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Clinical Research

Seven-Year Clinical Performance of Resin Composite Versus Resin-Modified Glass Ionomer Restorations in Noncarious Cervical Lesions

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Clinical Relevance

Long-term evaluation of material behavior is relevant for class V restorations. The resin-modified glass ionomer studied (Vitremer) showed superior clinical long-term retention rates compared with two-step etch-and-rinse adhesive and resin composite (Excite/Tetric Ceram) restorations.

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SUMMARY

Purpose: The purpose of this study was to comparatively assess the seven-year clinical performance of a one-bottle etch-and-rinse adhesive with resin composite (RC) and resin-modified glass ionomer (RMGI) restorations in noncarious cervical lesions.

Methods and Materials: One operator placed 70 restorations (35 restorations in each group) in 30 patients under rubber dam isolation without mechanical preparation. The restorations were directly assessed by two independent examiners, using modified US Public Health Service criteria at baseline and 6, 12, 24, 60, and 84 months. The obtained data were tabulated and statistically analyzed using the Fisher and McNemar tests. A difference was significant if $p<0.05$.

Results: Twenty patients were available for recall after seven years (66.6%), and 25 RC and 26 RMGI restorations out of 70 restorations were evaluated. Excellent agreement was registered for all criteria between examiners ($\kappa \geq 0.85$). Alfa and bravo scores were classified

as clinically acceptable. The McNemar test detected significant differences within RC restorations between baseline and seven-year evaluations for anatomic form, marginal integrity, and retention ($p<0.05$). For RMGI restorations, a significant difference was identified for marginal integrity ($p<0.05$). As to material comparison, the Fisher exact showed a better retention performance for RMGI restorations than for RC restorations ($p<0.05$). Twelve composite restorations were dislodged (52.0% retention) and three ionomer restorations were lost (88.5% retention). The cumulative success rate for RC and RMGI was 30% and 58.1%, respectively.

Conclusions: After seven years of service, the clinical performance of RMGI restorations was superior to that of the adhesive system/resin composite restorations in this study.

INTRODUCTION

About a quarter of the population has noncarious cervical lesions, and these lesions are significantly more prevalent at older ages, with premolars being the most affected teeth.[1]

Although the dentin characteristics of surfaces from abrasion/abfraction lesions may inhibit dentin etching and the formation of hybrid layers,[2] clinical bonding effectiveness has been shown in noncarious cervical lesions located mainly in dentin.[3] Therefore, it is expected that the clinical performance of restorations placed in noncarious cervical lesions would be more critical, especially in long-term evaluations.

Numerous studies have investigated the clinical behavior of noncarious cervical lesions restored with resin composite and glass ionomer cement. A large number of clinical trials are short-term evaluations. In general, in up to three years of follow-up, both resin composite and glass ionomer restorations have good performance.[4-11] The main causes of failure of this type of restoration are low retention rates for resin composite restorations[5,6,12-14] and poor color stability for glass ionomer restorations.[15,16]

Studies with longer evaluation periods show that resin composite materials tend to fail with time. Retention rates of such restorations are markedly lower when compared with glass ionomer restorations.[17,18] A 13-year follow up of class V noncarious cervical lesions verified a continuous degradation of the bond with a wide variation, independent of the adhesion strategy used, with the best retention for restorations performed with resin-modified glass ionomer cement (RMGI) and with adhesive restorations using four-step etch-and-rinse systems.[3]

A review of prospective clinical trials showed that restorations with glass ionomer resulted in the highest success rate in regard to retention if compared with adhesive systems and resin composite restorations.[18]

Long-term evaluations are especially interesting when considering the behavior of one-bottle or primer-adhesives. Currently, some problems have been identified with this category of adhesive system, such as permeability[19] and hydrolysis. Although a tendency exists toward adhesives with simplified application procedures, simplification appears to induce a loss of effectiveness in restorations of noncarious cervical lesions.[18]

Long-term clinical trials are certainly needed, because they remain the ultimate way to collect scientific evidence on the clinical effectiveness of restorative treatments. Thus, the aim of this study was to assess the seven-year clinical performance of a two-step etch-and-rinse adhesive system and resin composite system in comparison with a RMGI restorative material in noncarious cervical lesions in a prospective study.

METHODS AND MATERIALS

Patient Selection

Thirty volunteers (18 to 50 years of age) were properly instructed about the condition and objectives of the study and signed an informed consent and authorization form in order to participate in this investigation, following the guidelines of the local institutional review board (approved on February 24, 2000). Inclusion criteria were good oral hygiene, no periodontal disease or deleterious habits, and presence of at least two noncarious cervical lesions, following the split-mouth group design.

No lesions were less than 1 mm deep. Each patient randomly received at least one adhesive system/resin composite and one resin-modified glass ionomer restoration, for a total of 70 restorations. All types of class V noncarious lesions were included in the present study. As the association of abrasion, erosion, and abfraction is usually observed, all situations were considered for inclusion. Although the degree of dentin sclerosis was not considered an exclusion criterion, highly mineralized pigmented lesions were not observed.

