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GIC at It's best – A review on ceramic reinforced GIC

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Abstract
Objective: To review scientific literature on Amalgomer CR in dental materials, introducing its composition, its physical and anti-cariogenic properties of Amalgomer CR, and evaluating the Fluoride releasing capabilities of Amalgomer CR and its clinical use as stated by various studies done on it.
Materials & Methods: A search of English peer-reviewed dental literature from various databases that was conducted, and the key words included Amalgomer CR and dental restorations or restorative material or GIC.
Results & Discussion: From the reviewed article, it can be concluded that Amalgomer CR can be used as an effective restorative material due to its higher physio-mechanical properties and fluoride releasing capacities.

Keywords: Amalgomer CR, Dental materials, GIC

1. Introduction

Today, there are several fluoride-containing dental restoratives available in the market such as glass-ionomers, resin modified glass-ionomer cements, polyacid modified composites, composites, and giomers. Due to their different matrices and setting mechanisms, the products vary in their ability to release fluoride. The use of restorative materials with the highest long-term fluoride release is preferable, especially in patients with moderate-to-high caries activity. However the exact minimal fluoride concentration for caries inhibition has not been determined [1].

Glass-ionomer cements (G1C) possess certain unique properties like release of anti-cariogenic fluoride into adjacent tooth structures, chemical bonding to enamel and dentine, and a low coefficient of thermal expansion similar to tooth. They are, however, susceptible to fracture and exhibit low wear-resistance. These deficiencies have limited their use, and made them unsuitable for high-stress areas such as class I and II restorations. Because of their low tensile strength, fracture toughness and brittleness, a variety of modifiers have been added to conventional glass-ionomers, to improve their mechanical properties. These have included changing the composition—for example, the fluoride and sodium content and the aluminium: silica ratio; adding 'bioactive' components such as certain glasses and hydroxyapatite; and reinforcement by incorporating metal particles such as silver–tin alloy, gold, platinum, palladium, stainless steel, or fibers such as carbon, steel or glass [2].

In 1977, the addition of amalgam alloy powder to glass-ionomer was expected to increase the strength and provide radio-opacity. A variation of this proposed material was marketed as Miracle Mix (GC Corporation, Tokyo, Japan) in 1983. Subsequently, ESPE produced Ketac Silver (ESPE, Seefeld, Germany) where silver particles were sintered to the glass to form a cermet (ceramic-metal) cement. While some investigators found no significant difference between the strengths of conventional and metal-reinforced glass-ionomers, others have found otherwise. Because of the metal additives, metal-reinforced cements are not tooth-coloured and colour ranges from light to dark grey. Also, the absence of interfacial bonding, which is critical for efficient transfer of stress from the matrix in the metal reinforced GIC, may explain why metal-reinforced materials have not proved to be stronger or more durable than their metal-free counterparts [3].

In the late 1980´s, the addition of polymerizable hydrophilic resins to conventional glass-ionomer cements resulted, in the development of resin-modified formulas that set by a dual

reaction: the acid–base reaction and a free radical polymerization process. In general, resin modified glass-ionomer cements were reported to show better mechanical properties than conventional glass- ionomers, even though there are individual differences from one brand to another. Still their polymerization shrinkage and low wear resistance constitutes a major drawback [4].
Recently, a new ceramic-reinforced glass ionomer (Amalgomer CR) has been introduced to the dental market. This tooth-coloured product is proposed by the manufacturer to combine the high strength of a metallic restorative and the aesthetics and other advantages of glass ionomers [3].

2. Materials and Methods
The electronic database chosen for developing this review was PubMed database. Following keywords were used for searching relevant papers: (Amalgomer CR) and (dental restorations or restorative material or GIC). Papers were selected if the combination of words appeared anywhere in the paper, and were written in English. The reference list of each paper was reviewed and any paper appearing in the reference list was added to the list of papers to be manually reviewed.
The main aim of this paper was to review the literature for various studies done on Amalgomer CR determining its physical properties, its Fluoride releasing capabilities, its use as a restorative material for various clinical uses.

