the composite restoration is cured at low intensity initially for better consistency for the finishing procedure, then, followed by a final complete cure. The ramped method involves a gradual increase in light intensity of light cure, while in the pulse delay method, composite restoration is cured in pulses of exposure separated by intervals of darkness (Malhotra & Kundabala 2010). Existing findings of literature were ambiguous (Ernst et al. 2006; Fleming et al. 2007). Ernst et al. (2006) reported that the efficacy of the soft-start technique in improving the marginal adaptability of Class V restorations is material-dependent; Fleming et al. (2007) found that the technique did not result in lesser cuspal deformation and gingival microleakage in dentine; Rodrigues Jr. et al. (2010) reported that soft-start effectively reduced the microleakage in the enamel margin but not in the dentine or cementum margins.

Compared to conventional bioactive materials, CN and HVGIC have wider indications owing to their improved mechanical and aesthetic properties (Justen et al. 2024; Kasraei et al. 2022; SDI 2023). The remineralising capabilities of these materials are desirable, especially when the resin-based composites are commonly afflicted by secondary caries (Demarco et al. 2015). Limited literature can be found discussing the effect of light polymerisation methods on the microleakage of alkasite and HVGIC. Therefore, this study aimed to investigate the impact of light curing modes on the microleakage of Class II cavities restored with alkasite and HVGIC. The null hypothesis was there no differences in microleakage between both when polymerised using different light curing modes.

MATERIALS AND METHODS

Table 1 shows the materials that were evaluated and their technical profiles. There were two bulk-fill tooth-coloured restorative materials (Cention N [CN] and Riva Light Cure HVGIC [RV]).

SPECIMEN PREPARATION

Twenty sound premolars with no restorations or cracks and extracted within six months were collected. The teeth were disinfected with chloramine T for one week and kept in distilled water at 4 °C until further use. The teeth were divided into two groups consisting of ten teeth each, i.e., Group CN and Group RV.

For all teeth in groups CN and RV, Class II slot cavities were prepared on both mesial and distal surfaces, resulting in 40 standardized cavities (n=40) in total. The dimensions of the cavities were standardized as follows: 3 mm bucco-lingual width, 2 mm mesio-distal width and 5 mm depth with a cervical margin 1 mm below the cementoenamel junction (Figure 1).

Siqveland matrix band was placed around the cavity and the restorative materials were placed according to manufacturers' instructions. For group CN, no prior conditioning was done, and the cavity was restored using CN in two layers, i.e., the first layer of 4 mm followed by a 1 mm layer. For group RV, dentine conditioner (Riva, SDI, Bayswater, Victoria, Australia) was used and HVGIC was placed in three sequential increments, i.e., first increment of 2 mm, followed by a second increment of 2 mm, and lastly third increment of 1 mm. Each increments were cured individually after placement. The measurements of each layer were standardised using a Williams periodontal probe. The mesial and distal restorations on all samples were subjected to high power and soft start polymerisation (Table 2), respectively, using a polywave light-emitting diode (LED) curing light (Bluephase®N, Ivoclar Vivadent, Schaan, Liechtenstein). The light cure unit was maintained as close as possible to the occlusal surface of restoration. A radiometer (CureRite, Dentsply, Caulk, USA) was used to measure the light intensity which was kept constant throughout the study. The proximal surfaces of the restorations were then finished using medium and fine Soflex discs (3M ESPE, Seefeld, Germany). All the samples were thermocycled at 5 °C and 55 °C for 500 cycles. Two layers of varnish were applied 1 mm away from the cavity margins. All samples were immersed in 0.5% methylene blue dye for 24 h.