Table 1: *Composition of the Studied Materials*

Material	Composition
Excite	*Primer/Adhesive:* Phosphono-acid acrylate, hydroxyethyl methacrylate, Bis-GMA, dimethacrylate, highly dispersed silica, ethanol, catalysts, and stabilizers.
Tetric-Ceram	TEGDMA, barium glass, ytterbium trifluoride, barium-aluminum-fluorosilicate glass, highly dispersed silica, additives, catalysts, stabilizers, and pigments
Vitremer	*Primer:* polyacrylic acid modified with grafted pendant HEMA groups, 2-HEMA, ethanol, photocuring initiators.
	Powder: fluoroaluminosilicate glass (70 wt%), potassium persulphate and ascorbic acid (patented catalyst system), benzoyl peroxide.
	Liquid: a copolymer of polymaleic acid and HEMA= polyacrylic acid modified with grafted pendant HEMA groups (15 wt%), 2-HEMA (5 w%), water (8 wt%), camphorquinone, photoinitiator (microencapsulated water-soluble ascorbic acid/potassium persulfate).

Abbreviations: Bis-GMA, bisphenol A diglycidylmethacrylate; TEGDMA, triethyleneglycol-dimethacrylate; 2-HEMA, 2-hydroxyethyl methacrylate.

Restorative Procedures

Each patient received at least two or a multiple of two restorations. Each restorative material was randomly allocated to one of the randomized cervical lesions until the two treatments were present in the same subject and in equal numbers. The randomization process was performed by placing all the selected teeth on a list and assigning treatment according to a predefined sequence: 1) resin composite and 2) RMGI.

Restorative procedures were carried out by an experienced clinician, who was submitted to a calibration process that consisted of performing 10 repeated restorations of each material under direct supervision of the project's coordinator. The operator's questions were addressed and consensus was obtained during the calibration session. All restorations were placed under rubber dam isolation, and no cavity preparation was carried out. Enamel margins were not beveled and no mechanical retention was performed. Twenty-six patients received two restorations, three patients received four restorations, and one patient received six restorations.

Half of the cavities were restored with a two-step etch-and-rinse adhesive system and a resin composite (Excite/Tetric Ceram, Ivoclar Vivadent, Schaan, Liechtenstein) and the other half with the RMGI (Vitremer, 3M ESPE, St Paul, MN, USA) (Table 1), according to the manufacturer's instructions, as follows:

Excite/Tetric Ceram—Enamel was etched for 30 seconds and dentin for 15 seconds with 37% phosphoric acid gel (Total Etch, Ivoclar Vivadent), washed for 30 seconds, and dried gently. Absorbent paper was used to remove the excess water. One coat of the two-step etch-and-rinse adhesive system (Excite, Ivoclar Vivadent) was applied to the visibly moist dentin surface and brushed gently for 10 seconds. An air blast was applied to facilitate the evaporation of the alcohol solvent and the primer adhesive was light-cured for 20 seconds. Resin composite (Tetric Ceram, Ivoclar Vivadent) increments were inserted and light-cured for 40 seconds using a calibrated light-curing unit (XL 3000, 3M ESPE) at 600 mW/cm^2 with a curing radiometer (Demetron/Kerr, Orange, CA, USA). Composite excess was immediately removed using a No. 12 blade. Finishing and polishing was performed one week later using 12-fluted tungsten carbide burs (FG Bur, KG Sorensen, Brazil), abrasive cups (Enhance, Dentsply, USA), and disks (Sof-Lex polishing disks, 3M ESPE);

Vitremer—The RMGI (Vitremer, 3M ESPE) was used according to the manufacturer's instructions. Primer was applied for 30 seconds to the surface of the lesion using a micro-brush. Light-curing was conducted for 20 seconds using the same calibrated device that was used for resin composite restorations. The RMGI was manipulated in a 1:1 powder-to-liquid ratio and was inserted using disposable tips and a syringe (Centrix, Shelton, CT, USA). The restoration was light-cured for 40 seconds and excess material was immediately removed using a No. 12 surgical blade. Finishing and polishing were carried out similarly to resin composite restorations, one week after the restorations were placed.

Clinical Evaluation

Two independent and calibrated examiners other than the operator were responsible for the clinical evaluations. Calibration procedures were carried out using picture slides representing each condition to be assessed in the study. A double-blind design was originally assigned. In cases where the two examiners disagreed on a rating, both reexamined the restoration and arrived at a final joint decision.

