



# Demineralization around orthodontic brackets bonded with resin-modified glass ionomer cement and fluoride-releasing resin composite

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## Abstract

**Purpose:** Enamel demineralization adjacent to orthodontic brackets is one of the risks associated with orthodontic treatment. Glass ionomer cements have been shown to decrease enamel demineralization adjacent to brackets and bands but do not exhibit bond strengths comparable to resin composites. The purpose of this *in vitro* study was to compare a fluoride-releasing resin composite versus a resin-modified glass ionomer cement for inhibition of enamel demineralization surrounding orthodontic brackets.

**Methods:** Forty-five teeth were randomly assigned to 3 groups of 15 teeth. Fifteen were bonded with Concise (3M), a non-fluoride-releasing resin composite (control); 15 teeth were bonded with Light Bond (Reliance), a fluoride-releasing resin composite; and 15 teeth were bonded with Fuji Ortho LC (GC Corporation), a resin-modified glass ionomer cement. The teeth were placed in an artificial caries solution to create lesions. Following sectioning of the teeth in a buccolingual direction, polarized light microscopy was utilized to evaluate enamel demineralization adjacent to the orthodontic bracket. The area of the lesion was measured 100  $\mu\text{m}$  from the orthodontic bracket and bonding agent.

**Results:** MANOVA ( $P < .0001$ ) and Duncan's test ( $P < .05$ ) indicated the resin-modified glass ionomer cement (Fuji Ortho LC<sup>®</sup>) and the fluoride-releasing resin composite (Light Bond<sup>®</sup>) had significantly less adjacent enamel demineralization than the non-fluoride-releasing resin composite control. However, there was no significant difference between the resin-modified glass ionomer cement and the fluoride-releasing resin composite.

**Conclusions:** Based on the results of this *in vitro* study, it can be concluded that Fuji Ortho LC<sup>®</sup> and Light Bond<sup>®</sup> exhibit significant inhibition of adjacent demineralization compared to the non-fluoride-releasing control. (*Pediatr Dent* 23:255-259, 2001)

Enamel demineralization adjacent to orthodontic bands and brackets remains a concern to the practitioner. Reports of these "white spot lesions" have been made by several investigators and have been documented as early as one month after the start of treatment.<sup>1-3</sup> Increased difficulty of plaque removal around orthodontic brackets, increased bacterial adhesion to resin bonding materials, and increased oral bacteria during orthodontic treatment all contribute to demineralization adjacent to orthodontic brackets.<sup>3-6</sup>

The prevention of demineralization has become a critical concern during orthodontic therapy. Meticulous oral hygiene maintenance, fluoride rinses, and topical fluoride applications have been recommended.<sup>7-9</sup> Patient compliance is relied upon for these preventive therapies to be effective. Unfortunately, those patients who are at highest risk for demineralization are the least likely to follow a preventive regimen. One might expect that a cementing agent that releases fluoride might inhibit caries on tooth structure adjacent to the orthodontic bands or brackets.

Glass ionomer cements have demonstrated caries inhibition, as well as enamel remineralization, when utilized as a cementing agent for orthodontic bands.<sup>10</sup> Unfortunately, these cements did not provide the tensile strength necessary for bracket retention on anterior teeth.<sup>11-14</sup> The introduction of glass ionomer cements within a photopolymerized resin matrix has shown its ability to provide a better enamel bond strength, which makes this agent more appropriate for use in bracket retention.<sup>15</sup> The material has demonstrated caries inhibition when used as a base/liner, restoration, or bracket bonding agent.<sup>16-20</sup> Additional advantages of resin-modified glass ionomer cements for use as an orthodontic bonding agent are that acid etching or tooth preparation, other than cleansing with pumice, is not required, and bonding may occur in the presence of moisture.<sup>21,22</sup>