MICROLEAKAGE EVALUATION

The samples were embedded in resin blocks and then sectioned in the mesio-distal direction, giving rise to buccal and lingual sections. Occlusal and cervical readings were obtained from both buccal and lingual sections, respectively (Figure 2). All samples were evaluated by a single examiner using a stereomicroscope (Olympus, Tokyo, Japan) at 100× magnification. The extent of the microleakage was scored using the ISO microleakage scoring system (ISO/TS 11405:2015) as in Table 3. Three readings from each sample were taken and checked for intra-examiner reliability.

STATISTICAL ANALYSIS

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software (version 12.0.1, SPSS Inc, Chicago, IL, USA). Intra-examiner reliability was obtained by computing weighted Kappa. Mann-Whitney U Test was conducted to investigate the impact of test materials and light curing modes on microleakage of restorations at occlusal and cervical margins respectively. The impact of test materials, light curing modes and restoration margins (occlusal or cervical) on the microleakage scores was further analysed using multivariate logistic regression.

RESULTS AND DISCUSSION

Two readings were recorded from all samples by a single examiner. The average weighted Kappa value was 0.80, which indicated a substantial level of consistency (McHugh 2012). The microleakage results and respective medians are shown in Table 4, and Figures 3 and 4. At the occlusal margin, the majority of group CN samples presented with no microleakage, i.e., 60% and 75% for high power and soft start curing methods, respectively. For group RV, 90% of samples had a microleakage score of 1 for both curing methods.

Table 5 shows the multinomial logistic regression analysis between the independent variables (i.e., materials, light curing modes and margins) and microleakage scores. The RV had a significantly higher probability of exhibiting microleakage scores of 1 and 2 than CN. The cervical margin had a significantly higher probability of displaying microleakage scores of 2 and 3. There were no differences in microleakage scores between light curing modes.

Figure 4 simplified microleakage scores into no microleakage (score 0) and presence of microleakage (scores 1, 2 and 3). It was evident that more samples had cervical microleakage (82.5%) as compared to occlusal (62.5%), regardless of materials. The difference was statistically significant ($p<0.05$).

Microleakage evaluation can be done through several methods. The simplest is direct clinical observation by tactile sensation or visual to detect discolouration. This

TABLE 1. Technical profiles and manufacturers of the materials evaluated

Material (Abbreviation/Group)	Manufacturer	Type and curing method	Resin	Filler	Filler content % (W/V)
Cention N bulk-fill (CN)	Ivoclar-Vivadent, AG, Schaan, Liechtenstein	Alkasite (Self-curing powder/liquid with optional additional light-curing)	UDMA DCP Aromatic aliphatic-UDMA PEG-400 DMA	Br-Al-Si glass filler, Ytterbium trifluoride, Isofiller (Copolymer), Calcium Barium Aluminium Fluorosilicate glass and Calcium Fluorosilicate glass	78.4/61
Riva light-cure HVGIC (RV)	SDI Limited, Bayswater, Victoria, Australia	Encapsulated resin reinforced high viscosity glass ionomer cement (light-cured)	Compartment 1: Polyacrylic acid, Tartaric acid, HEMA, Dimethacrylate-cross-linker Acid monomer	Compartment 2: Fluoro-Alumino-Silicate glass	95.0 wt