Table 2: *Modified US Public Health System Criteria Rating System*

Category	Rating	Criteria
Retention	Alfa (A)	Restoration is present
	Charlie (C)	Restoration is partially or totally lost
Marginal integrity	Alfa (A)	No visible gap in which the explorer will penetrate
	Bravo (B)	There is a visible gap; the explorer will penetrate or catch
	Charlie (C)	The explorer penetrates the gap and dentin or base is exposed
	Delta (D)	The restoration is mobile, partially or totally fractured or lost
Marginal discoloration	Alfa (A)	No discoloration
	Bravo (B)	Discoloration is present but has not penetrated along all the margin
	Charlie (C)	Discoloration has penetrated along all the margin
Anatomic form	Alfa (A)	Restoration is continuous with existing anatomic form
	Bravo (B)	Restoration is discontinuous with existing anatomic form, but dentin or base is not exposed
	Charlie (C)	Sufficient material is lost to expose dentin or base
Secondary caries	Alfa (A)	No caries is present at the margin of the restoration
	Charlie (C)	There is evidence of caries at the margin of the restoration

Modified US Public Health Service criteria[20] were used to evaluate retention, marginal integrity, marginal discoloration, anatomic form, and secondary caries (Table 2) at baseline and 6, 12, 24, 60, and 84 months. The baseline rating was carried out one week after restoration, immediately after the finishing and polishing procedures.

Statistical Methods

Interexaminer agreement was assessed using κ. Excellent agreement was registered between both examiners for all criteria ($\kappa \geq 0.85$). Intragroup comparisons between baseline and other evaluation periods with the same material were performed by the McNemar test ($p<0.05$). Intergroup comparisons to identify differences between restorative materials at each period were conducted by Fisher exact tests ($p<0.05$). The cumulative survival rate was determined following the life table method.

RESULTS

Recall rates registered were 100% for baseline, 6, and 12 months; 93.3% for two years; 73.3% after five years; and 66.6% after seven years. The registered recall rates overcame the minimum requirement of the American Dental Association (ADA) guidelines[21] for sample size in clinical trials for restorative materials, which state that a minimum of 20 patients must be available for the two-year recall and 15 patients must be examined at the four-year evaluation.[21]

Data for retention, marginal integrity, marginal discoloration, anatomic form, and secondary caries of all evaluation periods are presented in Table 3. Numbers in parentheses indicate the total number of restorations classified as clinically acceptable (alfa and bravo ratings) in each evaluation period versus the total number of restorations assessed at that time.

Given that all patients were available for recall at 6 and 12 months, all 70 restorations could be assessed. Although four resin composite restorations were lost at six months and one more was lost at the one-year assessment, no significant differences were detected in all criteria for both materials at these periods.

At the two-year recall, two patients could not be found, so 66 restorations were assessed. Seven composite restorations were lost, whereas no ionomer restoration was lost. When comparing resin composite and RMGI restorations at the two-year recall, the only significant difference was for the retention criterion ($p=0.011$) in favor of RMGI restorations.

At the five-year recall, 22 volunteers returned for evaluation. Of 70 restorations, 55 were evaluated (27 resin composite restorations and 28 resin-modified glass ionomer restorations). Sixteen composite restorations were regarded as failures at this evaluation period (51.5% retention), whereas only one ionomer restoration was lost (96.4% retention). Significant differences were found for resin composite restorations between baseline and the five-year recall for marginal integrity and retention. For RMGI restorations, no significant differences were identified for all criteria. When comparing both materials, significant differences for retention after five years were found.

Table 3: *Clinical Evaluation of Resin Composite and Resin-Modified Glass Ionomer Restorations With Percentages Values of Clinically Acceptable Ratings (Alfa and Bravo)*

Category	Material	Baseline % A+B	6 months % A+B	1 year % A+B	2 years % A+B	5 years % A+B	7 years % A+B
Retention	RC	100% (35/35)[a]	88.2% (30/34)	85.7% (30/35)	78.8% (26/33)	51.5% (17/27)	52.0% (13/25)
	RMGI	100% (35/35)	100% (34/34)	100% (35/35)	100% (33/33) *	96.4% (27/28) *	88.5% (23/26) *
Marginal integrity	RC	97.2% (34/35)	100% (30/30)	100% (30/30)	100% (26/26)	76.5% (13/17)	69.2% (09/13)
	RMGI	100% (35/35)	100% (34/34)	100% (35/35)	100% (33/33)	85.2% (23/27)	87.0% (20/23)
Marginal discoloration	RC	100% (35/35)	100% (30/30)	100% (30/30)	100% (26/26)	100% (17/17)	100% (13/13)
	RMGI	100% (35/35)	100% (34/34)	100% (35/35)	100% (33/33)	100% (27/27)	100% (23/23)
Anatomic form	RC	100% (35/35)	96.6% (29/30)	96.6% (29/30)	96.2% (25/26)	88.2% (15/17)	92.3% (12/13)
	RMGI	100% (35/35)	100% (34/34)	100% (35/35)	100% (33/33)	85.2% (23/27)	91.3% (21/23)
Secondary caries	RC	100% (35/35)	100% (30/30)	100% (30/30)	100% (26/26)	88.2% (15/17)	92.3% (12/13)
	RMGI	100% (35/35)	100% (34/34)	100% (35/35)	100% (33/33)	100% (27/27)	91.3% (23/23)

Abbreviations: RC, resin composite (Excite/Tetric Ceram, Vivadent); RMGI, resin-modified glass ionomer cement (Vitremer, 3M ESPE Dental Products).
[a] *Numbers in parentheses represent restorations evaluated with success/total restorations evaluated.*
* *Indicates significant differences between tested materials for that criterion.*

At the seven-year recall, 20 volunteers returned for evaluation. Of 70 restorations, 51 were evaluated (25 resin composite restorations and 26 RMGI restorations). Twelve composite restorations were considered as failures at this evaluation period due to retention (52.0% retention), whereas three ionomer restorations were lost (88.5% retention). Greater retention was found after seven years if compared with five years for resin composite restorations because one patient who was not evaluated at five years returned after seven years.