It has been reported that the average force transmitted to a bracket during mastication ranges between 40 and 120 newtons.<sup>23,24</sup> Certain patients may be more demanding on bonding agents for retention of fixed orthodontic appliances. Many studies have shown the bracket debonding force of resin-modified glass ionomer cements to be significantly lower than that of the conventional resins.<sup>11-14</sup> Underwood, Rawls, and Zimmerman found a significant reduction in the progression of early demineralization with the use of fluoride-exchanging adhesive for bonding orthodontic brackets.<sup>25</sup> Bynum and Donly demonstrated that fluoridated resin composite restorations in direct interproximal contact with adjacent teeth may inhibit enamel demineralization and even promote incipient caries remineralization.<sup>26</sup>

When dental materials are selected for bonding orthodontic brackets, it is important to consider both bond strength and inhibition of demineralization. Therefore, a comprehensive

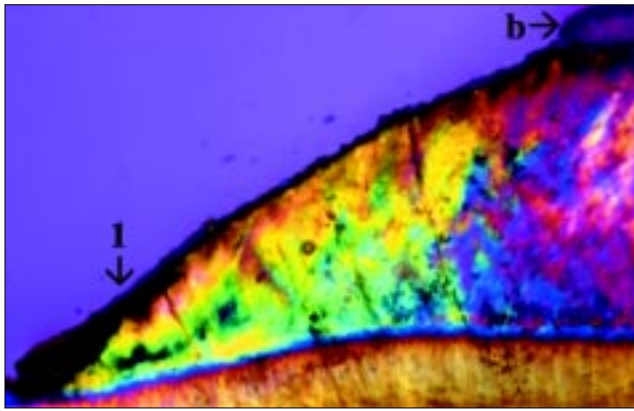


Fig 1. A representative example of the resin-modified glass ionomer cement, Fuji Ortho LC®, in which the location of the lesion (1) was greater than 100µm from the bracket base/residual bonding agent (b).

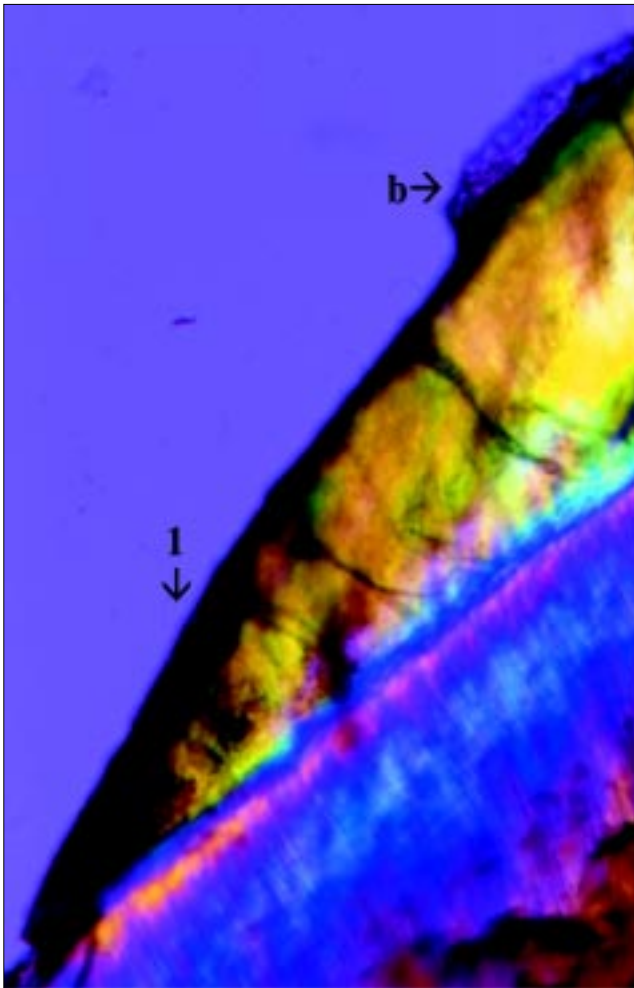


Fig 2. A representative example of the fluoride-releasing resin composite, Light Bond®, in which the location of the lesion (1) was noted to be greater than 100µm from the bracket base/residual bonding agent (b).

evaluation of these factors would be indicated. Numerous studies comparing bond strengths of resin-modified glass ionomer cements versus conventional resin composites have been well documented.<sup>21-24</sup> It would be beneficial to the orthodontic patient to find a bracket bonding agent with both sustained fluoride release and adequate bond strength.