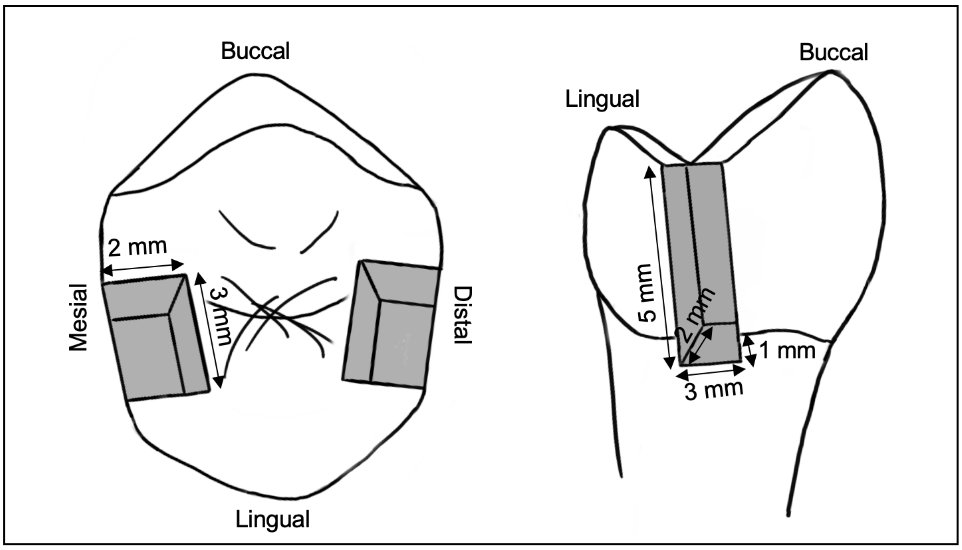

FIGURE 1. Cavity dimensions from occlusal and proximal views

TABLE 2. Light curing modes for prepared cavities on all samples

Materials	Light curing modes	
	Mesial surface	Distal surface
CN	High power	Soft-start
RV	High power	Soft-start

High power: 1200 mW/cm^2 for 10 s

Soft start: 0-650 mW/cm^2 in the beginning 5 s, followed by 1200 mW/cm^2 for 10 s

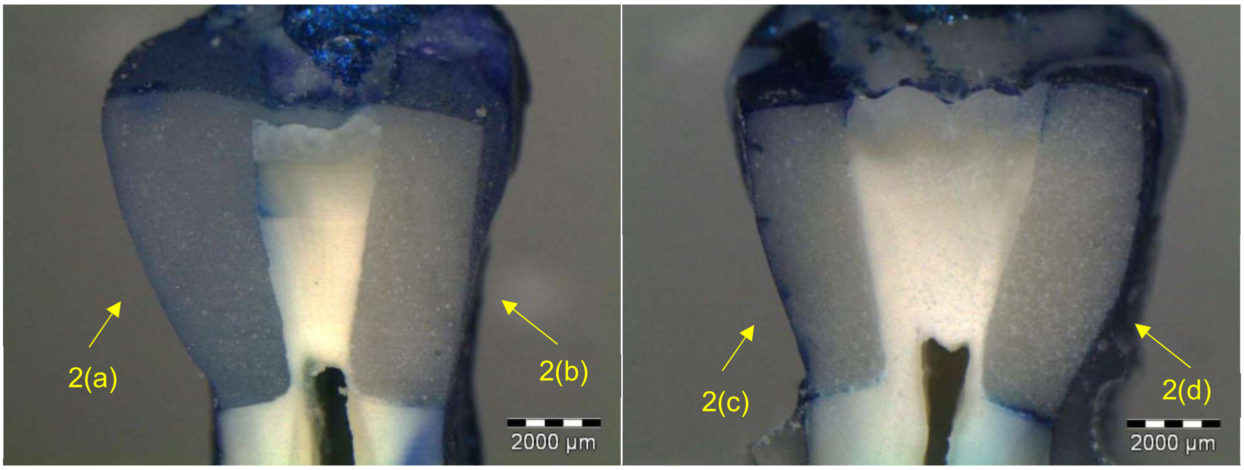

FIGURE 2. Sample of microleakage in sectioned samples, (a) CN cured under high power, (b) CN cured under soft-start, (c) RV cured under high power, and (d) RV cured under soft-start

TABLE 3. ISO microleakage scoring system (ISO/TS 11405:2015)

Score	Occlusal score	Cervical score
0	No dye penetration	No dye penetration
1	Dye penetration into enamel	Dye penetration into ½ of the cervical wall
2	Dye penetration into the dentine, not including the pulpal wall/gingival floor	Dye penetration into all the cervical wall
3	Dye penetration into the dentine including the pulpal wall	Dye penetration into the cervical and axial wall