The cumulative survival rates of retention for both tested groups were 95.8% and 63.7% for RMGI restorations (Vitremer) and 2-step etch-and-rinse adhesive and resin composite restorations (Excite/Tetric Ceram), respectively (Table 4).

The distribution of restorations regarding location and type of tooth for both tested groups is shown in Table 5. The number of restorations that failed with respect to retention is also cited in Table 5. The ages of the patients whose restorations failed for retention were 30, 35, and 50 for resin-modified glass ionomer restorations; and they were 18, 27, 32, 35, 36, 37, 40, 45, and 50 years for resin composite restorations.

The McNemar test detected significant differences for resin composite restorations between baseline and the seven-year recall for retention ($p=0.002$). For RMGI restorations, a significant difference was identified for marginal integrity ($p<0.05$, Figure 1). When comparing both materials, the Fisher exact test pointed out a significantly better performance for RMGI restorations than for resin composite restorations with respect to retention ($p<0.01$).

DISCUSSION

Noncarious class V clinical trials remain the ultimate testing method for the assessment of bonding

Table 4: *Cumulative Survival Rate of Retention for Both Tested Groups*

Material	Interval	Pair of Restorations at Start of Interval	Dropouts	Pair of Evaluated Restorations	Failures	Success	Survival Rate, %	Cumulative Survival Rate, %
RC	0-6 m	35	1	34	0	34	100.0	100.0
	6 m-1 y	34	3	31	3	28	90.8	90.8
	1-5 y	28	3	25	0	25	100.0	90.8
	5-7 y	25	3	22	7	15	70.2	63.7
RMGI	0-6 m	35	1	34	0	34	100.0	100.0
	6 m-1 y	34	6	28	0	28	100.0	100.0
	1-5 y	28	3	25	0	25	100.0	100.0
	5-7 y	25	2	23	1	22	95.8	95.8

Abbreviations: RC, resin composite (Excite/Tetric Ceram, Vivadent); RMGI, resin-modified glass ionomer cement (Vitremer, 3M ESPE Dental Products).
* *Wilcoxon (Gehan):* $p = 0.008$ *statistically significant difference.*

Table 5: *Distribution of Restorations Regarding Location and Type of Tooth for Both Tested Groups at Baseline. Numbers in Parentheses Represent Restorations Evaluated With Failure of Retention After 7 Years.*

Material	Location		Type			
	Upper	Lower	Premolar	Molar	Incisor	Canine
RC	26 (11)	9 (3)	27 (11)	4 (2)	1	3 (1)
RMGI	27 (4)	8 (1)	31 (5)	1	1	2

Abbreviations: RC, resin composite (Excite/Tetric Ceram, Vivadent); RMGI, resin modified glass ionomer cement (Vitremer, 3M ESPE Dental Products).

effectiveness.[22] Due to a lack of inherent macromechanical retention, adhesion is the most important factor in the retention of restorations in cervical abrasion/erosion lesions.[23] Microtensile adhesion tests have shown a correlation with marginal discoloration of clinical studies on class V nonretentive restorations; however, no significant correlation was found with the clinical index, retention rate, or marginal integrity.[24]

