

# Assessment of Microleakage Using Dye Penetration Method in Primary Teeth Restored with Tooth-colored Materials: An *In Vitro* Study

Sameer Punathil<sup>1</sup>, Sultan A Almalki<sup>2</sup>, AlBandary H AlJameel<sup>3</sup>, Inderjit M Gowdar<sup>4</sup>, Vijay Amarnath MC<sup>5</sup>, Krishnarao Chinnari<sup>6</sup>

## ABSTRACT

**Aim:** The present study aimed to assess the microleakage in primary teeth restored with tooth-colored materials using the dye penetration method. **Materials and methods:** A total of 60 healthy primary molar teeth were included in this study and standardized class II mesio-occlusal cavities were prepared on the samples. Consequently, these teeth were randomly divided into three experimental groups (p) such as group I: nano-filled resin-modified glass-ionomer, group II: nanocomposite resin, and group III: Centon N. After completing all the restorations, the restored teeth were subjected to 100 cycles of thermocycling. Next, all the surfaces of the tooth, except the restoration and adjacent to the restoration margins, were covered with two coats of nail varnish. The coated teeth were then submerged in a 0.5% basic fuchsin dye solution. The teeth were then sectioned along the center of each restoration mesiodistally. Each part was visualized under a stereomicroscope at 40 magnifications to assess microleakage.

**Results:** Out of all the included restorative materials, the least microleakage was demonstrated by teeth restored by the nano-filled resin-modified glass-ionomer (RMGI) group (1.05) followed by the Centon N group (1.84) and the nanocomposite resin group (3.03).

A statistical method involving the analysis of variance revealed a statistically significant difference among the different restorative materials. Multiple comparisons among the restorative materials showed a statistically significant difference between groups I and II and groups I and III for restorative materials (p<0.05). The dye penetration score 1 was more [11(55%)] for the nano-filled RMGI group, score 3 was more [12(60%)] for the nanocomposite resin group, and score 2 was more [9(45%)] for the Centon N group.

**Conclusion:** The present study showed significantly less microleakage associated with the nano-filled resin-modified glass ionomer group, nanocomposite resin and Centon N groups.

**Clinical significance:** Since many years, dentists have encountered a challenging problem with cervical lesions. Thus, an interdisciplinary treatment approach is the appropriate option in the management of carious teeth that involve gingival recession and cervical extension.

**Keywords:** Class II cavity preparation, Microleakage, Primary molars, Thermocycling.

The Journal of Contemporary Dental Practice (2019): 10.5005/jp-journals-10024-2596

## INTRODUCTION

The steps involved in the restoration of a carious tooth are preparation of a cavity, debridement of carious tissue and caries, removal of microorganisms, and restoration of the ensuing cavity with a suitable restorative material. The objective of tooth restoration is to reestablish the esthetics of the tooth and mastication and to avoid the return of caries while preserving the biologic integrity of the teeth in harmony with the conditions of the oral cavity. The most essential factor that decides the durability of the restoration is its ability to conform to the cut tooth surface and to seal the walls of the cavity. Ideally, a firm bond between the restorative material and tooth surface should result in a snug, concealed marginal interface. Despite the stupendous technological improvement, no restorative material impeccably adheres to the tooth surface. This results in a breach along the margins of the cavity and the restorative material thus, leading to microleakage.

Microleakage includes the movement of microorganisms, fluids, and chemical compounds along with the tooth restoration interface. The consequences of such microleakage are staining, discoloration of the restoration, sensitivity of tooth, relapse of caries, and, ultimately, failure of the restoration. Based on the above-mentioned consequences, the amount of microleakage becomes an important criterion for the selection of a restorative material.

<sup>1</sup>Department of Pediatric and Preventive Dentistry, Sree Anjaneya Institute of Dental Sciences, Calicut, Kerala, India

<sup>2</sup>Department of Preventive Dental Sciences, College of Dentistry, Umm Al-Qura University, Makkah, Kingdom of Saudi Arabia

<sup>3</sup>Department of Periodontics and Community Dentistry, College of Dentistry, King Saud University, Riyadh, Kingdom of Saudi Arabia

<sup>4</sup>Department of Pedodontics and Preventive Dentistry, Subbaiah Institute of Dental Sciences, Shimoga, Karnataka, India

<sup>5</sup>Department of Pedodontics and Preventive Dentistry, Vishnu Institute of Dental Sciences, Shimoga, Karnataka, India

<sup>6</sup>Department of Pedodontics and Preventive Dentistry, Vishnu Institute of Dental Sciences, Shimoga, Karnataka, India

Corresponding Author: Sameer Punathil, Department of Pediatric and Preventive Dentistry, Sree Anjaneya Institute of Dental Sciences, Calicut, Kerala, India, Phone: +91 9526227454, e-mail: sameeralshifa@gmail.com

DOI: 10.5005/jp-journals-10024-2596

To cite this article: Punathil S, Almalki SA. Assessment of Microleakage Using Dye Penetration Method in Primary Teeth Restored with Tooth-colored Materials: An *In Vitro* Study. J Contemp Dent Pract. 2019;20(7):778-782.

