Review Article

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GLASS IONOMER CEMENT ION EXCHANGE: A REVIEW

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ABSTRACT:

GIC is very versatile cement. It may be utilized as a definitive restorative material, a preparation liner, a restorative base material, a luting cement, or a fissure sealant. Recently, it was suggested that GIC could also be useful in the preventive area as therapeutic coating. This new terminology is being utilized to describe a material that can be painted on a susceptible surface and form a long-lasting coat to protect, both mechanically and chemically, against accumulation of plaque where patients are unable to maintain effective hygiene in certain parts of the oral cavity.

Keywords: Glass ionomer cement (GIC)

INTRODUCTION:

Glass ionomer cement (GIC) was first reported in the dental literature by Wilson and Kent in 1972 [1]. Since then, GIC has undergone continuous development, improvement and diversification, both in its constituents and clinical application to provide the material's unique characteristics [2,3]. Improvements on its delivery system, setting time, strength, light curing, increased molecular weight of the polyacid and adhesion have all been made since the initial introduction of the material [4]. Wilson and McLean introduced the GIC family of materials to the dental profession in 1988.[5] The four families of acid–base materials used in dentistry are: silicate, zinc phosphate, polycarboxylate, and glassionomer. They all utilize acid and base components. Currently, glassionomer is the only restorative material that is water-based and like silicate has an anticaries effect.[6-8] Current esthetic high-strength GICs are considered to be durable restorative dental cements.

ANTICARIES EFFECT

GICs are true acid–base cements where the base is the fluoroaluminosilicate glass powder and the liquid containing acid comes from the polyalkenoic family. In some glass formulations, the F rich phase of the glass can be visible (Fig. 1) and physically distinct. Apart from the base and acid, the third major component is water, its one of the major component of

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the liquid. The total water content of the set cement is somewhere between 11% and 24%. Being a true water-based material, GIC is also recognized as the only biologically active restorative material currently available.[9]

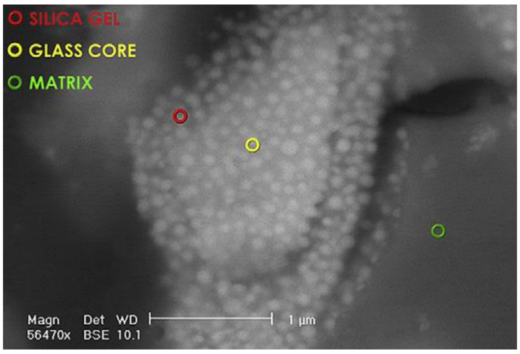


Fig. 1. Scanning electron microscope view of a set GIC showing a reacted glass particle in a set cement. The three areas of interest are: the silica ion–depleted gel phase, the glasscore with its fluoride-rich phase (dense white droplets), and the matrix of the cement. The minor crack is an artifact.

Water allows the acid–base reaction to occur and the migration of the various ions out of and into the matrix of the set cement. When the powder is brought into contact with the liquid, the acidity allows the matrix-forming cations, Ca or Sr and Al, to leach out of the glass. These will cross-link with the polyalkenoic chains to form metal polyacrylate salts, which form the matrix and solidify the mix.[10]

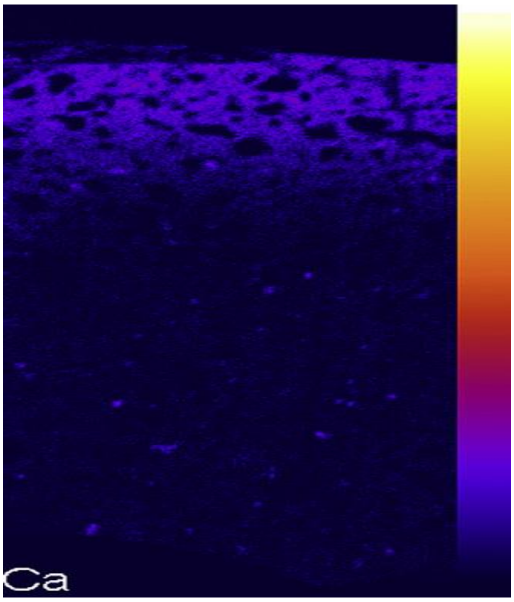
MOISTURE CONTROL

Setting of a GIC is a two-phase process. In the first phase, immediately after mixing, there is cross-linking of the poly-acid chains by either the Ca or Sr ions. This cross-linking during first phase is not stable and can be easily affected by excessive water loss or gain. In the second phase, within the solidified cement, the poly-acid chains are further cross-linked by trivalent Al ions and gives the material increased physical properties and reduced solubility. Early exposure to excess water during setting and desiccation, at any stage, will lead to poor clinical performance.