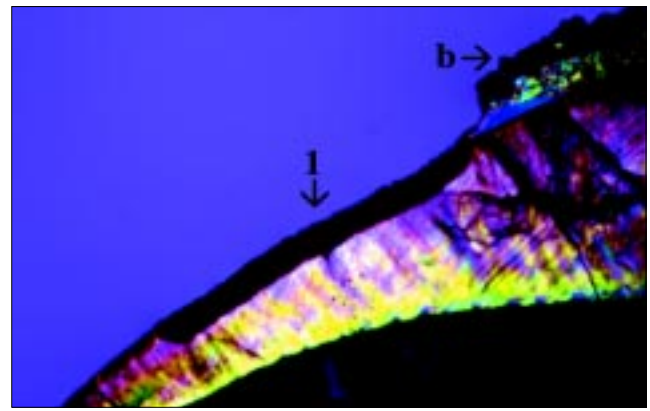


Fig 3. A representative example of the control group, Concise®, a non-fluoride-releasing resin composite, in which the location of the lesion (1) was directly adjacent to the bracket base/residual bonding agent (b).

The purpose of this *in vitro* study was to compare a fluoride-releasing resin composite versus a resin-modified glass ionomer cement for inhibition of enamel demineralization surrounding orthodontic brackets.

## Methods

Forty-five caries-free human molars and premolars, which had been stored for three months in formalin solution, were obtained, debrided of any remaining soft tissue, and randomly separated into three groups of 15. A power test from data obtained in previous studies indicated 15 specimens per group should provide statistically significant data at the 95% confidence level. All teeth were painted with an acid-protective varnish, excluding 2 x 4 mm windows on the buccal surfaces. Orthodontic brackets were then bonded to the exposed enamel. Ormesh Bicuspid/Cuspid Universal Stainless Steel Bonds (Ormco Corporation, Glendora, California) twin brackets were used in this study.

The following bonding agents were selected for comparison: 1) Fuji Ortho LC®, a resin-modified glass ionomer cement (GC Corporation, Scottsdale, AZ); 2) Light Bond®, a fluoride-releasing resin composite combined with the manufacturer's fluoride-releasing light cure sealant (Reliance Orthodontic Products Incorporation, Itasca, IL); and 3) Concise®, a non-fluoride-releasing resin composite (3M Dental Products Division, St. Paul, MN) as a control. The exposed enamel was etched with GC Ortho® Conditioner (10% polyacrylic acid) for group 1 and 37% phosphoric acid for groups two and three.

Since only the area of enamel where the brackets were to be bonded to was exposed, there was no etching of enamel adjacent to the bracket, which could prematurely initiate demineralization. Groups 2 and 3 required placement of a thin layer of unfilled resin prior to bonding of the bracket to the tooth surface. For group 1, the powder and liquid was mixed according to the manufacturers instructions. For each group, the bonding agents were applied to the mesh pad of each bracket, which was then positioned on the tooth, and the excess was removed.

To evaluate inhibition of enamel demineralization adjacent to the orthodontic bracket, the varnish was removed from a 1 X 4 mm window directly adjacent to the bracket. Artificial caries-like lesions were created in the exposed enamel by suspending the teeth in an artificial caries solution consisting of

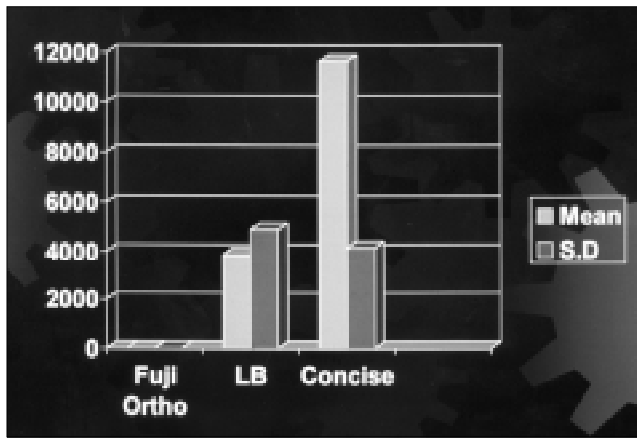


Fig 4. The area ( $\mu\text{m}^2$ ) of demineralization 100 $\mu\text{m}$  from the bracket base/residual bonding agent margin.

