**Mineralisation**

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# Fluoridated carbonatoapatite in the intermediate layer between glass ionomer and dentin.

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The intermediate layer between a glass ionomer restoration and dentin was examined morphologically by scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR). SEM showed strong bonding between the dentin and glass ionomer and formation of an intermediate layer between them. FTIR spectra of successive scrapings through the ionomer/dentin interface zone showed that the intermediate layer is composed primarily of mineral fluoridated carbonatoapatite. The presence of this sparingly soluble mineral at the interface between the tooth and the restoration may provide high resistance to secondary caries and may, thus, be of great clinical importance.

PMID: 8299867 [PubMed - indexed for MEDLINE]  
1 Dent Mater. 1993 Jan;9(1):33-6

# Hypermineralization of dentinal lesions adjacent to glass-ionomer cement restorations.

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Previous reports have shown a release of fluoride from glass-ionomer cement (GIC) restorations into the oral fluids. Fluoride in the ambient fluids has a caries-preventive effect by enhancing remineralization and inhibiting demineralization of the dental hard tissues. Therefore, the current investigation was undertaken to determine whether GIC fillings could contribute to the remineralization of caries lesions in dentin. Small circular preparations were made in disks of dentin which had incipient caries-like lesions in the remaining tissue. The preparations were filled with amalgam or composite materials (as controls) or with GIC. The specimens thus contained a restoration close to a dentinal caries-like lesion. The specimens were placed contralaterally in the buccal surfaces of removable partial dentures and were worn intra-orally by volunteers for a 12-week experimental period, after which the specimens were sectioned and analyzed by microradiography. All specimens with GIC restorations exhibited hypermineralization in the tissue bordering the filling and in the wall of the preparation which had been in contact with the restoration. The (caries-like) lesions were remineralized, even under conditions of heavy plaque formation. In contrast, specimens with amalgam or composite restorations showed further extensive demineralization. This study demonstrates a significant remineralization potential exerted by the fluoride-releasing GIC restorative material. Consequently, the choice of the restorative material might be crucial for the occurrence or prevention of recurrent caries around restorations.

PMID: 7629335 [PubMed - indexed for MEDLINE]  
1 J Dent Res. 1995 Jun;74(6):1266-71

# Hypermineralization of Dentinal Lesions Adjacent to Glass-ionomer Cement Restorations

Journal of Dental Research  
<http://jdr.sagepub.com/content/74/6/1266>  
The online version of this article can be found at:  
DOI: 10.1177/00220345950740060501  
J DENT RES 1995 74: 1266

J.M. ten Cate and R.N.B. van Duinen

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**Abstract**. Previous reports have shown a release of fluoride from glass-ionomer cement (GIC) restorations into the oral fluids. Fluoride in the ambient fluids has a caries-preventive effect by enhancing remineralization and inhibiting demineralization of the dental hard tissues. Therefore, the current investigation was undertaken to determine whether GIC fillings could contribute to the remineralization of caries lesions in dentin. Small circular preparations were made in disks of dentin which had incipient caries-like lesions in the remaining tissue. The preparations were filled with amalgam or composite materials (as controls) or with GIC. The specimens thus contained a restoration close to a dentinal caries-like lesion. The specimens were placed contralaterally in the buccal surfaces of removable partial dentures and were worn intra-orally by volunteers for a 12- week experimental period, after which the specimens were sectioned and analyzed by microradiography. All specimens with GIC restorations exhibited hypermineralization in the tissue bordering the filling and in the wall of the preparation which had been in contact with the restoration. The (caries-like) lesions were remineralized, even under conditions of heavy plaque formation. In contrast, specimens with amalgam or composite restorations showed further extensive demineralization. This study demonstrates a significant remineralization potential exerted by the fluoride-releasing GIC restorative material. Consequently, the choice of the restorative material might be crucial for the occurrence or prevention of recurrent caries around restorations.