Copyright © 2019, Sameer Punathil, Sultan A Almalki, AlBandary H AlJameel, Inderjit M Gowdar, Vijay Amarnath MC, Krishnarao Chinnari. All rights reserved. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) and the source are credited.

The available microleakage assays offer valuable information on the functioning of restorative materials. Various recommended methods for evaluating microleakage have been used. These include use of dyes, air pressure, radioactive isotopes, scanning electron microscope, micro-computed tomography (CT), neutron activation analysis, and bacterial activity analysis, each having both merits and demerits. Due to the lack of demonstration of the true nature of microleakage, few older methods are no longer used. Thus, this trial was carried out to compare and assess the extent of microleakage using the dye penetration method in primary teeth that were restored with tooth-colored materials.

## MATERIALS AND METHODS

This in vitro research was carried out at the Department of Pediatric and Preventive Dentistry, Sree Anjaneya Institute of Dental Sciences Kerala. A total of 60 healthy primary molars (Fig. 1) teeth extracted for various therapeutic reasons at the Department of Pediatric Dentistry were used to evaluate the extent of microleakage. All teeth were debrided and stored in distilled water at room temperature during the entire study period.

The included teeth were healthy, non-restored primary molars. The carious, fractured, or previously restored teeth were excluded from the study.

### Preparation of Class II Cavities

Class II mesio-occlusal cavities were made uniformly on the samples with the following dimensions: 2 mm wide buccolingually, 2 mm deep pulpally, and 1.5 mm wide gingival seat of the proximal box placed 1 mm above cement enamel junction. The cervical margin of the proximal box had to rest on enamel. The axiopulpal line angle was rounded and all the cavosurface line angles were butt-jointed.

The teeth were further randomly divided into three investigational groups (20, each group) and filled per the manufacturers instructions.

### Group I: Nano-filled Resin-modified Glass-ionomer

The cavity was initially treated with a thin smear of nano-ionomer primer for 15 seconds and a stream of dry air was used for 10 seconds to dry it thoroughly. With a visible light curing device, the smear

was light-cured for 20 seconds. After this, two pastes (Ketac N100 3M ESPE) of an equal amount were dispensed and mixed with a plastic spatula for 20 seconds. This mixture was then used to fill the cavity and was light-cured for 20 seconds.

### Group II: Nanocomposite Resin

The cavities in the teeth belonging to this group were rinsed with water and compressed air was used to dry it thoroughly, 37% phosphoric acid gel was used for 60 seconds for acid etching, and later, the cavity was again rinsed with water thoroughly for 30 seconds. Soon after this, compressed air was used for 15 seconds to dry the cavity completely, after which dentin primer bonding agent was coated; the bonding agent was coated onto the cavity over a duration of 60 seconds. Next, the procedure of light-curing the bonded cavity was performed for 20 seconds. Matrix bands that are translucent and supported by a retainer were used for isolation of the tooth. Nanocomposite resin (Z350, 3M ESPE Filtek™ Universal Restorative, USA) was added on to the cavity and cured increment-wise. After 15 minutes, the cured restoration was finished and polished.

### Group III: Cention N

The class II cavity prepared in teeth belonging to this group was rinsed thoroughly with water and dried with compressed air. The quantity of powder that was taken accounts for one measuring scoop and the amount of liquid taken was one drop (this matches to a ratio by weight of 4.6:1) [Ivoclar Vivadent] was taken. The powder was separated into two similar considerable parts using a plastic spatula. The liquid was spread to expand the surface. The main part of powder was mixed thoroughly with the whole liquid administered on the blending cushion. After each one of the segments has been mixed together, the remaining powder was involved and mixed until (45-60 seconds) a uniform consistency was achieved. The working time was 3 minutes from the beginning of mixing. The material was applied to the cavity, adapted, and condensed carefully. After placement, the restoration was light-cured for 40 seconds followed by finishing, polishing, and checked for occlusal high points.