2.2 mM  $\text{Ca}^{+2}$ , 2.2 mM  $\text{PO}_4^{-3}$ , and 50 mM acetic acid at pH 4.5<sup>27</sup> for 5 days. The presence of demineralization was visually confirmed by the presence of chalky white enamel. The teeth were then rinsed and stored in deionized water until sectioning.

The brackets were removed, leaving residual bonding agent on the tooth surface. The teeth were sectioned in a buccolingual direction parallel to the long axis of the tooth with a hard tissue microtome to obtain 100  $\mu\text{m}$  sections through the residual bonding agent and adjacent artificial carious lesion.

The sections were photographed under polarized light microscopy in a water imbibition medium which has a refractive index of 1.33 compared to the sound enamel refractive index of 1.62. Water imbibition represents greater than 5% pore volume in enamel. The area of the lesion was measured 100  $\mu\text{m}$  from the residual bonding agent with a computerized imaging system.

## Results

The results demonstrated the mean ( $\pm$  S.D.) area ( $\mu\text{m}^2$ ) of demineralization 100  $\mu\text{m}$  from the bracket to be: Fuji Ortho LC<sup>®</sup> (0 $\pm$ 0); Light Bond<sup>®</sup> (3869 $\pm$ 4895); and Concise<sup>®</sup> (11,636 $\pm$ 4157). Analysis of variance (MANOVA,  $P < .0001$ ) and Duncan's Multiple range test ( $P < .05$ ) indicated the resin-modified glass ionomer cement (Fuji Ortho LC<sup>®</sup>) and the fluoride-releasing resin composite (Light Bond<sup>®</sup>) had significantly less adjacent enamel demineralization than the non-fluoride-releasing resin composite (Concise<sup>®</sup>) control. However, there was no significant difference between the resin-modified glass ionomer cement and fluoride-releasing resin composite.

## Discussion

The results of this study suggest that both resin-modified glass ionomer cement and fluoride-releasing resin composite have the ability to inhibit demineralization of enamel adjacent to fixed orthodontic appliances. This is consistent with previous studies.<sup>25,28</sup> Applied clinically, this is of considerable benefit to the orthodontic patient who exhibits less than optimal oral hygiene and is difficult to motivate. Use of topical fluoride has been shown to decrease decalcification,<sup>29,30</sup> but this also depends on patient compliance. Donly, et al, demonstrated a mean remineralization effect produced by a fluoridated resin and a

resin-modified glass ionomer cement brushed with a fluoridated dentifrice.<sup>31</sup>

Although there was no statistically significant difference in inhibition of demineralization between Fuji Ortho LC<sup>®</sup> and Light Bond<sup>®</sup>, the area of lesions 100  $\mu\text{m}$  from the residual bonding agent/bracket base was slightly greater with Light Bond<sup>®</sup>. This may be attributed to the amount of fluoride released by the different bonding agents. Vieira, et al, found the resin-modified glass ionomer cement to release a significantly greater amount of fluoride than the fluoride-containing resin composite.<sup>32</sup> Strother, et al, demonstrated similar results.<sup>33</sup>

One of the primary differences of resin-modified glass ionomer cements versus fluoride-releasing resin composites is the process by which fluoride is released. Glass ionomer cements will release fluoride through passive diffusion and surface dissolution, whereas fluoridated resin composite will release fluoride through passive diffusion.<sup>34</sup> The main component of Fuji Ortho LC<sup>®</sup> is a fine fluoroaluminum glass powder, the liquid being polyacrylic acid, water, and a monomer as an activator. The resin compound is a mixture of three monomers, mainly 2-hydroxyethylmethacrylate (HEMA), which enhances the polymerization reaction. In addition, a small amount of camphorquinone functions as an activator for photopolymerization.<sup>35</sup>

Glass ionomer cements have been shown to have a burst effect, releasing considerably more fluoride *in vitro* soon after placement,<sup>36-38</sup> which may be of benefit over the fluoride-releasing resin composites.