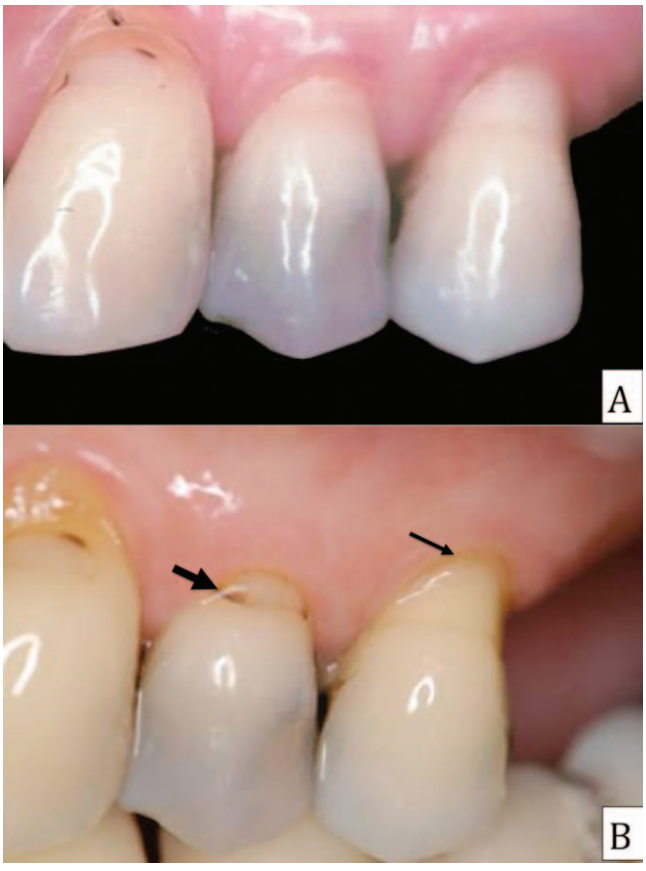

Figure 1. *The cervical lesions on both upper premolars were restored (tooth No. 14, Excite/Tetric; tooth No. 15, Vitremer). (A): Baseline. (B): Seven-year follow-up. At the 7-year recall, the Excite/Tetric restoration showed a small marginal defect and severe marginal discoloration at the cervical enamel margin (big arrow). The restoration was clinically unacceptable and needed to be replaced. The restoration of tooth No. 13 showed only a small marginal defect on the dentin side (small arrow).*

Adhesive materials such as resin composites, RMGI cements, or polyacid-modified resin composites have been mostly used to restore noncarious cervical lesions.[18] This study investigated the clinical performance of a two-step etch-and-rinse/resin composite system and RMGI cement. Retention was considerably lower for resin composite restorations after seven years when compared with RMGI restorations. These results are in accordance with earlier research studies.[3,23,25]

Because no cavity preparation was performed, including no enamel beveling, the true dentin bonding capacity of the restorative systems could be evaluated. Several research studies have used this experimental model to assess the clinical performance of materials in noncarious cervical lesions.[9,12,17]

The loss rate of composite restorations has always been a matter of interest. The low retention rate of resin composites is possibly due to the degradation of the adhesive bond. With former adhesive systems, lost composite restorations composed up to 80% of the total restorations after four years.[17] Other studies confirmed that two-step etch-and-rinse adhesives have shown satisfactory retention rates (80% to 93%) during the first two years of evaluation,[4,26,27] but in the present study the number of lost restorations after seven years of clinical service was considerable. Evidence exists now that two-step etch-and-rinse adhesives are regarded as permeable membranes after polymerization because they lack a comparatively more hydrophobic bonding resin layer.[19] Therefore, they allow the continuous transudation of dentinal fluid and do not provide a hermetic seal of deep dentin,[19] which may accelerate the degradation of the adhesive interface.

Differences of clinical success have been observed according to the type of adhesive system used. High retention rates of etch-and-rinse adhesives after a 24-month evaluation of noncarious cervical lesions were detected, as long as the clinician rubbed the adhesives vigorously onto the dentin surfaces.[7] In noncarious class V lesions, high retention rates were observed in a 13-year clinical evaluation of two

three-step etch-and-rinse adhesives, with values ranging between 85% and 94% depending on the resin composite used.[28] Van Dijken and Pallesen[29] observed that restorations placed with a self-etching primer (Xeno III) and a resin composite (Tetric Ceram) or a modified poly-acid resin composite (Dyract AP) in noncarious cervical lesions showed acceptable clinical rates of retention to dentin surfaces after seven years regardless of the restorative material used. After eight years of clinical service, the clinical effectiveness of a mild two-step self-etch adhesive (Clearfil SE) was excellent.[30] Selective phosphoric acid-etching of the enamel margins had only some minor positive effects in marginal defects/discolorations.[30]

A statistically significant difference was observed in a systematic review[18] of glass ionomer versus two-step etch-and-rinse in noncarious restorations. Glass ionomer restorations showed the highest success rate in regard to retention with a 1.9% mean annual loss of retention; whereas, the mean annual retention loss of two-step etch-and-rinse adhesive systems was 6.2%.[18] Similar observations have been recorded[31] with glass ionomers' retention loss of 2% ± 2%. However, another systematic review[32] about different adhesive systems used for the restoration of noncarious cervical lesions concluded that there is not enough evidence to support one adhesive or bonding strategy over another for the treatment of this type of lesion.

Another challenge is the characteristic of noncarious cervical lesions. Sclerotic dentin and tubule occlusion by mineral crystals are very often present. Additionally, many parts of the wedge-shaped cervical lesion contain a hypermineralized surface that resists acid etching.[2]

The effectiveness of cervical restorations is most often expressed as retention loss relative to the observation time. Hence, retention is one of the most important criteria and is often used to assess the longevity of a restorative material. Retention loss is a robust objective criterion that is affected by a low degree of variability between different examiners in contrast with other clinical criteria. The latest guidelines of the ADA for submission of dentin and enamel adhesive materials require as provisional acceptance a retention rate of at least 95% of the restorations placed at the six-month recall.[21] To obtain full acceptance, retention of 90% after 18 months is required. Unfortunately, the guidelines have no requirements for the long-term durability of adhesive systems. In a systematic review, 96% of glass ionomer and 51% of two-step etch-and-rinse class V restorations got the full ADA acceptance in the observation period of the studies varying between one-half and six years.[18] These results are in accordance with the data obtained in the present study.