After restoring all the teeth, the restored teeth were subjected to thermal cycling (100 cycles). The temperature and the duration of the thermal cycle as follows: 5°C, 30 seconds; 19°C, 20 seconds; 55°C,

Fig. 1: Primary molars used in the study

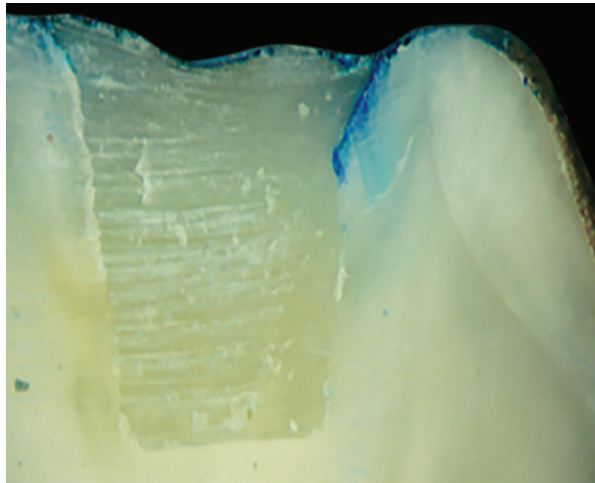


Fig. 2: Microleakage assessment using a stereomicroscope

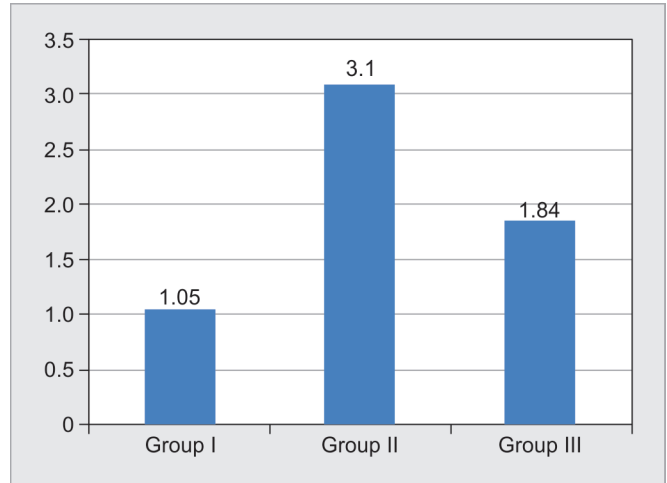


Fig. 3: Mean microleakage of three materials used in the study

30 seconds. Subsequent to thermocycling, two coats of fluoride varnish were applied onto the entire tooth surface except for the restoration and a 1-mm area around the margins of restoration. The green compound was used to mask the root apices. The teeth that were coated were later submerged for a period of 1 day at 37°C in the basic fuchsin dye solution (0.5%) (Basic Fuchsin Solution, 0.5 AQ, Rowley Biochemical, Danvers, MA). After removal from the dye, the teeth were thoroughly rinsed with water, desiccated, and then fixed in resin in advance to cutting. The teeth were cut along the mesiodistal extent over the middle of all the restorations. Each tooth part was seen under a stereomicroscope (Fig. 2) at magnification to assess microleakage. The linear diffusion of dye from the external margin of the cement was scored according to the criteria given by Popoff et al. which is as follows:  
 Score 0: No microleakage  
 Score 1: Dye penetration up to one-third of the axial wall  
 Score 2: Dye penetration up to two-thirds of the axial wall  
 Score 3: Dye penetration onto the entire axial wall  
 Score 4: Dye penetration onto the pulpal wall.

**Statistical Analysis**

A SPSS version 20 was adopted in this study. Statistical analysis was performed using the analysis of variance (ANOVA) test. The differences between each group were established using the Tukey post hoc test. The results were inferred to be statistically significant if a p value of 0.05 was obtained.

**RESULTS**

Table 1 and Figure 3 demonstrate the mean as well as the standard deviation of three restorative materials. The mean value for the nano-filled RMGI group was 1.05 – 0.21, the nanocomposite resin group was 3.10 – 0.03, and the Cention N group was 1.84.

