

**Comparative Evaluation of Microleakage of  
Zinc Phosphate, Resin Modified Glass Ionomer and  
Two Dual Cure Resin Cements-An In Vitro Study**

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## Certificate

This is to certify that the dissertation titled “**COMPARATIVE EVALUATION OF MICROLEAKAGE OF ZINC PHOSPHATE, RESIN MODIFIED GLASS IONOMER AND TWO DUAL CURE RESIN CEMENTS-AN INVITRO STUDY**” is a bonafide record work done under my guidance by **Dr. Jose Jacob**, during his post graduate study period between 2002-2005

This dissertation is submitted in partial fulfillment for the award of degree of **Master of Dental Surgery** in Branch III – Conservative Dentistry of the **Tamil Nadu Dr. M.G.R. Medical University**

It has not been submitted (partially or fully) for the award of any other degree or diploma

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## INTRODUCTION

Since the advent of acid etching technique by **Buonocore** in 1955, adhesive dentistry has developed to involve several clinical procedures<sup>10</sup>. It has improved the success of direct and indirect restorations.

Luting agents comprise a broad category of materials used to bond and seal dental restorations and prostheses to teeth. The longevity of indirect restorations is critically linked to the retention and marginal fit, which are affected by many factors. The dissolution, shrinkage on setting, strength and lack of adhesive bond to tooth and restoration are the major factors that lead to failure<sup>49</sup>. The microleakage that develops can occur between restorative-cement and / or tooth-cement interface. This can lead to post operative sensitivity, secondary caries and pulpal inflammation which will necessitate retreatment.<sup>44</sup>

Inlays, onlays, veneers and crowns are the main indirect restorations in operative dentistry. The advantages of indirect restorations are improved physical properties, wear resistance, reduced polymerization shrinkage, ability to strengthen remaining tooth structure, more precise control of contours and contacts, compatibility and good tissue response and increased auxiliary support<sup>18</sup>. Metals, ceramics and composites are mainly used for the fabrication of indirect restorations in operative dentistry. These materials will affect the efficiency of luting system as its ability to adhere to the restorative materials varies. The efficiency of the luting system to adhere to both the tooth and restoration is one of the determinant factors in the success of indirect restoration.

Zinc phosphate cement has been used for luting for more than a century. In spite of its well documented disadvantages such as high clinical solubility, lack of adhesion and low setting pH, a recent meta- analysis of

clinical data of conventional fixed partial dentures revealed an overall survival rate of 74.0% after 15 years.<sup>49</sup> This represents outstanding clinical success.

**The advent of adhesive cements came with the introduction of polyalkenoic acid, development of zinc poly carboxylate and glass ionomer cements.<sup>68</sup> These cements showed chemical adhesion to the tooth and affinity for metal ions and fluoride release, but they were weak in their tensile, compressive and shear strengths and were susceptible to tensile failure compared to resin cements.**

The introduction of resin modified glass ionomer cement in 1988 was a break through in the field of adhesive dentistry.<sup>68</sup> This material resulted in a hybridization between glass ionomer and resin systems. It shows many of the advantages of both the parent materials and is clinically superior to glass ionomer yet not as strong as resin luting cement.<sup>41</sup>

Resin cements brought forward a new avenue in luting, it sets by polymerization and adhesion through micromechanical retention. Resin systems have the advantage of superior physical and mechanical properties and absence of dissolution in the oral cavity.<sup>49,57</sup> Its disadvantages were the increased coefficient of thermal expansion and requirement of a bonding agent which made it more technique sensitive. However resin cement systems have proved to be effective luting agents.

The aim of the result study is to evaluate and compare the marginal adaptation of four different luting materials. The materials compared are zinc phosphate, resin modified glass ionomer, a commercial dual cure resin system and a newly developed dual cure resin system which is now under trial.

## REVIEW OF LITERATURE

1. **Nelson et al** in **1952**<sup>19</sup> carried out some classic and much quoted experiments to study the opening and closing of margins of restorations which were subjected to temperature changes. It was suggested that marginal percolation was caused by a difference in the coefficient of thermal expansion between the dental tissues and the restorative material and by thermal expansion of fluids occupying the crevice between tooth and restoration.
2. **Brannstrom** and **Nyborg** in **1971**<sup>8</sup> placed composite restorations in vivo, and after a period of time extracted the teeth and examined them histologically for the presence of bacteria between the restoration and cavity walls. Bacteria were found in this position, but it was reported that this leakage could be prevented by application of a cavity liner prior to placement of the restoration.
3. **Mondelhi J, Ishikirianan A, Galan J Jr.** in **1978**<sup>45</sup> in an invivo study was developed to observe the penetration of 131 INa around the margins of complete crown castings cemented with Zinc Phosphate cement with and without the application of different protective agents. They found least microleakage with teeth which were applied two layers of cavity varnish and amount of marginal leakage can be influenced by crown adaptation and the film thickness of the cement.
4. **P.A Darbyshire L.B.Messer W.H. Douglas (1988)**<sup>13</sup> examined the effectiveness of a dentin bonding agent and glass ionomer cement liner in reducing the marginal, microleakage at the cervical margins of class II