Fluoride may be added to resin composites as a part of the opaquel agent, associated with the glass filler of the resin composite, or merely added as a fluoride compound. Light Bond<sup>®</sup> has sodium fluoride associated with the glass filler. An interesting difference in this study compared with previous similar studies is that a fluoride-releasing adhesive was used in combination with the fluoride-releasing resin composite. A previous study has shown the ability of fluoride-releasing resin composites and hybrid glass ionomer cements to remineralize enamel that is demineralized at restoration margins.<sup>28</sup> Additionally, studies have confirmed both types of materials to exhibit uptake of fluoride delivered by dentifrices and topical fluoride treatments at the material surface and then slowly release this fluoride.<sup>26,34</sup> The bonding materials themselves or another type of fluoride-releasing reservoir attached to the orthodontic appliances could act as an additional preventive measure.

Fluoride release from Light Bond<sup>®</sup> is one of the benefits of this resin composite. Another advantage is the considerable bond strength. Historically, studies have shown glass ionomer cements to exhibit significantly lower bond strengths than resin composites for bonding orthodontic brackets.<sup>21-24</sup> In contrast to these studies, Lippitz, et al, concluded that Fuji Ortho LC<sup>®</sup>

Bonding Agent	Mean area ( $\pm$ S.D.) demineralization ( $\mu\text{m}^2$ ) 100 $\mu\text{m}$ adjacent to bonding agent
Fuji Ortho LC <sup>®</sup>	0 ( $\pm$ 0)
Light Bond <sup>®</sup>	3869 ( $\pm$ 4895)
Concise <sup>®</sup> (control)	11,636 ( $\pm$ 4157)*

\*Indicates significant difference from other groups ( $P < .05$ ).

had 24-hour and 30-day shear bond strengths that were statistically equivalent to those of the resin composite when used to bond mesh-backed stainless-steel brackets to etched enamel surfaces of extracted human premolars. They also determined shear bond strengths to be significantly lower in magnitude in the absence of etching with polyacrylic acid prior to bonding the brackets.<sup>39</sup>

It is important to consider the following criteria when selecting an orthodontic bonding agent: fluoride release, bond strength, ease of handling the material during bracket placement, ability to achieve adequate isolation, oral hygiene, and patient compliance with diet and use of topical fluoride.

## Conclusions

Based on the results of this *in vitro* study, it can be concluded that Fuji Ortho LC<sup>®</sup> and Light Bond<sup>®</sup> exhibit significant inhibition of demineralization compared to the non-fluoride-releasing control. This quality makes either bonding agent a potential improvement for use as an adjunctive preventive dentistry measure. Future clinical investigation is needed to adequately and comprehensively evaluate the effective release of fluoride from the different bonding agents as well as adequacy of bond strength.