High retention rates of Vitremer restorations may be attributed to their adequate mechanical properties and better adhesion to dental tissues.[33,34] Vitremer possesses two adhesion mechanisms: first, an auto-adhesive capacity by forming ionic bonds between the carboxyl groups of polyalkenoic acid and hydroxyapatite[35]; and second, micromechanical interlocking of the polymer.[36] In addition, it is suggested that the clinical retention of an adhesive restoration depends not only on the retention capacity of the adhesive system used but also on the viscoelastic properties of the restorative material tested.[37] It has been reported that the elastic modulus of glass ionomer cements is more similar to enamel and dentin than adhesives are.[38] It has been claimed that flexural deformation of a tooth in the cervical region is at least partly absorbed by restorative material. The materials with a modulus of elasticity similar to that of a tooth when used in cervical restorations tend to bend more like a tooth structure when subjected to a masticatory load and may flex and be retained.[39] The combination of these factors may have been responsible for the higher retention rate of glass ionomer restorations in the present study.

Although RMGI cements have shown good retention rates in the literature, the major problem with this material is poor color stability.[16,23,25,40] Sidhu[41] reviewed some of the existing literature on the clinical performance of RMGI cements and observed an adequate performance in terms of retention. Secondary caries as well as postoperative sensitivity are not a concern for this type of restorative procedure.[41] However, this is not necessarily true for marginal characteristics, surface properties, and color stability.[41] In cases where esthetics is essential, an association of RMGI cement and resin composite has been an optional restorative therapy. The combination of these restorative materials is a good alternative and seems to minimize restoration loss.[12,37,42]

The overall better behavior of ionomer restorations is in accordance with previous papers on short-term[4,15,43-44] or long-term evaluations.[40,45] Few clinical trials suggested a limited longevity for RMGI restorations compared with resin composite restorative materials.[15,46] This difference observed between the present study and other previous studies may be due to cavity or type of lesion. Additionally, the shape

and size of restorations, operator variability, occlusal factors, bonding capacity of the restorative system, application and curing technique used, and other factors during aging of the restoration such as temperature and pH cycles in the mouth[47] could account for the differences between the studies. In a five-year evaluation of class V restorations placed by UK general practitioners, different factors were associated with increased longevity. Greater durability of these restorations could be achieved by improving operator skills, followed by cavity preparation and appropriate material handling.[48] Additionally, Brackett and others[49] observed reduced percentages of clinical success of noncarious class V lesions restored by inexperienced operators due to limitations in the manufacturer's instructions of self-etching adhesives. In the present study, the restorations were performed by only one operator, in order to decrease the effect of the operator factor. This allows ranking of the restorative materials tested but does not give information about variations in durability of the materials due to operator variability.

The cumulative survival rates at the 5- to 7-year follow-up interval in the present study were 95.8% and 63.7% for RMGI restorations and resin composite restorations, respectively. These data are in agreement with long-term studies performed with similar materials, in which better performance of glass ionomer materials was also observed.[3] The comparison of the present data with studies[50] of equivalent evaluation periods revealed similarity to retention rates of resin composite restorations (range, 60% to 74%).

Apparently, light-cured or chemically cured glass ionomer cement continues to be the most retentive material for noncarious cervical lesions.[12-14,18]

CONCLUSION

Despite the limitations of this study, the overall clinical performance of resin-modified glass ionomer restorations (Vitremer) was superior to the two-step etch-and-rinse adhesive and resin composite (Excite/Tetric Ceram) restorations after seven years of evaluation.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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REFERENCES