posterior composite restorations after thermal and load cycling. They found both significantly reduced microleakage when glass ionomer was present the additional presence of the dentin bonding agent did not provide a statistically significant reduction of microleakage

5. **Prati C , Nucui C, Montanari G (1989)**<sup>51</sup> evaluated the effects of various dentin chemical pretreatments on shear bond strength and marginal microleakage of various glass ionomer cements and composite resin. Agents used for pre-treatment were polyacrylic acid, tannic acid, orthophosphoric acid, Tubulicid blue solution, hydrogen peroxide and sodium hypochlorite. They observed sodium hypochlorite and polyacrylic acid pretreatment significantly improved the adhesion of glass ionomer to a different degree in the various materials and they stated that treatment with sodium hypochlorite was the most effective in reducing marginal leakage.

6. **Micheal S.Jacobs A.Steward Windeler (1991)**<sup>40</sup> investigated the rate of Zinc phosphate luting cement solubility as it refers to the size of the marginal gap. They found statistically significant increase in cement dissolution as the marginal gap increases.

7. **Zaimoglu A, Karaagachioglu L,Uctasli (1992)**<sup>70</sup> investigated the microleakage beneath porcelain laminate veneers bonded with a light and chemical – cured composite resin luting agents. After thermo cycling, they found significantly greater microleakage at the cervical side than at the enamel margins.

8. **White SN, Sorensen JA, Kang SK, Caputo AA (1992)**<sup>66</sup> measured in vitro microleakage of conventional and new luting agents. Standardized preparations were made on 42 freshly extracted premolars and the castings were cemented with a standardized technique. High degree of dye ingress

was seen in specimens luted with polycarboxylate, zinc phosphate and conventional glass ionomer. Adhesive resin cement group showed least leakage.

9. **Blair KF, Koepper RG, Schwart RS (1993)**<sup>7</sup> evaluated the microleakage associated with several luting agents for ceramic inlays. The inlays were cemented with zinc phosphate, 2 resin cements without a bonding agent, and 2 resin cements with a bonding agent. The study suggested that the use of a dentin bonding agent with resin cement will reduce microleakage.

10. **White S.N, Yu Z, Tom JF (1994)**<sup>54</sup> investigated in vivo microleakage of various luting cements used for cast crowns. Standardized tooth preparations were completed on previously intact human molars in vivo and castings were made with a precious metal ceramic alloy by conventional techniques. The castings were luted with zinc phosphate, resin modified glass ionomer and a resin modified glass ionomer with a dentin bonding agent. After 6 months carefully extracted and tested the microleakage occurred. ANOVA disclosed significant differences between groups. Zinc phosphate group leaked significantly more than other cement groups

11. **Karl M Lyons, John C Rodda, James AA Hood (1997)**<sup>37</sup> used a pressure chamber to compare microleakage associated with complete metal crowns cemented to extracted teeth using 3 different luting agents – zinc phosphate, glass ionomer and a resin cement. Microleakage was found to occur in crowns cemented with the zinc phosphate and glass ionomer cements, no microleakage was detected with the resin cemented crowns.

12. **Browning WD, Safirstein J (1997)**<sup>9</sup> evaluated microleakage of class V composite inlays cemented with a resin modified glass ionomer and

conventional resin cement. Half of the inlay patterns in each cementation group were fabricated directly on the tooth, and half were fabricated indirectly on store dies. The resin cement was more significantly effective in preventing leakage than the resin-modified glass ionomer cement. There was no statistically significant difference between inlay fabrication techniques.

13. **Shiflett K, White SN (1997)**<sup>55</sup> evaluated the efficiency of new adhesive cements and conventional non adhesive controls to prevent microleakage under stainless crowns or primary anterior teeth. Standardised preparations were made and crowns were cemented with zinc phosphate, poly carboxylate, resin modified glass ionomer, a resin modified glass ionomer with a dentin bonding agent, resin cement and zinc oxide eugenol. They found resin modified glass ionomer with dentin bonding agent produced least microleakage. The adhesive cements significantly reduced micro leakage. Marked microleakage was observed with non adhesive controls.