**Key words**: dentin, glass-ionomer cement, hypermineralization, remineralization.

# Experimental studies on a new bioactive material: HAIonomer cements.

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**Source**

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**Abstract**

The lack of exotherm during setting, absence of monomer and improved release of incorporated therapeutic agents has resulted in the development of glass ionomer cements (GICs) for biomedical applications. In order to improve biocompatibility and biomechanically match GICs to bone, hydroxyapatite-ionomer (HAIonomer) hybrid cements were developed. Ultra-fine hydroxyapatite (HA) powders were produced using a new induction spraying technique that utilizes a radio-frequency source to spheriodize an atomized suspension containing HA crystallites. The spheriodized particulates were then held at 800 degrees C for 4 h in a carbolite furnace using a heating and cooling rate of 25 degrees C/min to obtain almost fully crystalline HA powders. The heat-treated particles were characterized and introduced into a commercial glass ionomer cement. 4 (H4), 12 (H12) and 28 (H28) vol% of fluoroalumino silicate were substituted by crystalline HA particles that were dispersed using a high-speed dispersion technique. The HAIonomer cements were subjected to hardness, compressive and diametral tensile strength testing based upon BS6039:1981. The storage time were extended to one week to investigate the effects of cement maturation on mechanical properties. Commercially available capsulated GIC (GC) and GIC at maximum powder:liquid ratio (GM) served as comparisons. Results were analyzed using factorial ANOVA/Scheffe's post-hoc tests and independent samples t-test at significance level 0.05. The effect of time on hardness was material dependent. With the exception of H12, a significant increase in hardness was observed for all materials at one week. A significant increase in compressive strength was, however, observed for H12 over time. At 1 day and 1 week, the hardness of H28 was significantly lower than for GM, H4, and H12. No significant difference in compression and diametral tensile strengths were observed between materials at both time intervals. Results show that HAIonomers is a promising material, which possess good mechanical properties. Potential uses of this new material include bone cements and performed implants for hard tissue replacement in the field of otological, oral-maxillofacial and orthopedic surgery.

PMID: 11774854 [PubMed - indexed for MEDLINE]   
1. Biomaterials. 2002 Feb;23(3):955-62.

# The Effect of Adding Hydroxyapatite on the Flexural Strength of Glass Ionomer Cement

Glass Ionomer Cement Kenji ARITA, Milanita E. LUCAS and Mizuho NISHINO Department of Pediatric Dentistry The University of Tokushima School of Dentistry

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Received December 16, 2002/Accepted March 28, 2003

**Abstract:**  
This present study investigated the effects of the addition of hydroxyapatite (HA) on the flexural strength and microstructure of conventional GIC, and its effect on the cement's initial flexural strength at different storage conditions. Specimens were fabricated by mixing HA in whisker or granule form into commercially prepared GIC, and these were subjected to a threepoint bending test and SEM observations. Some specimens were stored in different conditions from dry to wet for 15 minutes to an hour prior to testing. When compared to the control, specimens with 16-25% HA whiskers added at P/L 1.75 showed a significant increase in the flexural strength (p<0.05), and as well with 19% HA whiskers at P/L 1.75 (p<0.001) and 2.33 (p<0.05). A significant increase was also noted for those with 8-25% HA granules added at P/L's 1.75 (p<0.05), 2.5 (p<0.05) and 3.60 (p<0.01). The addition of HA hastens the development of early (15min, 1 hour) flexural strength of GIC in moist or wet conditions. These results indicate that the addition of HA, regardless of form, improve the flexural and microstructural properties of GIC.

**Key words:** Glass ionomer, Hydroxyapatite, Flexural strength  
  
PMID: 12873116 [PubMed - indexed for MEDLINE]  
1. Dent Mater J. 2003 Jun;22(2):126-36.

# Chemical exchange between glass-ionomer restorations and residual carious dentine in permanent molars: an in vivo study.

