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# MICROLEAKAGE EVALUATION OF LABORATORY-PROCESSED MOD RESIN COMPOSITE INLAYS BONDED TO DENTIN BY THREE RESIN CEMENT STRATEGIES

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## *ABSTRACT*

**Objective:** To evaluate microleakage of indirect resin composite inlays luted to dentin with three resin cement strategies in MOD Class II restorations after specimens storage in various media and different periods of time.

**Materials and Methods:** Intact 48 freshly extracted human third molars were collected and disinfected. Then, MOD Class II cavity design was prepared in all selected teeth. These prepared teeth were assigned into three major sets (n=16) regarding to the luting cement (etch-and-rinse, self-etch and self-adhesive), and restored with the indirect composite inlays. Each set was divided (n=8) according to the aging medium into distilled water and lactic acid, only four restored teeth were kept in each aging medium for 24 h, whereas the remaining was immersed for 168 h. All the specimens were covered by double coats of nail varnish till 1 mm away from the margins of restoration and sunken in a 2% methylene blue solution for one day. Each specimen was cut into two halves in mesio-distal direction then examined by Stereomicroscope. Pearson Chi-Square Test was used to analyze the collected scores.

**Results:** Pearson Chi-Square Test revealed that, there was a significant difference ($p<0.05$) between the three resin cement strategies in each storage medium and time. Etch & rinse (All-Bond 2/Choice) resin cement recorded the highest scores of dye penetration and self-etch (Panavia F2.0) resin cement showed the lowest scores.

**Conclusions:** Resin cement strategy, storage media and times showed a noticeable impact on the bond durability and microscopic gap formation between dentin and luting cement.

**KEYWORDS:** Laboratory-processed resin composite inlays, Resin cement, Microleakage

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## INTRODUCTION

As the result of the expanded requests for esthetic restorations and preservation of dental substrate, resin composites in gathering with adhesive systems are used as direct posterior restorations[1]. From the standpoint of clinical applications, direct restorations are usually more preferred because of easy handling and time saving, however, they have their own inherent limitations, such as polymerization shrinkage stresses, inadequate polymerization in interproximal areas, restoration of proximal contacts and dental contours[2]. Dental restorations made from indirect resin composite offer some benefits as compared to direct resin composite restorations, such as better mechanical performance and a significant reduction in polymerization shrinkage. Therefore, they could provide longer service time and better color stability and would reduce postoperative sensitivity[3].

Luting cements are appeared for keeping the restorations in a stabilized and durable within the oral cavity[4]. Resin cements are the material of choice for cementation of indirect adhesively cemented restorations. These have improved physical characteristics, lower solubility & better wear resistance and marginal closure. The longevity of indirect restorations is directly related to the adhesive effectiveness between dental tissues and resin cements. Therefore, a durable bond at the tooth restoration interface is fundamental for long-term success of an adhesive restoration.[5] Abundant innovations result in resin composite cements manufacturing which possess the identical structure of resin based restorative material but with reduced filler load for minimizing stickiness and permitting greater restoration adaptation to cavity wall[6, 7]. It can be hard for selecting the adequate resin cement to be used, because of many dentin adhesives production so as to obtain a proper adhesion between resin cement and tooth substrate[8]. Resin cements are classified regarding to dental surface pretreatment into: (1) etch-and-rinse, (2) self-etch, (3) self-adhesive[9, 10].

Etch & rinse resin cement strategy depends on application of etch & rinse bonding system succeeded by low viscous resin composite. Hence, it relies on many steps that are sophisticated, sensible and extra liable to manipulation faults as salivary infection which might impair the cement bond strength[8]. Meanwhile, self-etch resin cement strategy includes acidic monomers that join both etching and priming procedures into sole step, followed by the adhesive resin[11]. Self-adhesive resin cements become popular and widespread used to facilitate and lessen the application stages besides period wasted throughout adhesion process. They do not request dental substrate or restoration surface pretreatment[12]. The prevalent usage of resin cements and their subjection to the oral cavity need that, they reveal considerable sturdiness that could be accomplished by their impedance versus degeneration with diets, acids produced by plaque and enzymes that can be responsible for physical or chemical changes to the resin material like cement solubility. Resin cement absorbs water or any chemical substances, and liberate some ingredients resulting in its degeneration in consequence, failure of restorations[13]. Another features for example microleakage, sensibility after restorative technique, recurrent caries and restoration's stability, furthermore the cement biocompatibility, strength and volumetric stability are influenced by the disintegration of the cement[14, 15].