1. Wood I, Jawad Z, Paisley C, & Brunton P (2008) Non-carious cervical tooth surface loss: A literature review Journal of Dentistry **36(10)** 759-766.
2. Perdigão J (2010) Dentin bonding-variables related to the clinical situation and the substrate treatment *Dental Materials* **26(2)** 24-37.
3. van Dijken JW, & Pallesen U (2008) Long-term dentin retention of etch-and-rinse and self-etch adhesives and a resin-modified glass ionomer cement in non-carious cervical lesions *Dental Materials* **24(7)** 915-922.
4. Brackett MG, Dib A, Brackett WW, Estrada BE, & Reyes AA (2002) One-year clinical performance of a resin-modified glass ionomer and a resin composite restorative material in unprepared class V restorations *Operative Dentistry* **27(2)** 112-116.
5. Loguercio AD, Mânica D, Ferneda F, Zander-Grande C, Amaral R, Stanislawczuk R, de Carvalho RM, Manso A, & Reis A (2010) A randomized clinical evaluation of a one- and two-step self-etch adhesive over 24 months *Operative Dentistry* **35(3)** 265-272.
6. Reis A, Mânica D, Ferneda F, Amaral R, Stanislawczuk R, Manso A, de Carvalho RM, & Loguercio AD (2010) A 24-month randomized clinical trial of a two- and three-step etch-and-rinse technique *American Journal of Dentistry* **23(4)** 231-236.
7. Zander-Grande C, Ferreira SQ, da Costa TR, Loguercio AD, & Reis A (2011) Application of etch-and-rinse adhesives on dry and rewet dentin under rubbing action: A 24-month clinical evaluation *Journal of the American Dental Association* **142(7)** 828-835.
8. Qin W, Song Z, Ye YY, & Lin ZM (2013).Two-year clinical evaluation of composite resins in non-carious cervical lesions *Clinical Oral Investigations* **17(3)** 799-804.
9. Ermis RB, Van Landuyt KL, Cardoso MV, De Munck J, Van Meerbeek B, & Peumans M (2012) Clinical effectiveness of a one-step self-etch adhesive in non-carious cervical lesions at 2 years *Clinical Oral Investigations* **16(3)** 889-897.
10. Stojanac I, Premovic M, Ramic B, Drobac M, Stojsin I, & Petrovic L (2013) Noncarious cervical lesions restored with three different tooth-colored materials: Two-year results *Operative Dentistry* **38(1)**12-20.
11. Perdigão J, Dutra-Corrêa M, Saraceni S, Ciaramicoli M, & Kiyan V (2012) Randomized clinical trial of two resin-modified glass ionomer materials: 1-year results *Operative Dentistry* **37(6)** 591-601.
12. Powell LV, Johnson GH, & Gordon GE (1995) Factors associated with clinical success of cervical abrasion/erosion restorations *Operative Dentistry* **20(1)** 7-13.
13. Neo J, Chew CL, Yap A, & Sidhu S (1996) Clinical evaluation of tooth-colored materials in cervical lesions *American Journal of Dentistry* **9(1)** 15-18.
14. Burrow MF, & Tyas MJ (1999) 1-year clinical evaluation of one-step in non-carious cervical lesions *American Journal of Dentistry* **12(6)** 283-285.
15. Duke ES, & Trevino DF (1998 A resin-modified glass ionomer restorative: Three-year clinical results *Journal of Indiana Dental Association* **77(3)** 13-16.

16. Ozgünaltay G, & Onen A (2002) Three-year clinical evaluation of a resin modified glass-ionomer cement and a composite resin in non-carious class V lesions Journal of Oral Rehabilitation **29(11)** 1037-1041.

17. van Dijken JW (1994) Clinical evaluation of four dentin bonding agents in class V abrasion lesions: A four-year follow-up *Dental Materials* **10(5)** 319-324.

18. Heintze SD, & Roulet JF (2010) Glass ionomer derivates have better retention rates in cervical restorations compared to self-etching adhesive systems Journal of Evidence Based Dental Practice **10(1)** 18-20.

19. Tay FR, Frankenberger R, Krejci I, Bouillaguet S, Pashley DH, Carvalho RM, & Lai CN (2004) Single-bottle adhesives behave as permeable membranes after polymerization. I. In vivo evidence *Journal of Dentistry* **32(8)** 611-621.

20. Ryge G (1980) Clinical criteria *International Dental Journal* **30(4)** 347-358.

21. ADA Council on Scientific Affairs (1996) American Dental Association acceptance program guidelines: restorative materials. American Dental Association, Chicago, 1-14.

22. De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, & Van Meerbeek B (2005) A critical review of the durability of adhesion to tooth tissue: Methods and results *Journal of Dental Research* **84(2)** 118-1132.

23. Maneenut C, & Tyas MJ (1995) Clinical evaluation of resin-modified glass-ionomer restorative cements in cervical "abrasion" lesions: One-year results *Quintessence International* **26(10)** 739-743.

24. Heintze SD, Thunpithayakul C, Armstrong SR, & Rousson V (2011) Correlation between microtensile bond strength data and clinical outcome of class V restorations *Dental Materials* **27(2)** 114-1125.

25. Browning WD, Brackett WW, & Gilpatrick RO (2000) Two-year clinical comparison of a microfilled and a hybrid resin-based composite in non-carious class V lesions *Operative Dentistry* **25(1)** 46-50.

26. Merte K, Fröhlich M, Häfer M, Hirsch E, Schneider H, & Winkler M (2000) Two-year clinical performance of two primer adhesives on class V restorations *Journal of Biomedical Materials Research* **53(1)** 93-99.

27. van Dijken JW (2004) Durability of three simplified adhesive systems in class V non-carious cervical dentin lesions *American Journal of Dentistry* **17(1)** 27-32.

28. Peumans M, De Munck J, Van Landuyt KL, Poitevin A, Lambrechts P, & Van Meerbeek B (2012) A 13-year clinical evaluation of two three-step etch-and-rinse adhesives in non-carious class-V lesions *Clinical Oral Investigations* **16(1)** 129-137.

