MICROLEAKAGE OF CLASS II RESTORATION WITH COMPOSITE INLAY: AN *IN VITRO* STUDY

Tran Thien Man, Ho Xuan Anh Ngoc

Faculty of Odonto-Stomatology, Hue University of Medicine and Pharmacy, Vietnam

Abstract

Aims: This study aimed to evaluate the microleakage of Class II restoration susing three different techniques. **Materials and methods:** The study was carried out in the laboratory with paired comparision between groups. Thirty Class II cavities were prepared on extracted non-carious human permanent molars, randomly divided into 3 groups, which were then restored with 3 different methods. Group 1: indirect composite inlay (Tetric N-Ceram) cemented with resin-modified glass ionomer cement (Fuji Plus); Group 2: indirect composite inlay (Tetric N-Ceram) cemented flowable composite (Tetric N-flow); Group 3: direct composite restoration using Tetric N-Ceram. Before immersed to 2% methylene blue solution for 12 hours, all restorations were subjected to thermal cycling (100 cycles 5^0C – 55^0C). The extent of dye penetration along the gingival wall was assessed using a grade scale from 0 to 3 under 40 times magnification using digital camera Nikon D7000. **Results**: All types of restorations showed some rate of microleakage. In comparing the three techniques, group 1 demonstrated the significantly higher rate of leakage compared to the others ($p<0.05$), where as group 2 and 3 showed no significant difference. **Conclusion**: None of these three techniques is perfect to impede microleakage. Among the above-mentioned restorative methods, a considerably higher rate of microleakage exists when applying composite inlay cemented with Fuji Plus in comparison with the others. Composite inlay cemented with flowable composite (Tetric N – Flow) and direct composite restoration make no significant difference in their ability to prevent microleakage.

Key words: *Composite, Composite inlay, Composite restoration.*

1. BACKGROUND

The treatment of class II composite restoration faces various difficulties, such as cracking, restoration dislogment, open contact, marginal gap formation because of polymerization shrinkage, microleakage and differences of thermal expansion coefficent between composites and dental hard tissue [9]. Therefore, various techniques were introduced to improve the quality of Class II restoration, including indirect composite inlay. This technique was introduced in the early 1980's with the goal of decreasing weaknesses of direct composite restoration [8]. It is said that the technique can overcome challenges faced with direct composite technique such as isolation, post – treatment sensivity. The technique can produce acceptable or excellent clinical outcomes and are easier to fabricated as well as less expensive than ceramics [14]. Many studies evaluating the microleakeage around the margin of dental restorations were carried out worldwide to provide the best option for clinical treatment. In Vietnam, to the best of our knownledge, there are only in vitro studies evaluating the microleakage of direct composite restoration [3], [4] or of ceramic inlays [1], [2], [5]. Therefore the aim of this study were to:

- *Evaluate the microleakage of Class II restorations using direct composite restoration, indirect composite inlay cementedwith Fuji Plus and indirect composite inlay cemented with flowable composite Tetric N-flow.*

- *Compare the microleakage of the three techniques.*

Corresponding author: Tran Thien Man, email: thienmantranrhm@gmail.com
*- Received: 10/06/2015 * Revised: 30/06/2015 * Accepted: 10/07/2015*

2. MATERIALS AND METHODS

2.1. Sample preparation

In this study, 30 extracted human premolars (15 teeth) and molars (15teeth) which are non – carious and mature were used. They were randomly assigned into 3 groups: 5 molars and 5 premolars per group.Teeth were fixed in the cast and the mesial – occlusal inlay cavity was prepared with following criteria:

Table 1. Dimensions of preparations

Dimensions		Molars (mm)	Premolars (mm)
Width of isthmus		2.5	1.5
Mesio – distal width of occlusal cavity.		6	4
Pupal depth		2	2
Depth of proximal cavity (from the floor of occlusal cavity)		2	2
Proximal cavity	buccolingual	2	2
	mesiodistal	2	2
Cavity divergence: 5 degree Gingival margin was placed in enamel.			

For specimens of group 1 and 2, after cavity preparation, a single impression was made with vinyl polysiloxane materials and poured with stone, followed by the application of separating medium. The inlays were built up and polymerized with composite layers (Tetric N-Ceram) on stone dye. The inlays were then trimmed until and appropriate seating was archived. Polishing was carried out with flexible disks.