14. **Terry J. Lindquist & Jeffrey Connolly (2001)**<sup>58</sup> investigated microleakage of Zinc Phosphate cement and resin reinforced Glass Ionomer under ideal (dry) versus contaminated (wet) conditions and recorded less microleakage with resin reinforced Glass Ionomer (ideal or contaminated) than with Zinc Phosphate cement (ideal or contaminated). They also compared three foundations under both ideal and contaminated conditions and found less microleakage with a foundations of silver amalgam or composite resin when a bonding agent was used under ideal condition.

15. **Francesco Mannocci, Marco Ferrari & Timothy F.W. (2001)**<sup>22</sup> in a confocal microscopic study, evaluated the effectiveness of the seal

obtained with various luting agents used for cementing fibre posts in endodontically treated teeth the results showed that all resin cement groups leaked significantly less than the group cemented with Zinc Phosphate cement.

16. **Chuang SF, Jin YT, Tsai PF (2001)**<sup>12</sup> investigated the effect of various surface protections on micro leakage with class V resin modified glass ionomer restoration with both enamel and cementum margins. After thermocycling, the unprotected group showed maximum leakage at both enamel and cementum margins. Restorations protected with resin adhesive showed least leakage. They concluded that resin modified glass ionomers are moisture sensitive and recommended a resin adhesive for surface protection.

17. Koji Furukawa, Norimichi Inai, Junji Tagami (2001)<sup>34</sup> evaluated the effects of thickness and adhesion of 3 resin cements on the fracture resistance of a restoration is dependent upon the bond strength between a restoration and the tooth substrate.

18. **Hahn P, Attin T, Grofke M (2001)**<sup>26</sup> investigated the effect of the different viscosities of 2 resin luting cements on microleakage of ceramic inlays at dentinal margins. The effect of the width of the space between inlay and tooth on the quality of the marginal seal also evaluated. Results showed highly viscous resin cement performed well at dentin / composite margins than the low viscous cement. This was statistically significant and the finding were supported by SEM analysis.

19. **Alavi AA, Kianimanesh N (2002)**<sup>2</sup> evaluated the marginal sealing ability of class V direct and indirect resin composite restorations with 3 different dentin bonding systems. The coronal half of each preparation was in enamel and gingival half was in cementum or dentin. The

thermocycled specimens showed more leakage at the cementum margins. Less microleakage was observed in samples restored with indirect restorations.

20. **Gu XH, Mathiask K (2002)<sup>24</sup>** evaluated the marginal leakage of IPS – Empress 2, all ceramic crowns using 3 different cements. They observed Panavia (F) adhesive luting system demonstrated the least microleakage. Dyract compomer cement showed an intermediate level of microleakage and Harvard Zinc Phosphate cement was associated with severe microleakage in all specimens.
21. **Gupta S, Khinda VI, Grewal N (2002)<sup>23</sup>** compared the micro leakage at the tooth restoration interface extending below cemento-enamel junction when posterior composite restorations were placed directly in the cavity or when placed over a glass ionomer cement liner, both chemically cured and light cured. The results have shown that light cured glass ionomer when used as a liner under a composite restoration used below gingival cementum / dentin margin has the best sealing capability.
22. **Morakot Piemjai, Kumiko Miyasaka, Yasuhiko Iwasaki, Nobuo Nakabayashi in 2002<sup>46</sup>** stated demineralized dentin beneath set acid – base cement may adversely affect microleakage under fixed restorations. They found all cementum margins of the 3 acid base cements tested demonstrated significantly higher leakage scores than cementum margins for inlays cemented with the resin cement tested. No leakage along the tooth – cement interface was found for inlays retained with the adhesive resin cement.
23. **Haller B, Habner K, Moll K (2003)<sup>24</sup>** evaluated the marginal adaptation of ceramic inlays to dentin as influenced by different bonding systems and by luting resin composites marginal integrity was evaluated before and

after thermo cycling. The median percentages of continuous margin in dentin ranged from 80% to 100% before thermo cycling and from 53.5 % to 96.1 % after thermo cycling.