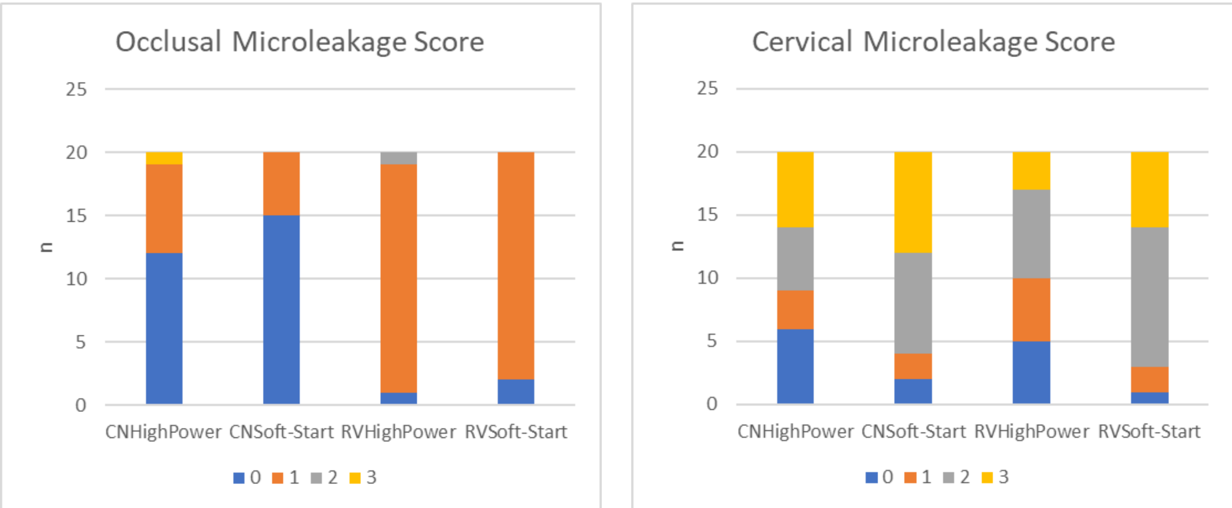

FIGURE 3. The occlusal and cervical microleakage scores of all groups (n=20)

TABLE 4. The microleakage scores and respective medians of all groups (n=20)

Material	Light curing mode	Occlusal Score, n (%)					Cervical Score, n (%)				
		0	1	2	3	Median	0	1	2	3	Median
CN	HP	12 (60)	7 (35)	0 (0)	1 (5)	0	6 (30)	3 (15)	5 (25)	6 (30)	2
	SS	15 (75)	5 (25)	0 (0)	0 (0)	0	2 (10)	2 (10)	8 (40)	8 (40)	2
RV	HP	1 (5)	18 (90)	1 (5)	0 (0)	1	5 (25)	5 (25)	7 (35)	3 (15)	1.5
	SS	2 (10)	18 (90)	0 (0)	0 (0)	1	1 (5)	2 (10)	11 (55)	6 (30)	2

CN = Cention N, RV = Riva light-cure HVGIC, HP = High power, SS = Soft-start

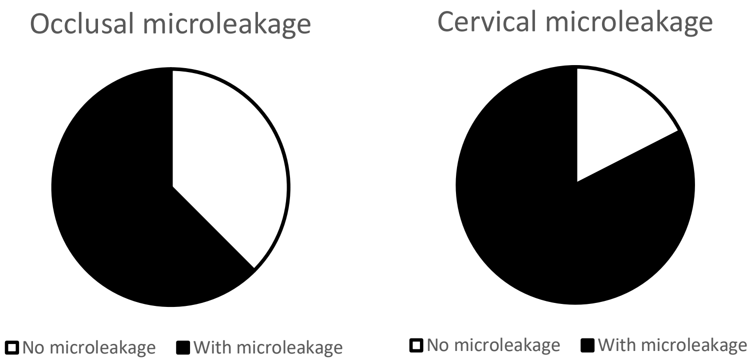

FIGURE 4. Presence of microleakage on occlusal and cervical margins of samples

TABLE 5. Multinomial logistic regression analysis between the independent variables (test materials, light curing modes and margins) and microleakage scores