The mean microleakage of different restorative materials is given in Table 2. Among the included restorative materials, the

Table 2: Mean microleakage of different restorative materials for the Groups

Groups	Mean – SD	F value	p value	Significance
Group I nano-filled RMGI	1.05 – 0.21	121.283	0.001	HS
Group II nanocomposite resin	3.10 – 0.03			
Group III Cention N	1.84 – 0.14			

p < 0.05; HS, highly significant

Table 3: Multiple comparisons Tukey HSD

Group	Compared with	Mean difference	J	Sig.
Group I	Group II	2.05*		0.001
	Group III	0.79		0.08
Group II	Group I	2.05*		0.001
	Group III	1.26*		0.001
Group III	Group I	0.79		0.06
	Group II	1.26*		0.001

\*Significant, p < 0.05

lowest microleakage was found to be associated with teeth restored by the nano-filled RMGI group (1.05), followed by the Cention N group (1.84) and the nanocomposite resin group (3.10). An analysis of variance revealed a statistically significant difference between the different restorative materials.

The multiple comparisons among the restorative materials are shown in Table 3. A statistically significant difference among group I vs group II and group II vs group III restorative material (p < 0.05) can be seen. However, no statistically significant difference was seen between groups I and III (5).

Table 4 shows the distribution of microleakage scores. Score 1 was more [11(55%)] among the nano-filled RMGI group, score 3 was more [12(60%)] among the nanocomposite resin group, and score 2 was more [9(45%)] among the Cention N group.

Table 1: Mean and standard deviation of three materials used in the study

Groups	n	Mean – Std. deviation
Group I nano-filled RMGI	20	1.05 – 0.21
Group II nanocomposite resin	20	3.10 – 0.03
Group III Cention N	20	1.84 – 0.14

**DISCUSSION**

There has been an endless quest for an appropriate restorative material and restoration technique that warrants firm adherence to the tooth surface with the purpose of reducing the likelihood of microleakage. It is of utmost importance to maintain the marginal seal over an extended period so as to minimize or at

Table 4: Distribution of microleakage scores

Groups	Microleakage scores of the specimens				
	Score 0	Score 1	Score 2	Score 3	Score 4
Group I nano- lled RMGI	8 (40%)	11 (55%)	1 (5%)	0	0
Group II nanocomposite resin	2 (10%)	1 (5%)	5 (25%)	12 (60%)	0
Group III Cention N	2 (10%)	8 (40%)	9 (45%)	1 (5%)	0

least stop potential problems that are encountered clinically as the marginal discoloration and secondary caries resulting microleakage.<sup>7</sup>

Microleakage that occurs along the boundary of tooth and restoration is the most challenging problem confronted with posterior resin restorations. Several different methods of restoration placement are being tried to minimize the shrinkage associated with polymerization of resins, with an objective to reduce the volume-based shrinkage and, ultimately, the bond to unbonded restoration surface.<sup>8</sup> The plastic deformation of plastic or resin flow that occurs during the polymerization may moderately compensate for the shrinkage stress that is created. The plastic deformation that is permanent mostly during the early stages of the process of setting of resin. With the ensuing process of setting, there is a steady decrease in the contraction and resin flow, resulting in increased stiffness of the kind of low-related compensation is effected by the C-Factor of restoration con guraton.<sup>9</sup>

In this study, the maximum microleakage was demonstrated by nanocomposite resin compared to other tooth-colored materials. The results of our study link with the results of studies in the past such as Derhami et al.,<sup>10</sup> Hilton et al.,<sup>11</sup> and Demarco et al.<sup>12</sup> which established the margins along the gingival surface of a composite-restored class II to be a potentially greater amount of microleakage compared to occlusal margins. This could be attributed to the reduced thickness of enamel along the cavosurface margin of the proximal aspect which requires the bonding of restorative materials to a greater amount of dentin; a complex, unreliable substance than enamel. Yet another cause for increased microleakage associated with the gingival margins is the dispersion of the light source from the restorative material at the base of the proximal box as compared to that at occlusal surfaces.

The property of the restorative material to firmly seal the margins decides its durability. Thus, the ability of restorative material to reduce the amount of microleakage along the boundary of tooth and restoration is vital in determining its clinical success. Several methods have been used to assess the degree of microleakage and the reliability of restorations along the margins. The dye diffusion method is one of the most frequently used methods. Various methods that measure the extent of microleakage have been adapted by studies that attempt to evaluate seal along the margins. These include the use of dyes, chemical markers, radioactive isotopes, air pressure, and electrochemical method. Some of the commonly used dyes are methylene blue, aniline blue, uorescein, eosin, erythrosin, and Indian ink.<sup>4</sup>

Fahmy and Farrag<sup>15</sup> used silorane or methacrylate nano- lled composite to restore primary molars that had class II cavities

in their recent study that aimed to assess the extent amount of microleakage. The methods adapted were an open sandwich, closed sandwich, and total bonding. The total bonding method demonstrated superior marginal sealing when compared with two sandwich techniques. Bezdim<sup>16</sup> demonstrated RMGI to not prevent the widespread microleakage along the margins of cervical regions of open sandwich restorations.