24. **Mota CS, Demarco FF, Camacho GB (2003)<sup>47</sup>** evaluated the microleakage in ceramic inlays using different resin cements with margins in enamel and cementum / dentin interfaces. After the cementation of inlays, samples were subjected to thermo cycling and dye penetration. They found statistically lower dye leakage at enamel margins than at cementum / dentin interfaces. Dual cure resin cement, RelyX ARC performed better than the other groups.
25. **Soares CJ, Martins LRM, Fernandes Neto (2003)<sup>56</sup>** evaluated the marginal adaptation of 4 different inlay indirect restorative systems: one ceramic inlay and 3 laboratory processed resin composites. Among all the materials, the marginal discrepancy recorded on the gingival margins was statistically larger than that recorded on the proximal and occlusal regions.
26. **Nuray Attar, Laura E. Tam Dorothy MC Comb in 2003,<sup>49</sup>** compared the flexural strength, modulus of elasticity and radio-opacity and PH of 5 types of luting agents; zinc phosphate, glass ionomer, resin modified glass ionomer and resin cements. The resin luting agents showed higher flexural strength than all other materials tested. The most radio opaque was zinc phosphate. Zinc phosphate and conventional glass ionomer were the most acidic, immediately after mixing but were least acidic after 24 hours.
27. **Romao W Jr. Miranda WG Jr. Cesar PF, Braga RR (2004)<sup>52</sup>** compared the cement thickness and microleakage of class II ceramic inlays. Standardized MOD class II inlay cavities with one proximal box extending below and the other extending above the cemented enamel junction were made. The inlays were cemented with dual cure resin cement. Samples were

mechanically and thermally cycled. Regarding dye penetration, more leakage was observed at cementum margins. No correlation was found between cement thickness and microleakage either in enamel or dentin.

28. **M. Behr, M Rosetritt, T.Regnet, R.Lang, G Handel in 2004<sup>6</sup>** compared the margined adaptation of a new self adhesive universal resin cement with only one application step, to the marginal adaptation of established cements and their corresponding adhesive systems. All investigated luting agents showed comparable amounts of “perfect margins” on SEM examination. But they found the self adhesive system had significantly lower dye penetration.
29. **M. Irie, K.Suzuki, D.C, Watts in 2004,<sup>29</sup>** investigated the effects of finishing time and 24 hours water storage on mechanical properties and marginal adaptation to dentin of seven modern luting cements. They found mechanical properties were increased significantly after 24 hours storage. The benefit of delaying the polishing or restorative procedure after 1-day storage on 3 types of luting agent was shown.

## **SUMMARY AND CONCLUSION**

**The study compared the marginal sealing ability of various commercially available luting cements and newly developed resin cement, which is under trial.**

The luting cements used were:-

- \* RelyX ARC – dual cure resin cement system ( 3 M ESPE )
- \* DCRC –10, newly developed dual cure resin cement system
- \* Fujicem–resin modified Glass ionomer–a paste–paste formulation  
(GC cop.)
- \* Zinc Phosphate (Harvard)

**The study was done on 40, intact, human maxillary premolars divided into groups of 10 teeth each. Class V inlay preparations were done on the buccal surfaces, 1.5 mm above and below the cement-enamel junction in order to achieve 2 different substrate for luting.**

The inlays of each group were cemented with the corresponding luting cements. After 24 hrs water immersion, all samples were subjected to thermal cycling ( $300 \pm 2^\circ\text{C}$  –  $55 \pm 2^\circ\text{C}$ ). Dye penetration was done with 0.5 % Basic fuchsin for 24 hours and longitudinal sections were made through the midline of the restorations in a facio – palatal direction. Scoring of leakage was done using a graded criteria under stereomicroscope.

**The results were statistically analyzed using Kruskal - wallis median Anova Test and Mann –Whitney U test. Group I, II and III showed less microleakage when compared to Group IV which was statistically significant. Higher level of dye penetration occurred at the cementum/dentin margins in every group. Both resin cements showed less microleakage among the luting cements tested.**

Within the limitations of this study, restorations cemented with adhesive luting cements (Fujicem, RelyX ARC and DCRC-10 resin cement system) produced a lesser leakage scores at both enamel and cementum / dentin margins than those cemented with Zinc Phosphate cement. Both adhesive resins luting system (RelyX ARC & DCRC-10) showed least leakage scores.

The presence of hybridized dentin could be correlated to the least penetration of dye in samples resin cement groups (Group I and Group II). Resin modified glass ionomer (Fujicem) group allowed a slightly higher level of dye penetration that was not statistically significant. The

performance of indigenously developed resin cement (Group II) is comparable to that of Rely X ARC (Group I).

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