Variables	Microleakage scores 1 OR (95% CI)	2 OR (95% CI)	3 OR (95% CI)
Materials			
RV	1 †	1 †	1 †
CN	0.10 (0.04 - 0.25)*	0.22 (0.07 - 0.75)*	0.55 (0.15 - 1.95)
Light curing modes			
Soft-start	1 †	1 †	1 †
High power	1.14 (0.47 - 2.80)	0.36 (0.12 - 1.12)	0.38 (0.12 - 1.24)
Margins			
Cervical	1 †	1 †	1 †
Occlusal	2.34 (0.81 - 6.76)	0.01 (0.00 - 0.12)*	0.02 (0.00 - 0.15)*

CN = Cention N; RV = Riva light-cure HVGIC; OR = odds ratio;
95% CI = 95% confidence interval; † = Reference category; * = statistically significant (p < 0.05)

study, similar to most microleakage studies, involved the use of an organic dye which penetrates the ce between restoration and tooth structure, followed by qualitative assessment using standard criteria. Quantitative methods were developed later, which employed the use of spectrophotometry and neutron activation. However, various organic dyes remain widely used today due to their cost-effectiveness and ease of use without the necessity for reactive chemicals or radiation (Bajabaa et al. 2021; Kini et al. 2019).

The polymerisation of resin composite occurred as weak Van der Waals were replaced by stronger covalent bonds that form between individual monomers (Soares et al. 2017). This in turn gives rise to volumetric shrinkage as the inter-monomer distance tightens, hence generating contraction stress towards the adhesive system and cavity walls. The shrinkage stress subsequently causes adhesion failure, microleakage and secondary caries (Mariani, Sutrisno & Usman 2018).

This study showed that the impact of light curing mode on the microleakage of samples was statistically insignificant. This finding was in agreement with several studies which reported the ineffectiveness of soft-start polymerisation in reducing microleakage (Kubo et al. 2004; Marghalani 2014; Samir, Abdel-Fattah & Adly 2020; Santos et al. 2013). The soft-start polymerisation in this study was two-stepped. The initial low intensity in the pre-gel phase allowed the low viscosity material to compensate for the contraction stress generated from the polymerisation (Rodrigues Jr. et al. 2010). The following high intensity was then required to complete the polymerisation and achieve good mechanical properties (Al-Assadi, GhaniNema & Muhamedali 2020). Yap, Soh and Siow (2002) reported that the beneficial effect of initial low-intensity curing was nullified by the final high-intensity curing at more than 500 mW/cm^2, leading to the generation of high polymerisation shrinkage towards the end of the polymerisation.

Between test materials, CN had significantly less occlusal microleakage as compared to RV. This was attributed to the presence of Isofiller which was partially functionalized by silanes acting as a shrinkage stress reliever (Ivoclar Vivadent 2016). Nanofiller silica particles or silane coupling agents allowed the resin monomer to react freely without interaction with the filler (Malhotra & Acharya 2010). Moreover, CN has a low elastic modulus at 10 GPa, which can act as an elastic buffer by increasing the flexibility of the bonded assembly and absorbing shrinkage stress (Asli et al. 2017). This finding was in agreement with multiple studies (George & Bhandry 2018; Mazumdar, Das & Das 2019; Meshram et al. 2019; Sujith et al. 2020). On the other hand, the high viscosity of HVGIC impedes good wetting of the tooth surface, thus, compromising the seal of the tooth-restoration interface. The initial setting phase of GIC is also moisture-sensitive. Early exposure to water leads to the leeching of matrix-forming ions, while excessive dehydration forms craze or cracked surfaces. Both could subsequently lead to marginal leakage (George & Bhandry 2018).