Ngo HC, Mount G, Mc Intyre J, Tuisuva J, Von Doussa RJ.

**Source**

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**Abstract**

**OBJECTIVE:**

To evaluate the remineralization of carious dentine following the restoration of an extensive lesion in a permanent molar with a high strength glass-ionomer cement (GIC).

**MATERIALS AND METHODS:**

Thirteen first permanent molars, which were scheduled for extraction because of the presence of extensive caries lesions, were selected for this study. They were first restored, according to the ART technique, using encapsulated Fuji IX(GP), which contains a strontium glass rather than the traditional calcium glass. The cavities were prepared with a clean enamel margin and minimal removal of the carious dentine around the walls. After a period of 1-3 months they were harvested and subsequently sectioned and examined using an electron probe microanalysis (EPMA) and scanning electron microscopy (SEM).

**RESULTS:**

EPMA demonstrated that both fluorine and strontium ions had penetrated deep into the underlying demineralized dentine. The only possible source of these ions was the GIC restoration.

**CONCLUSION:**

The pattern of penetration of the fluorine and strontium ions into the dentine was consistent with a remineralization process.

PMID: 16540227 [PubMed - indexed for MEDLINE]  
1. J Dent. 2006 Sep;34(8):608-13. Epub 2006 Mar 15.

# Effects of incorporation of hydroxyapatite and fluoroapatite nanobioceramics into conventional glass ionomer cements (GIC).

Moshaverinia A, Ansari S, Moshaverinia M, Roohpour N, Darr JA, Rehman I.

Department of Materials, Interdisciplinary Research Centre in Biomedical Materials, Queen Mary University of London, Mile End Road, London E1 4NS, UK.

Hydroxyapatite (HA) has excellent biological behavior, and its composition and crystal structure are similar to the apatite in the human dental structure and skeletal system; a number of researchers have attempted to evaluate the effect of the addition of HA powders to restorative dental materials.  
In this study, nanohydroxy and fluoroapatite were synthesized using an ethanol based sol-gel technique. The synthesized nanoceramic particles were incorporated into commercial glass ionomer powder (Fuji II GC) and were characterized using Fourier transform infrared and Raman spectroscopy, X-ray diffraction and scanning electron microscopy. Compressive, diametral tensile and biaxial flexural strengths of the modified glass ionomer cements were evaluated. The effect of nanohydroxyapatite and fluoroapatite on the bond strength of glass ionomer cement to dentin was also investigated.  
Results showed that after 1 and 7 days of setting, the nanohydroxyapatite/fluoroapatite added cements exhibited higher compressive strength (177-179MPa), higher diametral tensile strength (19-20MPa) and higher biaxial flexural strength (26-28MPa) as compared with the control group (160MPa in CS, 14MPa in DTS and 18MPa in biaxial flexural strength). The experimental cements also exhibited higher bond strength to dentin after 7 and 30 days of storage in distilled water.  
It was concluded that glass ionomer cements containing nanobioceramics are promising restorative dental materials with both improved mechanical properties and improved bond strength to dentin.  
  
PMID: 17921077 [PubMed - indexed for MEDLINE]  
1 [Acta Biomater.](http://www.ncbi.nlm.nih.gov/pubmed/?term=Effects+of+incorporation+of+hydroxyapatite+and+fluoroapatite+nanobioceramics+into+conventional+glass+ionomer+cements+(GIC).) 2008 Mar;4(2):432-40. Epub 2007 Aug 25.

# Effects of environmental calcium and phosphate on wear and strength of glass ionomers exposed to acidic conditions.

Wang XY, Yap AU.

