2001

ISSN 0970-2199

JOURNAL OF PIERRE FAUCHARD ACADEMY

WORLD ORAL HEALTH

Volume 15 March 2001 Number 1

EVALUATION OF AMALGAM RESTORATIONS BONDED WITH GLASS IONOMER CEMENT

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Dental amalgam has the unique distinction of being used for over 150 years as the primary posterior restorative material in dentistry[1]. Inspite of its physical properties, one of amalgams major shortcomings has been its inability to bond to the tooth structure, leading to the problem of microleakage.[2,3,4] This phenomenon of microleakage remains the darkest blemish on the prospect of amalgam being an effective restorative material. This lack of any bonding has made amalgam depend upon mechanical undercuts, grooves, pins and slots for retention purpose. Various researchers have advocated several materials to enhance the marginal seal by bonding amalgam to the tooth structure. These include Oxalates, Copal varnish, and the 4 methacryloxyethyl trimellitate anhydride, or 4 – META group of polymers; with all exhibiting mixed results.[5,6,7].

The glass ionomer group of restoratives, introduced by Wilson in 1974, have a record of proven clinical performance. They appear to be suitable for use as bond mediating agents between amalgam and tooth structure as they are capable of chemically bonding to tooth structure and perhaps, also to all the components of silver amalgam[8,9,10]. One of the unique features of glass ionomer cement is its inherent ability of establishing ionic bond with tooth structure which has been found to be significant, durable and adequate for use in many clinical situations[11].

The objective of this study was to evaluate the efficiency of glass ionomer cement as an amalgam bonding agent. in comparison with the conventionally used copal varnish.

MATERIALS AND METHODS

The test specimens comprised of sixty freshly extracted bicuspids that were stored in 2% buffered formalin all through the duration of the study. Class 5 cavity preparations were placed on the facial surfaces of each tooth using a high speed handpiece with air and water spray and a #35 bur. The preparations were 1.5 mm deep, oblong in shape, measuring 2 x 6 mm, parallel to the cementoenamel junction (CEJ), and the gingival half of the preparations extended 0.5 mm below the CEJ. Cavosurface walls were finished to a butt joint with a # 55 slow speed bur. Cavity preparations were rinsed for 20 seconds with an air/water spray and gently air dried for 30 seconds. The four test groups used in this study (n = 15) are shown in Table 1.

Table 1 - Test Groups and Bonding agents

Group	Bonding Agent
1.	None
2.	Copal Varnish
3.	Glass Ionomer Type I
4.	Glass Inomer Type II

The unlined group acted as the control group while Copal varnish was used as the liner in Group 2. Copal Varnish was applied in two thin layers, allowing the first layer to air dry for 30 seconds prior to applying the second layer. Fuji I(GC) and Fuji II (GC) were the lining agents employed in Groups 3 and 4 respectively. (Table 1) All the materials were manipulated according to the manufacturer instructions. As the high copper amalgam trituration was progressing the glass ionomer mix was applied to the cavity surface up to the cavo surface margin with the help of a brush. A thin film was placed, covering all the cavity surfaces including the pulpal wall. The amalgam triturate ready for condensation was rapidly condensed into the cavity before the cement layer was allowed

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TABLE 2 -- RESULTS (n= 15 sections per group)

BONDING AGENT	MICROLEAKGE				MEAN
	0	1	2	3	
None	0	1	6	8	3.07
Copal Varnish	0	3	7	5	2.13
GIC Type I	12	2	1	0	0.26
GIC Type II	11	3	1	0	0.31

to set. Restorations were overfilled, burnished, and carved back to proper contour. Specimens were then placed in normal saline at 37° C for one month. After this time period, teeth were thermally stressed for 300 cycles in deionized water between 5 and 55° C using a dwell time of 30 seconds each. The teeth then had their root apices sealed with glass ionomer cement followed by dental compound. The entire tooth surface was painted with two coats of fingernail polish to within 1 mm of the restoration margins and then placed in 4% Eosin dye in a 37° C bath for 48 hours. Teeth were then cut serially into two sections. Sections were treated with 0.5% citric acid to remove the smear layer created during sectioning and rinsed with distilled water. Each section was viewed under an Olympus SC 35 stereomicroscope (Olympus Corp) at X 10 magnification and blindly scored for microleakage by a second investigator. Microleakage scores were based on the degree of dye penetration according to the following scale[12] (see Figure 1) :

= No leakage

= Dye penetration less than half way to the axial wall

= Dye penetration greater than half way to the axial wall

= Dye penetration along the axial wall

Statistical analysis was performed on the original data utilizing Kruskal – Wallis analysis of variance. If a significant difference was found in the ANOVA analysis, the data were then subjected to Dunn multiple comparison tests to determine where those differences occurred. All statistical tests were run at a significance level of $P < 0.05$ using the Stat Primer program.