The occlusal tooth-restoration interface had significantly less microleakage in contrast to the cervical tooth-restoration interface. Most CN samples had no microleakage on the occlusal margin while the majority of RV samples had occlusal microleakage only up to enamel (score 1). On the other hand, at the cervical tooth-restoration interface, all samples presented with varying degrees of microleakage, up to the axial wall (score 3). This finding was expected and was elucidated by most of the studies (Al-Assadi, GhaniNema & Muhamedali 2020; Mazumdar, Das & Das 2019; Santos et al. 2013; Sujith et al. 2020; Zakavi et al. 2014). This was due to the homogeneity of enamel at the occlusal margin which had lower organic content (2%) than that of cervical dentine (30%). The heterogeneity of dentine and the constant outward flow of dentinal fluid made the surface a less favourable bonding substrate (Zakavi et al. 2014).

In practice, these findings suggest that clinicians should prioritise the choice of bonding materials and ensure adequate enamel presence over employing different light curing modes. Additionally, careful consideration should be given to the viscosity of the materials used to balance handling ease and effective bonding. This is particularly important in materials that require hand mixing as the powder-liquid ratio can affect their final properties.

One of the limitations of this study was the samples collected from different age groups, hence maturity and composition of the tooth may have influenced the integrity of the tooth-restoration interface. The nature of this *in-vitro* study prevented the replication of the actual clinical situation, where restorations placed were subjected to chemical challenges in the dynamic environment of the oral cavity. Visual scoring of microleakage being a qualitative assessment, also had the drawback of subjectivity when conducted by a single examiner. The microleakage results demonstrated by dye penetration can also be influenced by their pH and application times, which complicates the comparison of findings between studies. The evaluation of microleakage from more sections is also more accurate because dye penetration and interfacial gap width vary throughout the interface. This can be improved by contemporary methods such as microcomputed tomography and confocal laser scanning microscopy that provide 3D images of the sample (AlHabdan 2017).

CONCLUSION

Within the limitation of this *in-vitro* study, the following conclusions may be drawn: 1. Light curing mode had no significant impact on microleakage, 2. Cention-N samples had less microleakage than Riva HVGIC and 3. The occlusal margin had less microleakage than the cervical margin.

ACKNOWLEDGEMENTS

This project is funded by Universiti Malaya grant, UMG006E-2024. We gratefully acknowledge the staff of the Biomaterial Research Laboratory, Faculty of Dentistry, Universiti Malaya for their invaluable assistance during our laboratory sessions.

REFERENCES

Al-Assadi, H.Z., GhaniNema, T. & Muhamedali, A.M. 2020. Evaluation of the effect of different light cure devices/modes on the micro-leakage of class V composite restoration (A comparative *in vitro* study). *Annals of Tropical Medicine and Public Health* 23(S9): SP2392.

AlHabdan, A.A. 2017. Review of microleakage evaluation tools. *Journal of International Oral Health* 9(4): 141-145.

Asli, N., Nizam, N.A., Ab Aziz, Z.A. & Azami, N.H. 2017. Microleakage of different thickness of restorative materials used in endodontically treated teeth by dye penetration. *Annals of Dentistry University of Malaya* 24(2): 1-7.

Bajabaa, S., Balbaid, S., Taleb, M., Islam, L., Elharazeen, S. & Alagha, E. 2021. Microleakage evaluation in class V cavities restored with five different resin composites: *in vitro* dye leakage study. *Clinical, Cosmetic and Investigational Dentistry* 13: 405-411.

Berg, J.H. & Croll, T.P. 2015. Glass ionomer restorative cement systems: An update. *Pediatric Dentistry* 37(2): 116-124.