2.2. Restorative procedure

- Group 1: indirect composite inlay (Tetric N-Ceram) cementedwith Fuji Plus:

Prepared cavity was cleaned and dried. Resin-modified glass ionomer cement (RMGC) Fuji Plus was placed into the cavity and on the inlay which was then placed into the cavity. Excess luting material was remove and the inlay was keep in place for setting.

- Group 2: indirect composite inlay (Tetric N-Ceram) cementedwith flowable composite (Tetric N-Flow):

Prepared cavity was cleaned and dried, followed by 37% Phosphoric acid placement into the cavity for 15 seconds. The cavity was cleaned again with water and then dried with gentle air before priming and bonding procedure. Inlay was placed into the cavity which was filled with a thin layer of flowable composite (Tetric N-Flow). Excess composite was removed, followed by light – curing polymerization for 40 seconds each wall (buccal, lingual and occlusal).

- Group 3: direct composite restoration (Tetric N-Ceram):

Prepared cavity was cleaned and dried, followed by 37% phosphoric acid placement into the cavity for 15 seconds. The cavity was cleaned again with water and then dried with gentle air before priming and bonding procedure. A thin layer of flowable composite (Tetric N-Flow) was filled into the cavity and then light – cure for 20 seconds. The restoration was carried out using incremental layering techniques.

2.3. Assessment procedure

After cementation, the specimens were removed from the cast and immersed into sodium chloride 0.9% solution for 24 hours. All of the restored teeth were then subjected to 100 cycles of thermal stress in which the teeth were alternatively immersed in water baths of 5^{o}C and 55^{o}C in a dwell time of 25 seconds and a transfer time of 5 seconds. The root apexes were sealed by wax. All of the restored teeth were entirely coated with a thin layer of bonding agent, except for the

restoration and 1mm around the restoration margin. Light – curing polymerization was carried out for 20 seconds after wards. The specimens were then treated with 2 layers of nail varnish in a similar way with bonding agent. The restorations were soaked in 2% Methylene blue solution for 12h and then were cleaned. Sectioning the restoration was mesio-distally done by low-speed diamond blades at the center of the restoration. Polishing was achieved with flexible disks. Nikon D7000 with 40 times magnification was used to examine the sections. The penetration degree of the methylene blue solution was measured as follows [1], [5]:

0: no penetration.

1: penetration to less than half of gingival wall.

2: penetration to less than half of gingival wall but not to axial wall.

3: penetration to axial wall.

The penetration was measured on both sectioned halves of the restoration. The higher penetration degree was chosen as the penetration degree of the tooth. Data were statistically analyzed using the Mann – Whitney U – test for pairwise comparison at a significance level of $p < 0.05$ (SPSS 20.0).

3. RESULTS

Table 2. Analytic resultsof the degree of microleakage between group 1 and group 2

Group	Number of teeth	Mean ± SD	Mean rank	Sum of ranks
Group 1 Composite inlay - Fuji Plus	10	2.3 ± 0.8	14.1	141.0
Group 2 Composite inlay - Tetric N-Flow	10	0.8 ± 1.0	6.9	69.0
Total	20			
p	**0.005 < 0.05**			

The comparison results reveals that microleakage degee in Group 1 is significantly higher than that of Group 2, with p-value = 0.005 < 0.05.

Table 3. Analytic results of the degree of microleakage between group 1 and group 3

Group	Number of teeth	Mean ± SD	Mean rank	Sum of ranks
Group1 Composite inlay - Fuji Plus	10	2.3 ± 0.8	13.4	134.0
Group3 Direct composite Tetric N-Ceram	10	1.2 ± 1.0	7.6	76.0
Total	20			
p	**0.023 < 0.05**			

The comparison results reveals that microleakage degee in Group 1 is also significantly higher than that of Group 3, with p-value = 0.023 < 0.05.

Table 4. Analytic results of the degree of microleakage between group 2 and group 3

Group	Number of teeth	Mean ± SD	Mean rank	Sum of ranks
Group2 Composite inlay - Tetric N-Flow	10	0.8 ± 1.0	9.3	93.0
Group3 Direct composite Tetric N-Ceram	10	1.2 ± 1.0	11.7	117.0
Total	20			
p	**0.34 > 0.05**			

The comparison results reveals that microleakage degee in Group 3 tends to higher than that of Group 2, with p-value = 0.34> 0.05.