## References

- O'Reilly MM, Featherstone JD. Demineralization and remineralization around orthodontic appliances: an *in vivo* study. *Amer J Orthod Dentofac Orthop* 92:33-40, 1987.
- Gorelick L, Geiger AM, Gwinnett AJ. Incidence of white spot formation after bonding and banding. *Am J Orthod* 81:93-98, 1982.
- Zachrisson BU, Zachrisson S. Caries incidence and oral hygiene during orthodontic treatment. *Scand J Dent Res* 79:394-401, 1971.
- Gwinnett AJ, Ceen RF. Plaque distribution on bonded brackets: a scanning microscope study. *Am J Orthod* 75:667-677, 1979.
- Bloom RH, Brown LR. A study of the effects of orthodontic appliances on the oral microbial flora. *Oral Surg* 17:658-667, 1964.
- Adams RJ. The effects of fixed orthodontic appliances on the cariogenicity, quantity, and microscopic morphology of oral lactobacilli. *J Oral Med* 22:88-98, 1967.
- Bishara SE, Chan DCN, Abadir EA. The effect on the bonding strength of fluoride application after etching. *Am J Orthod Dentofac Orthop* 95:259-260, 1989.
- Zachrisson BU. Fluoride application procedures in orthodontic practices, current concepts. *Angle Orthod* 45:72-81, 1975.
- Muhler JC. Dental caries – orthodontic appliances – SnF<sub>2</sub>. *J Dent Child* 37:218-221, 1970.
- Donly KJ, Istre S, Istre T. Enamel remineralization at orthodontic band margins cemented with glass ionomer. *J Dent Res* 71:237, 1992.
- Shamma I, Ngan P, Kim H, Kao E, Gladwin M, Gunel E, Brown C. Comparison of bracket debonding force between two conventional resin adhesives and a resin-reinforced glass ionomer cement: an *in vitro* and *in vivo* study. *Angle Orthod* 69:463-469, 1999.
- Chung CH, Cuozzo, Mante FK. Shear bond strength of a resin-reinforced glass ionomer cement: an *in vitro* comparative study. *Am J Orthod Dentofac Orthop* 115:52-54, 1999.
- Cohen S, Marulli R, Binder RE, Vaidyanathan TK. Shear bond strengths of chemically and light-cured resin modified ionomers. *J Clin Orthod* 32:423-426, 1998.
- Messersmith ML, Devine SM, Zionie AE. Effects of tooth surface preparation on the shear bond strength of resin modified glass ionomer cements. *J Clin Orthod* 31:503-509, 1997.
- Compton AM, Meyers CE, Hondrum SO, Lorton L. Comparison of the shear bond strength of a light cured glass ionomer for uses as an orthodontic bonding agent. *Am J Orthodont Dentofac Orthop* 101:138-144, 1992.
- Vorhies AB, Donly KJ, Staley RN, Wefel JS. Enamel demineralization adjacent to orthodontic brackets bonded with hybrid glass ionomer cements: an *in vitro* study. *Am J Orthod Dentofac Orthop* 114:668-674, 1998.
- Griffin F, Donly KJ, Erickson R. Caries inhibition of fluoride-releasing liners. *Am J Dent* 5:293-295, 1992.
- Jensen ME, Wefel JS, Hammesfahr PD. Fluoride-releasing liners: *in vitro* recurrent caries. *Gen Dent* 39:12-17, 1991.
- Jensen ME, Garcia-Godoy F, Wefel JS. Artificial root caries in amalgam restorations: effect on light-cured fluoride-releasing liners. *Am J Dent* 3:295-298, 1990.
- Garcia-Godoy F, Jensen ME. Artificial recurrent caries in glass ionomer-lined amalgam restorations. *Am J Dent* 3:89-93, 1990.
- Powers JM, Kim HB, Turner DS. Orthodontic adhesives and bond strength testing. *Semin Orthod* 3:147-156, 1997.
- Jobalia SB, Valente RM, DeRijk WG, BeGole EA, Evans CA. Bond strength of visible light-cured glass ionomer orthodontic cement. *Am J Orthod Dentofac Orthop* 112:205-208, 1997.
- Reynolds IR. A review of direct orthodontic bonding. *Br J Orthod* 2:171-178, 1997.
- McSherry PF. An *in vitro* evaluation of the tensile and shear strengths of four adhesives used in orthodontics. *Eur J Orthod* 18:319-327, 1996.
- Underwood ML, Rawis HR, Zimmerman BF. Clinical evaluation of a fluoride-exchanging resin as an orthodontic adhesive. *Am J Orthod Dentofac Orthop* 96:93-99, 1999.
- Bynum AM, Donly KJ. Enamel de/remineralization on teeth adjacent to fluoride-releasing materials without dentifrice exposure. *J Dent Child* 66:89-92, 1999.
- ten Cate JM, Duijsters PP. Alternating demineralization and remineralization of artificial enamel lesions. *Caries Res* 16:201-210, 1982.
- Donly KJ, Gomez C. *In vitro* demineralization-remineralization of enamel caries at restoration margins utilizing fluoride-releasing composite resin. *Quintessence Int* 25:355-358, 1994.
- Driscoll WS, Swango PA, Horowitz AM, et al. Caries-preventive effects of daily and weekly fluoride rinsing in a fluoridated community: final results after 30 months. *JADA* 105:1010-1013, 1982.
- Heifetz SB, Meyers RJ, Kingman A. A comparison of the anticaries effectiveness of daily and weekly rinsing with sodium fluoride solutions: final results after three years. *Pediatr Dent* 4:300-303, 1982.
- Donly KJ, Segura A, Wefel JS, Hogan MM. Evaluating the effects of fluoride-releasing dental materials on adjacent interproximal caries. *JADA* 130:817-825, 1999.
- Vieira AR, DeSouza IPR, Modesto A. Fluoride uptake and release by composites and glass ionomers in a high caries challenge situation. *Am J Dent* 12:14-18, 1999.