Bicalho, A.A., Valdívia, A.D., Barreto, B.C., Tantbirojn, D., Versluis, A. & Soares, C.J. 2014. Incremental filling technique and composite material. Part II: shrinkage and shrinkage stresses. *Operative Dentistry* 39(2): E83-92.

Dall'Magro, E., Sinhoreti, M.A., Correr, A.B., Correr-Sobrinho, L., Consani, S. & Puppin-Rontani, R.M. 2007. Effect of different initial light intensity by the soft-start photoactivation on the bond strength and Knoop hardness of a dental composite. *Brazillian Dental Journal* 18(2): 107-112.

Demarco, F.F., Collares, K., Coelho-de-Souza, F.H., Correa, M.B., Cenci, M.S., Moraes, R.R., & Opdam, N.J. 2015. Anterior composite restorations: A systematic review on long-term survival and reasons for failure. *Dental Materials* 31(10): 1214-1224.

Ernst, C.P., Brand, N., Frommator, U., Rippin, G. & Willershausen, B. 2003. Reduction of polymerization shrinkage stress and marginal microleakage using soft-start polymerization. *Journal of Esthetic and Restorative Dentistry* 15(2): 93-103.

Fisher, J., Varenne, B., Narvaez, D. & Vickers, C. 2018. The Minamata Convention and the phase down of dental amalgam. *Bulletin of the World Health Organization* 96(6): 436-438.

Fleming, G.J., Cara, R.R., Palin, W.M. & Burke, F.J. 2007. Cuspal movement and microleakage in premolar teeth restored with resin-based filling materials cured using a 'soft-start' polymerisation protocol. *Dental Materials* 23(5): 637-643.

Friedl, K., Hiller, K.A. & Friedl, K.H. 2011. Clinical performance of a new glass ionomer based restoration system: A retrospective cohort study. *Dental Materials* 27(10): 1031-1037.

George, P. & Bhandary, S. 2018. A comparative microleakage analysis of a newer restorative material–an *exvivo* study. *IOSR Journal of Dental and Medical Sciences* 17: 56-60.

Hesse, D., Bonifácio, C.C., Kleverlaan, C.J. & Raggio, D.P. 2018. Clinical wear of approximal glass ionomer restorations protected with a nanofilled self-adhesive light-cured protective coating. *Journal of Applied Oral Science* 26: e20180094.

Ivoclar Vivadent. 2016. AG Research and Development. Cention N scientific documentation.

Justen, M., Scheck, D., Münchow, E.A. & Jardim, J.J. 2024. Is Cention-N comparable to other direct dental restorative materials? A systematic review with network meta-analysis of *in vitro* studies. *Dental Materials* 40(9): 1341-1352.

Kasraei, S., Haghi, S., Farzad, A., Malek, M. & Nejadkarimi, S. 2022. Comparative of flexural strength, hardness, and fluoride release of two bioactive restorative materials with RMGI and composite resin. *Brazilian Journal of Oral Sciences* 21: e225263.

Kidd, E.A. 1976. Microleakage: A review. *Journal of Dentistry* 4(5): 199-206.

Kini, A., Shetty, S., Bhat, R. & Shetty, P. 2019. Microleakage evaluation of an alkasite restorative material: An *in vitro* dye penetration study. *The Journal of Contemporary Dental Practice* 20(11): 1315-1318.

Kubo, S., Yokota, H., Yokota, H. & Hayashi, Y. 2004. The effect of light-curing modes on the microleakage of cervical resin composite restorations. *Journal of Dentistry* 32(3): 247-254.

Malhotra, N. & Acharya, S. 2010. Strategies to overcome polymerization shrinkage - materials and techniques. A review. *Dental Update* 37(2): 115-125.

Malhotra, N. & Kundabala, M. 2010. Light-curing considerations for resin-based composite materials: A review. Part II. *Compendium of Continuing Education in Dentistry* 31(8): 584-588.