Microleakage is known as imperceptible passage of liquids, bacteria and ions via a microgap between the cavity wall and restoration that has an effect on the durability of restoration and is responsible for post-operative sensitivity, and marginal discoloration[16]. The penetration of cariogenic bacteria leads to reproduction of caries, inflammation and necrosis of the pulp[17]. Marginal seepage is caused due to numerous agents, involving improper adhesion between resins cement and tooth structure. Consequently, inlay marginal adaptation is an essential element that has an important function on the durability of the restorations[18]. Earlier researches assessed resin cements solubility in various storage media like water, artificial saliva, and ethanol. While, little studies estimated the influence of acids produced by the dental plaque like lactic acid on these properties. Previous results revealed that, lactic acid that is recognized as a major byproduct of bacterial metabolism in human dental plaque had injurious influence on resin cement breakdown[19, 20]. Therefore, laboratory investigation is essential for the evaluation of microleakage of indirect MOD resin composite inlays luted to dentin using different resin cement strategies after specimens' storage in distilled water and lactic acid for 24 h and 168 h.

## MATERIALS AND METHODS

Laboratory-processed resin composite inlays, SR Nexo (Ivoclar Vivadent AGSchaan, Liechtenstein) luted with three resin composite cements: an etch-and-rinse dual-cured All-Bond 2/Choice (Bisco, Inc., Schaumburg, IL, USA), self-etch dual-cured Panavia F2.0 (Kurary medical, Okayama, Japan) and self-adhesive dual-cured Maxicem (Kerr, Orange, CA, USA). The details of all materials is presented in **Table 1 and 2**.

Table (1) Indirect resin composite restorative system

| Material | Composition | Manufacturer |
|---|---|---|
| **SR Nexo liner** | Dimethacrylates (48wt.%), barium glass filler, silicone dioxide (51wt.%), additional contents are catalysts, stabilizers and pigments (<1wt.%). | Ivoclar Vivadent AG Schaan, Liechtenstein |
| **SR Nexo paste** Layering materials (incisal & dentin) | Dimethacrylates (17-19wt.%), copolymer and silicone dioxide (82-83wt.%), inorganic filler (64-65wt.%), inorganic filler (64-65wt.%) (<1wt.%). | Ivoclar Vivadent AG Schaan, Liechtenstein |

Freshly extracted sound human third molars were collected for the study. The ethics committee at Mansoura University granted ethical approval before commencement of the study. Teeth were hand-scaled (Zeffiro, Lascod, Florence, Italy), decontaminated in aqueous solution of 0.5% chloramine for 48 hours and inspected by binocular Stereomicroscope 30)X magnification, SZ TP, Olympus, Tokyo, Japan) to preclude the defective teeth. A total of 48 molars were chosen, preserved in distilled water and refrigerated at 4$^{o}$C

TABLE (2). Resin composite cements

| Resin cement | Components | Composition | Manufacturer |
|---|---|---|---|
| **All-Bond 2/ Choice** | Uni-Etch | 32% Phosphoric acid gel, xanthum gum thickener | Bisco, Inc., Schaumburg, IL, USA |
| | Primer A | NTG-GMA, acetone, ethanol, water | |
| | Primer B | BPDM, photoinitiator, acetone | |
| | Pre-Bond resin | Bis-GMA, TEGDMA, benzoyl peroxide, BHT | |
| | D/E bonding resin | Bis-GMA, UDMA, HEMA | |
| **Panavia F 2.0** | ED primer: | | Kurary medical, Okayama, Japan |
| | Primer A | HEMA,10- MDP, chemical initiator, water, 5-NMSA | |
| | Primer B | 5-NMSA, chemical initiator, water panavia F2.0 | |
| | A paste | Quartz, glass,10- MDP, methacrylate, photoinitiator | |
| | B paste | Silanated barium glass, NaF, methacrylate, chemical initiator | |
| **Maxcem** | | GPDM, functional metacrilates, initiators, stabilizers, barium glass and aluminium–fluoride–silicate glass | Kerr, Orange, CA, USA |

until being used. The distilled water was changed periodically every 5 days. For teeth firmness, the roots were submerged inside a cylindrical shaped polyvinyl chloride rings, 1 mm beneath cemento-enamel junction, utilizing auto-cured acrylic resin (Acrostone, Cairo, Egypt). Initial impression was taken for every tooth prior to the cavity preparation. A particular inlay kit (Komet, Brasseler GmbH & Co. KG, Lemgo, Germany) was utilized for the preparation of MOD cavity design together with high speed handpiece and water coolant.