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**Abstract**

This study evaluated the effects of environmental calcium and phosphate on wear resistance, strength, and surface morphology of highly viscous glass-ionomers (HVGICs) (Fuji IX Fast [FN] and KetacMolar [KM]) when exposed to acidic conditions. Fabricated specimens were randomly divided into five groups and kept in acidic solutions (pH 3) with varied levels of calcium and phosphate ranging from 0 to 2.4 mM. After 4 weeks of conditioning, the specimens were subjected to wear testing, shear punch, and surface roughness testing as well as SEM evaluation. Multiple comparisons of wear depth (microm), shear strength (MPa), and surface roughness (Ra) between acidic conditions were performed using ANOVA/post-hoc Scheffe's test (p < 0.05). Results showed that FN and KM exposed to acidic conditions had varied wear resistance, shear strength, surface roughness, and structure depending on environmental phosphate level. Increased level of environmental phosphate led to rougher surface, greater wear resistance, and strength of FN and KM than the controls (acid of pH 3). Under SEM, the surface of both FN and KM specimens were covered by numerous small particles when environmental phosphate was high. Results suggest that environmental phosphate may improve wear resistance and shear strength of HVGICs when challenged by acids.

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PMID: 18506830 [PubMed - indexed for MEDLINE]   
1. J Biomed Mater Res B Appl Biomater. 2009 Feb;88(2):458-64.

# Failure of a glass ionomer to remineralize apatite-depleted dentin.

Kim YK, Yiu CK, Kim JR, Gu L, Kim SK, Weller RN, Pashley DH, Tay FR.

**Source**

Department of Conservative Dentistry, School of Dentistry, Kyungpook National University, Daegu, Korea.

**Abstract**

Remineralization of demineralized dentin lesions adjacent to glass-ionomer cements (GICs) has been reported in the literature. This study tested the hypothesis that a strontium-based GIC can remineralize completely demineralized dentin by nucleation of new apatite crystallites within an apatite-free dentin matrix. Human dentin specimens were acid-etched, bonded with Fuji IX(GP), and immersed in a calcium-and-phosphate-containing 1.5X simulated body fluid (SBF) for 1-4 months. Polyacrylic acid and polyvinylphosphonic acid biomimetic analogs were added to the SBFs to create 2 additional remineralization media. Specimens were processed by transmission electron microscopy (TEM). No apatite deposition could be identified in the completely demineralized dentin in any of the specimens immersed in the 3 remineralization media, despite TEM/EDX evidence of diffusion of ions specific to the strontium-based GIC into the demineralized dentin. The hypothesis was rejected; mineral concentration alone is not a sufficient endpoint for assessing the success of contemporary remineralization strategies.

PMCID: PMC2826886 Free PMC Article  
PMID: 20110510 [PubMed - indexed for MEDLINE]   
1. J Dent Res. 2010 Mar;89(3):230-5. Epub 2010 Jan 28.

# Crystal growth by restorative filling materials.

Endo K, Hashimoto M, Haraguchi K, Ohno H.

Division of Biomaterials and Bioengineering, School of Dentistry, Health Sciences University of Hokkaido, Ishikari-Tobetsu, Hokkaido, Japan.

**Abstract**

This study examined the activity and ability of materials to mineralize teeth in gaps, simulating microleakage between the materials and teeth. Three restorative materials (two glass ionomer cements and a compomer) were used in this study. Cured disks of restoratives were placed over flat human tooth surfaces (enamel and dentin), separated by a standardized 20-μm interfacial space, and stored in water for 24 h or 1 yr. After the water-storage period, the materials were detached from the teeth and the opposing surfaces were examined by scanning electron microscopy (SEM) and electron probe micro analysis (EPMA).Hemispherical-shaped precipitations, composed of minute semicircle plate-like crystals, were observed by SEM on the enamel surface after 1 yr of water storage for glass ionomer cement. The amount of crystal growth with the chemical-cured type of glass ionomer cement was greater than with the dual-cured type of glass ionomer cement. However, there was no crystal formation in the compomer. Moreover, no structural changes were observed on dentin surfaces for any material in water after 1 yr. The elements detected in the crystals by EPMA were calcium (Ca), phosphorus (P), and aluminum (Al). The two glass ionomer cements tested have the ability to induce crystals whose composition might be derived from cured glass ionomers.