RESULTS

Table 2 displays the microleakage data. The microleakage scores of the Copal varnish group is high and is significantly lesser to the no liner group which acted as the control. The performance of both Type I and Type II Glass Ionomer cement was far superior than the Copal varnish group as evident by their low microleakage scores. The difference in scores between both Type I and Type II GIC was not statistically significant.

DISCUSSION

Microleakage is defined as the clinically undetectable passage of bacteria, fluids, molecules, or ions between a cavity wall and the restorative material applied to it[7]. Numerous studies have identified microleakage as the most significant problem with amalgam because of interfacial gap formation[13,14]. This gap is thought to be the result of several variables, which include lack of chemical adhesion, differing thermal coefficient of expansion between tooth and amalgam, dimensional changes on setting of the amalgam, inadequate condensation and adaptation to cavity walls, and improper trituration[14,15,16]. Microleakage as a result of this gap can result in

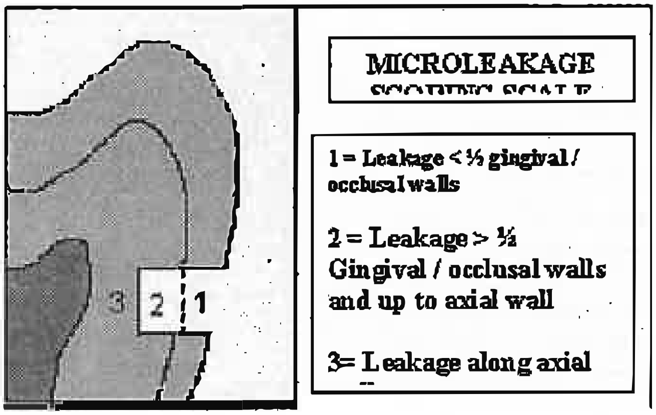

Figure 1: Microleakage Scoring Scale

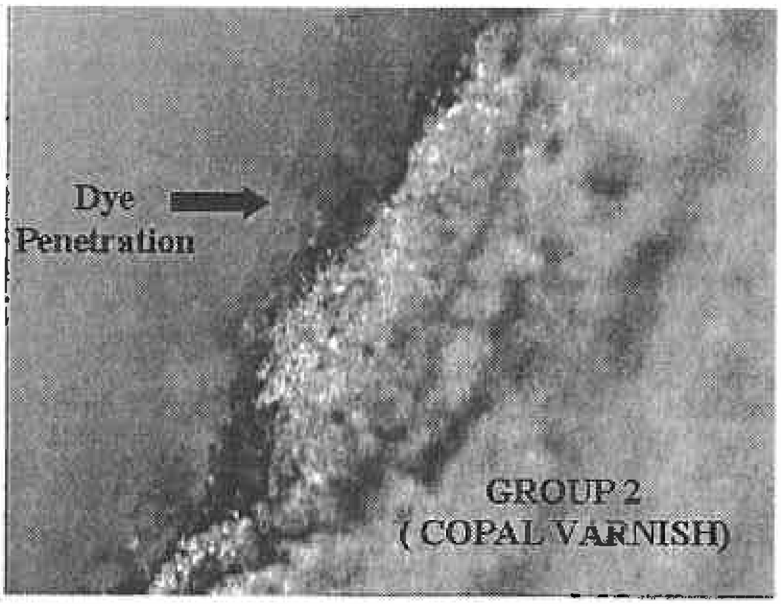

Figure 2: Dye penetration in Copal Varnish Group

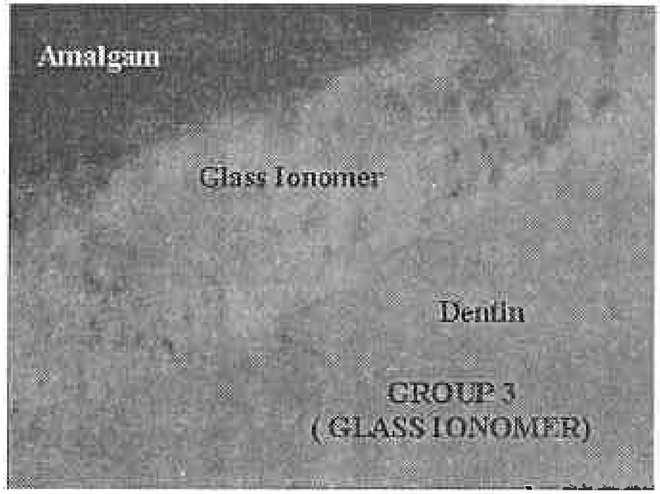

Figure 3: Amalgam bonded with glass ionomer

pulpal irritation, postoperative sensitivity, tooth discoloration, and secondary caries[7]. Corrosion of conventional, low copper amalgam alloys over several months has been proven to reduce microleakage[17]. High copper amalgam alloys have eliminated the highly corrosive gamma two phase in the setting reaction and consequently have delayed the development of this corrosion related seal[18].

Various types of liners have been used to provide a dentin seal prior to corrosion product formation within the interfacial gap. Copal varnish has been the traditional liner used with amalgam alloys to prevent initial microleakage[19]. According to the results of the present study, the use of the copal varnish as treatment on the cavity walls before the placement of the amalgam restoration showed a superior effect when it was compared to the control group, although its effectiveness in reducing the marginal leakage showed a lower effect than other tested treatments. The lack of adhesion to the dental structure and its high solubility may explain such behavior[20]. Fitchie et al[21] concluded that the space left after the dissolution of the varnish was too large to be self sealed by the high copper amalgam alloys. The manufacturers instructions to use two layers of cavity varnish will lead to an increase in the thickness of this liner, which, in turn, may contribute to the formation of a greater space after its dissolution.