Nano- lled RMGI is an innovative development that scienti cally combines the pro ts of a light-cured resin-modi ed glass ionomer and nano- ller bond technology. Similar to other RMGIs, nano- lled RMGI which is a true RMGI goes through the reactions of both glass ionomer and free radical, and this has been clearly demonstrated by infrared (IR) analysis.

This study demonstrated a nano- lled resin-modi ed glass ionomer to be associated with less microleakage compared to other materials. This nding is the same as that obtained by Abd El Halim and Zaki,<sup>18</sup> who reported the bond along the tooth restoration interface to be of a higher magni cation of the nano- lled RMGI, which they showed an unclear boundary between the margin of the tooth structure and the restoration, proposing the formation of a chemical bond between the tooth and glass-ionomer cement (GIC). The most probable reason for the association of increased microleakage with GIC and RMGIC could be the nonuse of primer with these types of glass ionomers, while nano- lled RMGI has the advantage of the use of primer that has an acidic nature. The primer functions to transform the smear layer and wet the tooth surface so as to enable rm bonding between the restorative material and hard tissue.

The lowest microleakage was found to be associated with nano ionomer and was more reliable than the other materials, and adequately signi cantly well with the tooth structure. When used to restore class V cavities, it demonstrated an improved performance than the other two materials. Nano-ionomer cements have been recommended by Wadenya et al.<sup>19</sup> to be used for regular dental procedures and atraumatic restorative techniques. Upadhyay and Pascoe<sup>20</sup> reported the lowest microleakage associated with nano- lled resin-modi ed glass ionomer. The use of nano- lled resin-modi ed glass ionomer has been recommended for all types of restorations in the primary tooth and been called as tissue-speci c direct tooth repair. The smaller particle size of nano-ionomer may have provided increased surface area and improved material ow, resulting in enhanced adaptation with tooth interface.

In the current study, Cention N demonstrated less microleakage than nanocomposite resin. Cention N is a direct, tooth-colored restorative material that is used as a basic lling material. The powder contains di erent glass fillers, initiators, and pigments, while the liquid consists of dimethacrylates and initiators. Cention N displays a simple polymer network density and extent of polymerization degree of the entire depth of the restoration and this is mainly because of the unique combination of cross-linking methacrylate monomers with self-cure initiator that is stable and efficient.<sup>21</sup>

In the current study, Cention N demonstrated less microleakage than nanocomposite resin. This result is similar to the study done by Samanta et al.<sup>21</sup> stating that Cention N shows a high polymer network density and degree of polymerization over the complete depths of the restoration. It also contains a special iso ller which behaves as a shrinkage stress reliever and reduces the shrinkage force.

The least leakage at the dentin restoration junction was found with teeth restored with Cention N. This is because of the

tooth restoration interface that is largely sealed with an acid-resistant, resin dentin interdiffusion zone, i.e., a hybrid layer. The present study findings are in accordance with that of the study conducted by Lopes and Meshram and Meshram. The liquid contains four different dimethacrylates, other additives, and initiators. A combination of urethane dimethacrylate (UDMA), an aromatic aliphatic UDMA, tricyclodecane-dimethanol dimethacrylate (DCP), and PEG-400DMA cross-links during polymerization to form good long-term stability and strong mechanical properties.

However, as the present study was an *in vitro* study, other *in vivo* studies are required in the future to substantiate these results. The crucial properties such as durability of restoration, strength, and marginal adaptability should be clinically assessed.

## CONCLUSION

This study concludes that nano-filled resin-modified glass ionomer showed significantly less microleakage compared to nanocomposite resin and Cention N. In due course, it is important to design *in vivo* studies that would assess microleakage under the factual conditions of the oral environment.