ION EXCHANGE BETWEEN GIC AND THE EXTERNAL ENVIRONMENT

GIC is a rich reservoir of apatite forming ions such as fluoride, calcium, strontium, and phosphate. In the aqueous environment of the oral cavity, these are released through an ion exchange process with the environment. There is a natural exchange between Sr and Ca ions.[11]

As Sr leaves the set cement, an equivalent number of Ca ions from saliva enter the matrix of the cement to maintain electrolytic balance (Fig. 2).



An elemental distribution map showing Ca (purple) in the matrix of a Sr-based GIC that was stored in saliva for 7 days.

One of the major advantages of GIC is the long-term release of fluoride and other ions. This is characterized by an initial high peak that will decline rapidly to a lower level and sustained over a number of years.[12] It has been shown that there is a topping-up effect [13,14] with the material up-taking fluoride from external sources such as toothpaste and topical fluoride gel. As the level of fluoride, and other ions, in GIC can be recharged, this class of material can be used as a reservoir for fluoride and may act as a slow F release device. GIC also can provide protection by the combined effect of mechanical and chemical means. This ion exchange is not only restricted to fluoride. The essential elements in a GIC include Ca, or Sr, Al, Si, and F. After the completion of the setting reaction, a portion of these ions is available for transfer from the matrix to the surrounding environment.

ION EXCHANGE BETWEEN GIC AND CARIOUS DENTINE

The term internal remineralization was introduced to describe the interaction between GIC and carious dentine, and to suggest that GIC is an essential tool in the management of deep caries lesions in permanent teeth as it supplies apatite-forming ions to the partially demineralized dentine at the base of cavity.

The first suggestion that we should move away from this concept was proposed by Fusayama [15] and then Massler [16]. They both suggested that there were two layers in carious dentine. The outer layer was heavily infected by microorganisms and was broken down to the extent that it could not be remineralized at all. However, there was also an inner layer, immediately adjacent to sound dentine on the floor of the lesion, that could be partially remineralized even though it contained some bacteria, because it still retained some of the original dentine tubule structure. This was called the affected layer, and it was suggested that it should not be removed during cavity preparation as it could be remineralized. However, this suggestion was not widely accepted, because there was no reliable method to differentiate between the infected from affected layers of the dentin in the dental office.

When GIC is placed in direct contact with affected dentine, the migration of apatite forming elements F and Sr from the GIC to carious dentine can be extensive. In a clinical trial study, [7] these two elements were found to have penentrate deep into the lesion with the maximum depth reaching over 1.5 mm. The controlling factor was the depth of the lesion and the physical state of the demineralized dentine. Therefore, It was suggested that GIC, through its self-adhesive characteristics, will provide a complete and long-lasting seal, preventing the ingress of bacteria and potential nutrients. GIC can be placed in close proximity to the pulp without the risk of inducing irreversible inflammation and the placement of calcium hydroxide is no longer needed, unless there is a direct pulp exposure. Providing that the restoration is completely sealed then there is no risk in leaving the demineralized dentin under the GIC lining.

PROTECTION FOR ROOT SURFACES IN ELDERLY PATIENTS

Root caries can be defined as caries lesions initiated on exposed root surfaces. At an early stage, they are difficult to detect visually, because the first changes are in surface hardness and texture of the affected areas. Unlike enamel lesions, discoloration comes much later, and they are usually masked by plaque and inflammation of the surrounding soft tissue. Once established, the lesions can spread incisally by undermining the thin enamel at the CEJ, but more often, they spread below the gum level.

A thin film of GIC adheres well to the root surface and acts as a mechanical barrier to protect the area and minimize plaque accumulation. It releases significantly much more F than the traditional restorative GICs and if recharged with a daily exposure to fluoridated toothpaste, then the F release can be maintained indefinitely. A thin film of half a millimeter or less will allow ions such as calcium and fluoride to cross from saliva to the underlying root surface and remineralize it further.

CONCLUSION:

Since the development of glass ionomer cements nearly three decades ago, these materials have found increasing applications in clinical dentistry. Clinical experience has defined the practical advantages and disadvantages of glass ionomer cement system. This has resulted in improved formulations and more controlled techniques. Of course it is difficult to produce an ideal material, but with the current level of intensive research on glass ionomers, the deficiencies that exist can be eliminated, or at least reduced, resulting in an ever – improving range of materials of this type.

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