More recently, dentin bonding agents have been evaluated as liners for amalgam alloys and have usually produced significant improvement in the reduction of microleakage versus copal varnish[22,23]. Most of these studies were of short duration, and the ability of these dentin-bonding systems to reduce microleakage over time has not been fully explored. A recent long term microleakage study using a 4 – META dentin bonding system showed reduced effectiveness in preventing microleakage when 1 year data were compared to the initial data[3]. Further, their long term biocompatibility and clinical performance is yet to be adequately assessed.

More than 20 years of clinical experience with glass ionomers has shown them to be versatile materials that are simple to handle and relatively tolerant of variations in clinical techniques[24]. Apart from fluoride release and biocompatibility the most significant advantage of using glass ionomers as amalgam bonding agents is their "ion exchange adhesion" with tooth structure, which is unique in dentistry and of great value.

When bonding two fixed substrates with a bonding agent, failure can occur at:

a. The interface between the bonding agent and either of the two substrates.

b. Within the substrates.

c. Within the bonding agent itself.

SEM examinations of bond failures between bonded amalgam and tooth structure have revealed that the weak link is at the amalgam – bonding agent interface[25]. If the bonding agent remained bonded to the amalgam and if bond failure were to occur at the bonding agent - tooth interface, then a number of problems could arise. Dentin tubules would not be sealed and postoperative sensitivity could occur. Bacteria could infiltrate between the bonded surface and unprotected dentin. Essentially, the amalgam restoration would be isolated from the tooth by a polymeric layer. Metallic ions from the amalgam would not be present in the gap between the adhesive and tooth structure and sealing with corrosion products would probably not occur.

In the case of amalgam bonded to the tooth structure with glass ionomers, failure usually occurs at the amalgam – glass ionomer interface; as the Ionic

Adhesion between the tooth structure and ionomer is very strong. In such cases the dentinal tubules would be sealed and postoperative sensitivity due to the hydrodynamic effect would be negated. In time, corrosion products would then fill the interface between amalgam and the glass ionomer. Although the prepared tooth would not be strengthened under these circumstances, postoperative sensitivity would be reduced or eliminated and the tooth would be protected from the decalcifying action of caries producing bacteria.

CONCLUSIONS

According to the conditions and results of this in vitro study, the following conclusions can be drawn:

1. The use of treatments on dentin cavity walls is important in reducing microleakage around freshly packed amalgam restorations.
2. Amalgam bonded with Glass ionomer exhibited the most significant decrease in microleakage
3. Both Type I and Type II Glass Ionomer cement are equally effective as an amalgam bonding agent.
4. Copal varnish was the least efficient: however, it was significantly better than the control group.

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