For cavity measurements standardization, the handpiece was secured in a distinctive device that was formed at Production Engineering and Mechanical Design Department, Faculty of Engineering, Mansoura University. The dimensions were 4 mm buccolingual width, 3 mm isthmus depth, 4 mm mesial and distal depth and 1.5 mm gingival floor width from the margin to axial wall. A final impression was taken for every MOD cavity, then delivered to the technician for inlays fabrication relative to manufacturer's references. At first, a model sealer was placed to stiffen the surface of the die stone, followed by the application of SR model Separator in two thin coats (3 minute/coat). A thick layer of SR Nexco Liner was positioned over the cavity walls and floor then light-cured using LED Bluephase C5 (Ivoclar, Vivadent, Amherst, NY, USA) with an output density of 655 mW/cm2. The irradiance was checked prior every procedure using Demetron LED light meters (Demetron Research Corp., Danbury, CT, USA).

The inlay was built up by incremental application and curing of SR Nexo Dentin and SR Nexo Incisal. After that, the outer surface of all inlays was covered by SR Nexo gel before placing in the furnace (Targis Power TP3 Upgrade, Ivoclar Vivadent AG Schaan, Liechtenstein) to complete the polymerization process. Inlays were finished by flexible discs (Sof-Lex XT Pop On, 3M ESPE) according to the recommended grit sequence and polished by leather buff wheels together with Universal Polishing Paste (Ivoclar Vivadent AG Schaan, Liechtenstein). Finally, the internal surfaces of all inlays were sandblasted using 80-100 µm AL2 O3 at 1 bar pressure so as to have a potent bond to the luting resin cement.

Regarding to resin cement strategy used for luting the indirect inlays, the 48 prepared MOD cavities with corresponding restorations were randomly assigned into three major sets (n=16): etch-and rinse All-Bond 2/Choice, self-etch Panavia F2.0 and self-adhesive Maxcem. The cementation process was carried out in relation to the manufacturer's recommendations. Each set was equally divided (n=8) according to the aging medium into distilled water and lactic acid. After that, only four restored teeth were kept in each aging medium for 24 h, whereas the remaining was immersed for 168 h (one week). Subsequent to aging, all the specimens were covered by double layers of nail varnish except the restorations and 1mm away from their margins and sunken in a 2% methylene blue solution for one day. Each specimen was perfectly washed by running water and cut in mesio-distal direction using an automated diamond saw (Isomet 4000, Buehler Ltd., Lake Bluff, IL, USA) under profuse water coolant. A horizontal cut was done 1mm below cemento-enamel junction to obtain two halves that used for score inspection of dye penetration under Stereomicroscope as illustrated in **Table 3** [21].

TABLE (3) Dye penetration scoring system for microleakage

| Score | Specification |
|---|---|
| **0** | No dye penetration |
| **1** | Dye penetration extending less than or up to one half of cervical wall |
| **2** | Dye penetration greater than one half of the cavity depth but not extending to the axial wall |
| **3** | Dye penetration to and along the axial wall |

**Statistical Analysis**

The scores were collected and statistically analyzed using Pearson Chi-Square Test.

## RESULTS

There was a significant difference ($p<0.05$) between all the resin cements. The greatest scores of dye penetration were gained from specimens cemented by All-Bond 2/Choice resin cement, followed by Maxcem resin cement, while the lowest ones were attained with Panavia F2.0.

Concerning with storage medium types, results indicated a significant difference ($p<0.05$) between both types of storage media where, lactic acid exhibited the huge scores of dye penetration, meanwhile distilled water revealed the least ones.