33. Strother JM, Kohn DH, Dennison JB, Clarkson BH. Fluoride release and re-uptake in direct tooth-colored restorative materials. *Dent Mater* 14:129-136, 1998.
34. Donly KJ, Nelson JJ. Fluoride release of restorative materials exposed to a fluoridated dentifrice. *J Dent Child* 249-250, 1997.
35. Silverman E, Cohen M, Demke R, Silverman M. A new light-cured glass ionomer cement that bonds brackets to teeth without etching in the presence of saliva. *Am J Orthod Dentofac Orthop* 108:231-236, 1995.
36. Preston AJ, Mair LH, Agalamanyi EA, Higham SM. Fluoride release from aesthetic dental materials. *J Oral Rehab* 26:123-129, 1999.
37. Eichmiller FC, Marjenhoff WA. Fluoride-releasing dental restorative materials. *Oper Dent* 23:218-228, 1998.
38. Ashcraft DB, Staley RN, Jakobsen JR. Fluoride release and shear bond strengths of three light-cured glass ionomer cements. *Am J Orthod Dentofac Orthop* 111:260-265, 1997.
39. Lippitz SJ, Staley RN, Jakobsen JR. *In vitro* study of 24-hour and 30-day shear bond strengths of three resin-glass ionomer cements used to bond orthodontic brackets. *Am J Orthod Dentofac Orthop* 113:620-624, 1998.

## ABSTRACT OF THE SCIENTIFIC LITERATURE



### THE EFFECTIVENESS OF THE VARICELLA VACCINE IN CLINICAL PRACTICE

A live attenuated varicella vaccine was approved for use in 1995 and is recommended for all susceptible persons 12 months of age or older. The study is a case control one that examined two controls for each child with chickenpox. The children were matched with both age and the pediatric practice where they were followed. The children were assessed for severity of disease at day 3, 4 and 5 of the illness. The lesions were also tested for varicella-zoster virus by polymerase chain reaction (PCR). Of the 56 vaccinated children with chickenpox, 86% had mild disease whereas only 48% of unvaccinated children with chickenpox had mild disease. Among the 202 children with PCR confirmed varicella zoster infection and their 398 matched controls, 23% of the children with chickenpox and 61% of the matched controls had received the vaccine (vaccine effectiveness 85%; 95% confidence interval, 78 to 90%; p=0.001). Against moderately severe and severe disease the vaccine was 97 percent effective. The authors concluded that varicella vaccine is highly effective in clinical practice.

**Comments:** One of the more disturbing trends in modern parenting is a reluctance to allow children to be immunized. Immunization has been a major factor in reducing serious childhood infectious diseases. As this study of the varicella vaccine illustrates, vaccination can help lessen the risk of disease as well as influence its clinical course. CH

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The effectiveness of the varicella vaccine in clinical practice. Vasquez M, LaRussa PS, Gerhson AA, Steinberg SP, Freudigman K and Shapiro ED. *N Eng J Med* 2001. 344: 955-60.