Marghalani, H.Y. 2014. The influence of different light-curing modes on microleakage of posterior resin composites. *Journal of Adhesion Science and Technology* 28(2): 136-150.

Mariani, A., Sutrisno, G. & Usman, M. 2018. Marginal microleakage of composite resin restorations with surface sealant and bonding agent application after finishing and polishing. *Journal of Physics: Conference Series* 1073(4): 042005.

Mazumdar, P., Das, A. & Das, U.K. 2019. Comparative evaluation of microleakage of three different direct restorative materials (silver amalgam, glass ionomer cement, Cention N), in class II restorations using stereomicroscope: An *in vitro* study. *Indian Journal of Dental Research* 30(2): 277-281.

McHugh, M.L. 2012. Interrater reliability: The kappa statistic. *Biochemia Medica* 22(3): 276-282.

Meshram, P., Meshram, V., Palve, D., Patil, S., Gade, V. & Raut, A. 2019. Comparative evaluation of microleakage around Class V cavities restored with alkasite restorative material with and without bonding agent and flowable composite resin: An *in vitro* study. *Indian Journal of Dental Research* 30(3): 403-407.

Rodrigues Jr., S.A., Pin, L.F.D.S., Machado, G., Della Bona, Á. & Demarco, F.F. 2010. Influence of different restorative techniques on marginal seal of class II composite restorations. *Journal of Applied Oral Science* 18: 37-43.

Samir, N.S., Abdel-Fattah, W.M. & Adly, M.M. 2020 Effect of light curing modes on polymerisation shrinkage and marginal integrity of different flowable bulk-fill composites (*in vitro* study). *Alexandria Dental Journal* 46(2): 76-83.

Santos, G.O., Poskus, L.T., Guimarães, J.G. & Silva, E.M. 2013. Influence of light-curing mode on the sealing of resin composite restoration. *Revista de Odontologia da UNESP* 35(4): 269-273.

SDI. 2023. *Riva Light Cure Light Cured Resin Reinforced Glass Ionomer Restorative Material.* Riva light cure_sdi_brochures_au.pdf Southern Dental Industries (SDI). 2017. High viscosity light cured resin reinforced glass ionomer restorative material instructions for use. SDI Limited.

Soares, C.J., Rodrigues, M.D., Vilela, A.B., Pfeifer, C.S., Tantbirojn, D. & Versluis, A. 2017. Polymerization shrinkage stress of composite resins and resin cements–What do we need to know? *Brazillian Oral Research* 31(suppl 1): e62.

Sujith, R., Yadav, T.G., Pitalia, D., Babaji, P., Apoorva, K. & Sharma, A. 2020. Comparative evaluation of mechanical and microleakage properties of cention-n, composite, and glass ionomer cement restorative materials. *The Journal of Contemporary Dental Practice* 21(6): 691-695.

Tiba, A., Zeller, G.G., Estrich, C.G. & Hong, A. 2013. A laboratory evaluation of bulk-fill versus traditional multi-increment-fill resin-based composites. *The Journal of the American Dental Association* 144(10): 1182-1183.

Van Ende, A., De Munck, J., Lise, D.P. & Van Meerbeek, B. 2017. Bulk-fill composites: A review of the current literature. *The Journal of Adhesive Dentistry* 19(2): 95-109.

Yap, A.U., Soh, M.S. & Siow, K.S. 2002. Post-gel shrinkage with pulse activation and soft-start polymerization. *Operative Dentistry* 27(1): 81-87.

Zakavi, F., Hagh, L.G., Sadeghian, S., Freckelton, V., Daraeighadikolaei, A., Ghanatir, E. & Zarnaghash, N. 2014. Evaluation of microleakage of class II dental composite resin restorations cured with LED or QTH dental curing light; Blind, cluster randomized, *in vitro* cross sectional study. *BMC Research Notes* 7(1): 1-9.

*Corresponding author; email: nazlin@um.edu.my