4. DISCUSSION

All of the subjects in this study exhibited some degree of microleakage. The result is in agreement with the study of Browning et al. (1997). The authors stated that microleakage can be found between tooth substrate and marginal restoration which is fabricated from polymer – based materials [7]. This finding is similar to other reported studies [11], [14], [16]. The reason could be due to the broken adhesive bond that occurs due to unavoidable polymerization contraction of the material when set [14]. In addition, Gerdolle D. A. (2005) stated shrinkage stress inherited in composite resin could be strong enough to form marginal gap and following leakage [12]. Resin - modified glass ionomer cement (RMGIC) (Fuji Plus) has a different setting mechanism which reacts through an acid – base procedure [13]. In this setting procedure, volumetric shrinkage can occur through a polymerization process involving the reaction between 2-hydroxyethyl methacrylate (HEMA) and urethane dimethacrylate – based monomers[13], [14].

According to leakage scores (table 2 and 3) marginal sealing efficacy using RMGIC (Fuji Plus) was significantly lower than those of the two resin composites. This finding is in line with other studies [1], [12], [14]. As mentioned above, marginal gap formation in the initial phase of setting process of luting agent can lead to subsequent leakage. Therefore, the larger rate of the cement setting shrinkage is the higher degree of the leakage could be. Irie M. (2001) demonstrated that the rate of setting shrinkage of Fuji Plus is significantly higher than those of the two other resin – based cements (Compolute and Panavia 21) [14]. More over, marginal gap formation also depends on the bond strength of the luting material. If the bond strength of the luting material is high enough to compensate for the stress shrinkage itself, the marginal gap formation will not occur [14]. RMGIC was proved to have weaker bond strength to tooth structures compared to resin composite [11], [15] that could explain the high level of leakage.

The present study demonstrated that group 2 (composite inlay – Tetric N-Flow) has an insignificantly lower degree of microleakage than group 3 (direct composite restoration) does. This finding concurs with the study of Alavi, Kianimanesh (2002) which reported that there is no significant difference of microleakage between direct and indirect composite restorations in class V cavity [6].

Other studies illustrated the differences. Travis S. và Martin F. E. (1993) examined 32 class II restorations using direct and indirect composite inlays and they reported the indirect restorations have the significantly lower dye penetration compared to direct restorations [18]. Some studies had similar findings with those authors [14], [16]. Meanwhile, Yanikoglu F. (1990) conducted a study comparing the microleakage between direct composite technique and direct inlay technique that showed the significantly less microleakage of the direct composite placement [19].

Theoretically, indirect composite inlay which has its volumetric shrinkage taken place extraorally should reduce marginal gap formation. Therefore, this technique should show more benefits than direct composite restoration in terms of decreasing initial gap formation and subsequent microleakage [10]. However, this study showed no significant difference between the two techniques. One possible explanation could be the location of the finishing line. Alavi, Kianimanesh (2002) demonstrated shrinkage stress has the most significant influence on marginal gap formation when the gingival margin is placed in dentin or cementum, especially in class II restoration [6]. Additionally, Soares C.J. et al. (2005) related that there was no significant difference between the direct and indirect restoration in relation to microleakage when the gingival margin was placed in the enamel [17]. In the present study, the preparation gingival margin placed in enamel was used and that could explain for the results.

5. CONCLUSION

None of the 3 techniques perfectly prevented microleakage. For all of the mentioned restorative techniques, composite inlay cemented with Fuji

Plus showed the significantly higher rate of microleakage compared to the others. Composite inlay cemented with flowable composite (Tetric N – Flow) and direct composite restoration were not significantly different in the ability of preventing microleakage.