In case of the different periods of storage time, a significant difference ($p<0.05$) was recorded between the two aging periods, where 168 h storage time demonstrated bigger scores of dye penetration than 24 h. Results are manifested in **Table 4.**

TABLE (4) Pearson Chi-Square results

| Material | | Scores | | | | Total | P-value |
|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | | |
| All-Bond 2/Choice | Number | 6 | 24 | 20 | 14 | 64 | 0.055 |
| | Percentage | 9.4% | 37.5% | 31.3% | 21.8% | 100% | |
| Panavia F2.0 | Number | 20 | 32 | 10 | 2 | 64 | |
| | Percentage | 31.3% | 50% | 15.6% | 3.1% | 100% | |
| Maxcem | Number | 10 | 30 | 18 | 6 | 64 | |
| | Percentage | 15.6% | 46.9% | 28.1% | 9.4% | 100% | |
| Total | Number | **36** | **86** | **48** | **22** | **192** | |
| | Percentage | 18.8% | 44.8% | 25.0% | 11.5% | 100% | |
| Storage media | | Scores | | | | Total | P-value |
| | | 0 | 1 | 2 | 3 | | |
| Distilled water | Number | 28 | 50 | 15 | 3 | **96** | 0.0001 |
| | Percentage | 29.2% | 52.1% | 15.6% | 3.1% | 100% | |
| Lactic acid | Number | 8 | 36 | 33 | 19 | **96** | |
| | Percentage | 8.3% | 37.5% | 34.4% | 19.8% | 100% | |
| Total | Number | **36** | **86** | **48** | **22** | **192** | |
| | Percentage | 18.8% | 44.8% | 25.0% | 11.5% | 100% | |
| Storage time | | Scores | | | | Total | P-value |
| | | 0 | 1 | 2 | 3 | | |
| 24 h | Number | 34 | 50 | 9 | 3 | **96** | 0.0001 |
| | Percentage | 35.4% | 52.1% | 9.4% | 3.1% | 100% | |
| 168 h | Number | 2 | 36 | 39 | 19 | **96** | |
| | Percentage | 2.1% | 37.5% | 40.6% | 19.8% | 100% | |
| Total | Number | **36** | **86** | **48** | **22** | **192** | |
| | Percentage | 18.8% | 44.8% | 25.0% | 11.5% | 100% | |

## DISCUSSION

A laboratory processed resin composite was chosen in the current study due to its minimal cost, low polymerization shrinkage and enhanced mechanical behavior, which permit it to be utilized as a substitute for direct posterior composite restoration[22, 23]. Huge MOD cavity design made in molars was selected since, it is recognized as the minimal long-lasting form on account of excess forces applied in posterior area and the enlargement of restoration[24]. Using a particular kit stabilized in a high-speed handpiece that fixed to specific device was necessary to prevent improper results translation[25]. In case of *in-vitro* studies, the bonded restorations durability can be tested using various types of artificial aging techniques as water, thermocycling, load cycling and degeneration by acids. Earlier investigations have assessed the mechanical properties of resin cements. Meanwhile, insignificant details concerning resin cement degradation in oral cavity have been obtainable[26].

Distilled water is believed a resin cement solvent by ISO. Despite the fact that oral biofilm reproduces many acids, however lactic acid was picked as a solvent, since it records the largest percentage of acids produced by dental plaque colonized bacteria. The unpolymerized monomers found in the resin cement matrix may be responsible for water and lactic acid absorption, generating pressure then creating microcrevices which perform as pathways for solvent infiltration that results in resin matrix softening, simplifies filler drop-out and minimizes the mechanical behavior[27]. Through the premier week, the chief ingredients liberated from resin cements are the remaining unpolymerized monomers. Also, numerous solvents may seep out any constituent from the polymerized resin cement within the first three days. So, the period of one week was selected for the current research as the extreme aging time for resin cements.

Microleakage is the best agreeable test to evaluate marginal adaptation efficacy. Dye penetration assessment explains a quantitative measurement and a useful aid for marginal integrity evaluation[28]. The results of the current study showed high degree of dye penetration with lactic acid more than distilled water immersion. Also, specimens stored for 168 h demonstrated more dye penetration than 24 h storage time. Moreover, Panavia F2.0 resin cement showed the superior outcomes and least dye penetration scores, succeeded by Maxcem resin cement and lastly All-Bond 2/Choice resin cement. This may be demonstrated by the various averages of sorption by their resin matrices.

The great amount of hydrogen bonds developed by the dimethacrylate monomers that present in the organic matrix of All-Bond 2/Choice resin cement with water and acids may be responsible for increasing liquid sucking, increasing resin breakdown and therefore, reducing its mechanical properties. Meanwhile, Panavia F2.0 involves 10-MDP (10-methacryloxy decyl-dihydrogen phosphate) in its structure, which is considered an excellent hydrolytically stable monomer due to its long carbonyl chain. This can explain why it revealed the lowest scores for dye penetration[29].

## CONCLUSIONS

Resin cement strategy, storage media and storage times had a noticeable effect on the durability of cement/dentin interface.

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