## REFERENCES

- Shih W-Y. Microleakage in different primary tooth restorations. *J Clin Med Assoc* 2016;79:e228 e234. DOI: 10.1016/j.jcma.2015.10.007.
- Martin E. Adaptation and micro-leakage of composite resin study. *J Interdiscip Dentistry* 2012;2:164 169. DOI: 10.4103/2229-7819.1984.tb05303.x.
- Varpio M, Warfvinge J, et al. Proximo-occlusal composite restorations in primary molars-marginal adaptation. Bacterial penetration and pulpal reactions. *Acta Odontol Scand* 1990;48:161e7. DOI: 10.3109/00016359009005871.
- Öztürk F, Ersöz M, et al. Micro-CT evaluation of microleakage under orthodontic ceramic brackets bonded with different bonding techniques and adhesives. *Eur J Orthod* 2016;38:163 169. DOI: 10.1093/ejo/cjv023.
- Bonilla ED, Stevenson RG, et al. Microleakage resistance of minimally invasive Class I flowable composite restorations. *Oper Dent* 2012;37:290 298. DOI: 10.2341/11-106-L.
- Popo DA, Gonçalves FS, et al. Repair of amalgam restorations with composite resin and bonded amalgam: a microleakage study. *Indian J Dent Res* 2011;22:799 803. DOI: 10.4103/0970-9290.946723.
- Sahu D, Somani R, et al. Comparative evaluation of microleakage of various glass-ionomer cements in *in vitro* study. *Int J Prev Clin Dent Res* 2018;5:17 20.
- Moezyzadeh M, Kazemipour M. Effect of different placement techniques on microleakage of class V composite restorations. *J Dent* 2009;6:121 129.
- Chahreli SB, Tirali RE, et al. Microleakage of newly developed glass ionomer cement in primary teeth. *Eur J Dent* 2013;7:15 21. DOI: 10.4103/1305-7456.119058.
- Derhami K, Colli P, et al. Microleakage in Class 2 composite restorations. *Oper Dent* 1995;20:100 105.
- Hilton TJ, Schwartz RS, et al. Microleakage of four class II resin composite insertion techniques at intra oral temperature. *Quintessence Int* 1997;28:135 144.
- Demarco FF, Ramos OL, et al. Influence of different restorative techniques on microleakage in class II cavities with gingival wall in cementum. *Oper Dent* 2001;26:253 259.
- Wadenya R, Mante FK. An *in vitro* comparison of marginal microleakage of alternative restorative treatment and conventional glass ionomer restorations in extracted permanent molars. *Pediatr Dent* 2007;29:303 307.
- Youssef MN, Youssef FA, et al. Effect of enamel preparation method on *in vitro* marginal microleakage of a flowable composite used as pit and fissure sealant. *Int J Paediatr Dent* 2006;16:342 347. DOI: 10.1111/j.1365-263X.2006.00751.x.
- Fahmy AE, Farrag NM. Microleakage and shear punch bond strength in Class II primary molars cavities restored with low shrink silorane based vs methacrylate based composite using three different techniques. *J Clin Pediatr Dent* 2010;35(2):173 182. DOI: 10.17796/jcpd.35.2.u6142007hj421041.
- Beznos C. Microleakage at the cervical margin of composite Class II cavities with different restorative techniques. *Oper Dent* 2001;26(1):60 69.
- Chauhan SK, Gupta J, et al. Comparative evaluation of microleakage in Class V cavities using various glass ionomer cements. *Indian J Dent* 2013;48:113 117.
- Abd El Halim S, Zaki D. Comparative evaluation of microleakage among three different glass ionomer types. *Oper Dent* 2011;36:36 42. DOI: 10.2341/10-123-LR.
- Wadenya R, Smith J, et al. Microleakage of nano particles filled resin modified glass ionomer using atraumatic restorative technique in primary molars. *NY State Dent J* 2010;76:36 39.
- Upadhyay S, Rao A. Nanoionomer: evaluation of microleakage. *Indian Soc Pedod Prev Dent* 2011;29:21 24.
- George P, Bhandary S. A Comparative Microleakage Analysis of a Newer Restorative Material. *Indian J Oral and Maxillofacial Surg* 2018;76(12):56 60.
- Samanta S, Das UK, et al. Comparison of Microleakage In Class V Cavity Restored with Flowable Composite Resin, Glass Ionomer Cement and Cention N. *Imp J Interdiscip Res* 2017;3(8):180 183.
- Lopes M Ultra morphological study of the interface: dentin-Cention N as a function of saliva contamination and the usage of an adhesive system. *Scientific documentation of Cention N*. 2015:24 25.
- Meshram PV, Meshram VS. Comparative evaluation of microleakage around class v cavities restored with new alkasite material and two different flowable composites in *in vitro* study. *Int J Curr Res* 2018;10(04):67780 67783.