REFERENCES

1. Võ Văn Nhân, Hoàng Tử Hùng, Hoàng Đạo Bảo Trâm (2011), "Giới thiệu hệ thống CAD/CAM Nha khoa (Hệ thống Cerec 2) và ứng dụng nghiên cứu in vitro vi kẽ phục hồi xoang loại II", *Tuyển tập công trình nghiên cứu khoa học Răng Hàm Mặt,* NXB Trường Đại học Y Dược TP. HCM, tr. 111 - 120.
2. Hoàng Đạo Bảo Trâm, Hoàng Tử Hùng (1999), *Đánh giá in vitro vi kẽ của phục hồi xoang loại II sử dụng SONICSYS*, Luận văn thạc sĩ Trường Đại học Y Dược TP. HCM.
3. Nguyễn Thị Thanh Vân, Hoàng Tử Hùng (1999), "Ảnh hưởng của kỹ thuật trám composite lên sự hình thành vi kẽ", *Tuyển tập công trình nghiên cứu khoa học Răng Hàm Mặt,* NXB Trường Đại học Y Dược - TP.HCM, tr. 76 - 92.
4. Dương Thị Hoài Xuân, Hoàng Tử Hùng (1999), "Đánh giá in vitro sự hình thành vi kẽ bờ nướu miếng trám composite trực tiếp xoang loại II", *Tuyển tập công trình nghiên cứu khoa học Răng Hàm Mặt,* NXB Trường Đại học Y Dược - TP. HCM, tr 93 - 104.
5. Nguyễn Thị Kim Yến, Hoàng Tử Hùng (2011), "Đánh giá in vitro vi kẽ trong phục hồi xoang loại II sử dụng Inlay Cerana", *Tuyển tập công trình nghiên cứu khoa học Răng Hàm Mặt,* NXB Trường Đại học Y Dược - Thành phố Hồ Chí Minh, tr. 98 - 105.
6. Alavi A. A., Kianimanesh N. (2002), "Microleakage of direct and indirect composite restorations with three dentin bonding agents", *Oper Dent,* 27 (1), pp. 19-24.
7. Browning W. D., Safirstein J. (1997), "Effect of gap size and cement type on gingival microleakage in Class V resin composite inlays", *Quintessence Int,* 28 (8), pp. 541-544.
8. Burke F. J., Watts D. C., Wilson N. H., Wilson M. A. (2011), "Current status and rationale for composite inlays and onlays", *Br Dent J,* 170 (7), pp. 269-273.
9. Dietrich T., Losche A. C., Losche G. M., Roulet J. F. (2010), "Marginal adaptation of direct composite and sandwich restorations in Class II cavities with cervical margins in dentine", *J Dent,* 27 (2), pp. 119-128.
10. Gaber D.A. (1994), *Porcelain & Composite Inlays & Onlays: Esthetic Posterior Restorations,* Quintessence Publishing, pp. 129.
11. Gallo J. R., Comeaux R., Haines B., Xu X., Burgess J. O. (2001), "Shear bond strength of four filled dentin bonding systems", *Oper Dent,* 26 (1), pp. 44-47.
12. Gerdolle D. A., Mortier E., Loos-Ayav C., Jacquot B., Panighi M. M. (2005), "In vitro evaluation of microleakage of indirect composite inlays cemented with four luting agents", *J Prosthet Dent,* 93 (6), pp. 563-570.
13. Gladys S., Van Meerbeek B., Lambrechts P., Vanherle G. (2008), "Marginal adaptation and retention of a glass-ionomer, resin - modified glass-ionomers and a polyacid-modified resin composite in cervical Class-V lesions", *Dent Mater,* 14 (4), pp. 294-306.
14. Irie M., Suzuki K. (2001), "Current luting cements: marginal gap formation of composite inlay and their mechanical properties", *Dent Mater,* 17 (4), pp. 347-353.
15. Nakanuma K., Hayakawa T., Tomita T., Yamazaki M. (1998), "Effect of the application of dentin primers and a dentin bonding agent on the adhesion between the resin - modified glass-ionomer cement and dentin", *Dent Mater,* 14 (4), pp. 281-286.
16. Shortall A. C., Baylis R. L., Baylis M. A., Grundy J. R. (1989), "Marginal seal comparisons between resin-bonded Class II porcelain inlays, posterior composite restorations, and direct composite resin inlays", *Int J Prosthodont,* 2 (3), pp. 217-223.
17. Soares C. J., Celiberto L., Dechichi P., Fonseca R. B., Martins L. R. (2005), "Marginal integrity and microleakage of direct and indirect composite inlays: SEM and stereomicroscopic evaluation", *Braz Oral Res 2005 Oct-Dec,* 19(4), pp. 295–301.
18. Travis S., Martin F.E. (1993), "In-vitro Microleakage around Posterior Composite restorations and Posterior Composite Inlays", *J Dent Res 1993 April,* Australian and New Zealand Division 105, pp. 23-27.
19. Yanikoglu F., Schere W. (1990), "Comparison of microleakage between direct placement technics and direct inlay technics", *J Marmara Univ Dent Fac,* 1 (1), pp. 40-46.