PMID: 20831583 [PubMed - in process]  
1. Eur J Oral Sci. 2010 Oct;118(5):489-93. doi: 10.1111/j.1600-0722.2010.00764.x.

# In vitro study of the effects of fluoride-releasing dental materials on remineralization in an enamel erosion model.

Zhou SL, Zhou J, Watanabe S, Watanabe K, Wen LY, Xuan K.

**Source**

Department of Pediatric Dentistry, School of Stomatology, Fourth Military Medical University, 145 West Changle Road, Xi'an 710032, China.

**Abstract**

**OBJECTIVES**:

This study was conducted to compare the remineralization effects of five regimens on the loss of fluorescence intensity, surface microhardness, roughness and microstructure of bovine enamel after remineralization. We hope that these results can provide some basis for the clinical application of these materials.

**METHODS:**

One hundred bovine incisors were prepared and divided into the following five groups, which were treated with distinct dental materials: (1) Clinpro™ XT varnish (CV), (2) F-varnish (FV), (3) Tooth Mousse (TM), (4) Fuji III LC(®) light-cured glass ionomer pit and fissure sealant (FJ) and (5) Base Cement(®) glass polyalkenoate cement (BC). Subsequently, they were detected using four different methods: quantitative light-induced fluorescence, microhardness, surface 3D topography and scanning electron microscopy (SEM).

**RESULTS:**

The loss of fluorescence intensity of CV, BC and FJ groups showed significant decreases after remineralization (p<0.05). The microhardness values of the BC group were significantly higher than those of the other groups (p<0.05) after 6 weeks of remineralization. The CV group's surface roughness was significantly lower than those of the other groups after 6 weeks of remineralization (p<0.05). Regarding microstructure values, the FV group showed many round particles deposited in the bovine enamel after remineralization. However, the other four groups mainly showed needle-like crystals.

**CONCLUSIONS:**

Glass ionomer cement (GIC)-based dental materials can promote more remineralization of the artificial enamel lesions than can NaF-based dental materials. Resin-modified GIC materials (e.g., CV and FJ) have the potential for more controlled and sustained release of remineralized agents. The effect of TM requires further study.

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PMID: 22227269 [PubMed - as supplied by publisher]  
1. J Dent. 2012 Mar;40(3):255-63. doi: 10.1016/j.jdent.2011.12.016. Epub 2011 Dec 28.

# Ion migration from fluoride-releasing dental restorative materials into dental hard tissues.

Gjorgievska E, Nicholson JW, Grcev AT.

**Source**

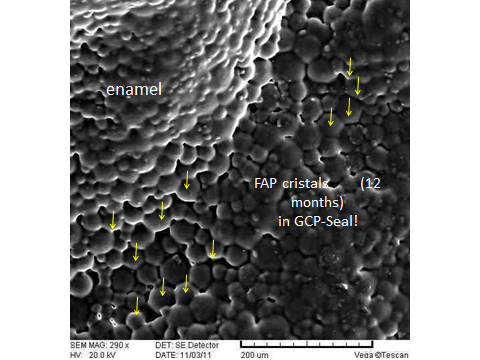
Department of Paediatric and Preventive Dentistry, Faculty of Dental Medicine, University "Ss. Cyril and Methodius" Skopje, Skopje, Republic of Macedonia.