29. van Dijken JW, & Pallesen U (2012) A 7-year randomized prospective study of a one-step self-etching adhesive in non-carious cervical lesions. The effect of curing modes and restorative material *Journal of Dentistry* **40(12)** 1060-1067.

30. Peumans M, De Munck J, Van Landuyt KL, Poitevin A, Lambrechts P, & Van Meerbeek B (2010) Eight-year clinical evaluation of a 2-step self-etch adhesive with and without selective enamel etching *Dental Materials* **26(12)** 1176-1184.

31. Van Meerbeek B, Peumans M, Poitevin A, Mine A, Van Ende A, Neves A, & De Munck J (2010) Relationship between bond-strength tests and clinical outcomes *Dental Materials* **26(2)** 100-121.

32. Chee B, Rickman LJ, & Satterthwaite JD (2012) Adhesives for the restoration of non-carious cervical lesions: A systematic review *Journal of Dentistry* **40(6)** 443-452.

33. Sidhu SK, & Watson TF (1995) Resin-modified glass ionomer materials. A status report for the American Journal of Dentistry *American Journal of Dentistry* **8(1)**: 59-67.

34. Yap AU, & Neo JC (1995) Non-carious cervical tooth loss. Part 2: Management *Dental Update* **22(9)** 364-368.

35. van Dijken JW (2000) Clinical evaluation of three adhesive systems in class V non carious lesions *Dental Materials* **16(4)** 285-291.

36. Van Meerbeek B, Yoshida W, Lambrechts P, Vanherle G, Wakasa K, & Nakayama Y (1998) Mechanisms of bonding of a resin modified glass ionomer adhesive to dentin *Journal of Dental Research* **77(Special Issue A)** Abstract #2236, p 911.

37. van Dijken JW (2005) Retention of a resin-modified glass ionomer adhesive in non-carious cervical lesions. A 6-year follow-up *Journal of Dentistry* **33(7)** 541-547.

38. Magni E, Ferrari M, Hickel R, & Ilie N (2010) Evaluation of the mechanical properties of dental adhesives and glass-ionomer cements *Clinical Oral Investigations* **14(1)** 79-87.

39. Heymann HO, Sturdevant JR, Bayne SC, Wilder AD, Sluder TB, & Brunson WD (1991) Examining tooth flexure effect on cervical restorations: A two-year clinical study *Journal of the American Dental Association* **122(5)** 41-47.

40. Loguercio AD, Reis A, Barbosa AN, & Roulet JF (2003) Five-year double-blind randomized clinical evaluation of a resin-modified glass ionomer and a polyacid-modified resin in noncarious cervical lesions *Journal of Adhesive Dentistry* **5(4)** 323-332.

41. Sidhu SK (2010) Clinical evaluations of resin-modified glass-ionomer restorations *Dental Materials* **26(1)** 7-12.

42. Peumans M, Van Meerbeek B, Lambrechts P, & Vanherle G (2003) Two-year clinical effectiveness of a resin modified glass ionomer adhesive *American Journal of Dentistry* **16(6)** 363-368.

43. Santiago SL, Franco EB, Mendonça JS, Lauris JR, & Navarro MF (2003) One-year clinical evaluation of tooth-colored materials in non-carious cervical lesions *Journal of Applied Oral Science* **11(3)** 175-180.

44. Santiago SL, Passos VF, Vieira AH, Navarro MF, Lauris JR, & Franco EB. (2010) Two-year clinical evaluation of resinous restorative systems in non-carious cervical lesions *Brazilian Dental* Journal **21(3)** 229-234.

45. Franco EB, Benetti AR, Ishikiriama SK, Santiago SL, Lauris JR, Jorge MF, & Navarro MF (2006) 5-year clinical performance of resin composite versus resin modified glass ionomer restorative system in non-carious cervical lesions *Operative Dentistry* **31(4)** 403-408.

46. Folwaczny M, Loher C, Mehl A, Kunzelmann KH, & Hickel R (2001) Class V lesions restored with four different tooth-colored materials—3-year results *Clinical Oral Investigations* **5(1)** 31-39.

47. van Dijken JW (2003) A 6-year clinical evaluation of class I poly-acid modified resin composite/resin composite laminate restorations cured with a two-step curing technique *Dental Materials* **19(5)** 423-428.

48. Stewardson D, Creanor S, Thornley P, Bigg T, Bromage C, Browne A, Cottam D, Dalby D, Gilmour J, Horton J, Roberts E, Westoby L, & Burke T (2012) The survival of class V restorations in general dental practice: Part 3, five-year survival *British Dental Journal* **212(9)** E14.

49. Brackett MG, Dib A, Franco G, Estrada BE, & Brackett WW (2010) Two-year clinical performance of Clearfil SE and Clearfil S3 in restoration of unabraded non-carious class V lesions *Operative Dentistry* **35(3)** 273-278.

50. van Dijken JW (2010) A prospective 8-year evaluation of a mild two-step self-etching adhesive and a heavily filled two-step etch-and-rinse system in non-carious cervical lesions *Dental Materials* **26(9)** 940-946.