**Abstract**

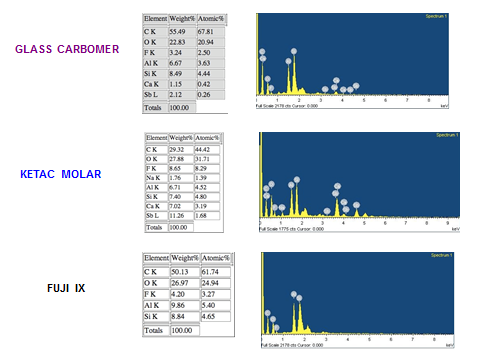
This study was carried out in order to determine the extent to which ions released from fluoride-containing dental restoratives migrated through the enamel and dentine of extracted teeth. A total of 40 permanent human 3rd molars were used. They were extracted for orthodontic reasons, and employed within 1 month of extraction. A cervical (Class V) cavity was prepared in each tooth, then filled with one of: a conventional glass-ionomer, a resin-modified glass-ionomer, a polyacid-modified composite resin ("compomer") or a fluoride-releasing resin composite. Ten samples were prepared per material. After 1 month, five specimens per material were prepared and examined under SEM/EDX. Concentrations of sodium, aluminium, strontium, fluorine, magnesium, silicon, phosphorus and calcium were determined within the tooth. After 18 months, the remaining five specimens for each material were prepared and studied in the same way. The greatest extent of ion migration into the tooth was found with the conventional glass-ionomer and least migration was found for the fluoride-releasing composite, which showed no evidence of fluoride migration at all. Levels of migrating ions were generally higher in the 18 month specimens than in the 1 month specimens, and also higher in the dentine than in the enamel. Ions released by restorative dental materials have been shown conclusively for the first time to be capable of migrating into the enamel and dentine surrounding the restoration. The conventional glass-ionomer showed the highest level of ion migration whereas the fluoridated composite resin showed little if any ion migration. This suggests that the conventional glass-ionomer has the greatest caries inhibiting effects of all the materials tested, and the fluoridated composite the least.

PMID: 22532098 [PubMed - as supplied by publisher]  
1. J Mater Sci Mater Med. 2012 Apr 25. [Epub ahead of print]

# Image 1



# Image 2



# Chemical composition of human enamel and dentin. Preliminary results to determination of the effective atomic number

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**Abstract.**  
The theoretical or practical dosimetry involving radiation interactions in humans needs the reliable elemental composition data of body tissues. The object of this research was to obtain the characterization dental hard tissues and to determine its effective atomic number. An analytical research of inorganic composition, from 30 intact human molars, extracted for periodontal reasons, was performed by Neutron Activation Analysis (NAA), ICP/AES, Thermogravimetric (TG) and Differential Thermal Analysis (DTA). The coronal dentin and enamel were separated by two techniques: (1) - mechanically by chipping and breaking by chirurgic hammer, allowed to dry in an electric oven for 5 hours at 1600C. (2) - through by high-running round steel burs. The samples were thoroughly cleaned with distilled deionizer water and sent for analysis in CDTN/CNEN laboratories, Belo Horizonte, Minas Gerais, Brazil. The results showed concentrations of 11 elements measured in dentin and enamel. The five elements of the higher concentration by neutron activation analysis and ICP/AES were Ca, P, Na, Mg and Al. Thermogravimetric analysis of enamel showed a loss of water of hydroxyapatite to 5000C. Thermogravimetric analyses of dentin showed tree temperatures at which mass loss occur. These processes are related to superficial water loss (100oC); organic decomposition and water liberation from hydroxyapaptite (100oC to 600oC); and the beginning of hydroxyapatite decomposition (600oC to 850oC). Differences, in mineral concentration, were found between enamel and dentin, with higher concentrations in enamel. The two techniques proposed to separated dentin and enamel, no presented differences in elements concentration, statement that the high-running round steel burs technique didn’t affected the samples.

**KEYWORDS**: Dental materials, Dentin, enamel, Thermal analysis, nuclear analysis, dosimetry

**CONCLUSION**

The analyses through INAA, ICP/AES and TGA/D allowed for the identification of the element composition present in dentin and enamel. These analyses are a tool for the quantitative and qualitative determination of components of human dental which are necessary for the evaluation of the effective atomic number. The results of this study show the advantages in analyzing the enamel and dentin separately. It was possible to identifying the composition of these portions in human teeth and the difference in the mineral and organic composition.