2.1 Amalgomer CR
Amalgomer CR is ceramic reinforced GIC, which not only complies with the international standards of GIC but with the standard for amalgams. The ceramic also helps in imparting excellent wear and erosion resistance and also enhances the radiopacity and all round strength of the cement.

Available in:

12g Hand Mix (Powder/Water)
Hand Mix 12g Powder/5ml Liquid

Fig 1: Amalgomer CR

2.2 Composition of Amalgomer CR
According to the manufacturers the composition of Amalgomer CR comprise of powder and liquid components.
Powder component comprises of Fluoro-aluminosilicate glass, polyacrylic acid powder, tartaric acid powder and ceramic reinforcing powder.

Liquid component comprises of polyacrylic acid and distilled water.

Table 1: Composition of Amalgomer CR

Material	Component	Initial Setting Time
Amalgomer CR	**Powder:** Fluoro-aluminosilicate glass, polyacrylic acid powder, tartaric acid powder and ceramic reinforcing powder. **Liquid:** Polyacrylic acid and distilled water	3mins 30secs

2.3 Physical Properties of Amalgomer CR
This tooth-coloured product is proposed by the manufacturer to combine the high strength of a metallic restorative, and the aesthetics and other advantages of glass- ionomers.

Table 2: Physical properties of Amalgomer CR

Compressive strength @ 1hour (Mpa)	215
Compressive strength @ 24 hours (Mpa)	346
Compressive strength @ 1month (Mpa)	423
ACTA wear test (um/2,00,000 cycles)	36
Lactic acid jet erosion (um/hr)	0.9
Flexural strength-3 point bend (Mpa)	36.3
Fracture Toughness (Mpa/m)	0.85
Young's Modulus (Gpa)	13.3

According to its setting mechanism, Amalgomer CR is a conventional acid–base reaction GIC. The product includes a particulate ceramic component with the intention of increasing its strength, supposedly without sacrificing appearance (although it is opaque white) or other general characteristics of GIC. It has been shown elsewhere that zirconia is the major if not the only (crystalline) component of the additive of this product, similar to that of other laboratory studies done by *Gu YW, Biomaterials 2005; 26(7): 713–20* [2].
Zirconia is known to be an excellent material for strengthening and toughening in certain composite contexts because of its peculiar character of a phase transformation from tetragonal to monoclinic under stress. This transformation produces a 4% change of volume which generates a local compressive stress, which then offsets crack-opening tension and so inhibits crack propagation and increasing the incorporating material's fracture resistance [2].
This effect in otherwise very brittle ceramics may have prompted its use in GIC, although it is not known that it would function in this manner in the more ductile matrix. In addition, the manufacturer claims that the ceramic filler is able to react partially with the matrix, which may produce some bonding (and so matrix constraint) and also possibly an altered polysalt matrix [2].

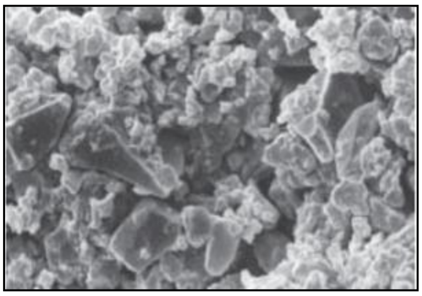

Fig 2: SEM Photograph (x3500) of the ceramic reinforced glass ionomer Amalgomer

2.4 Studies on Physical Properties (Compressive strength; Flexural strength; Fracture toughness) and Anti-cariogenic Properties of Amalgomer CR

Neveen M. Ayad, Salwa A. Elnogoly, Osama M. Badie et al determined the compressive strength (CS), diametric tensile strength (DTS), surface hardness (SH), and surface roughness (SR) of a ceramic-reinforced glass ionomer in comparison to a high-copper dental amalgam. It was concluded that the physico-mechanical properties of the tooth-coloured ceramic-reinforced glass ionomer were so close and sometimes significantly superior to dental amalgam [3].

The mean values and standard deviations of the CS, DTS, SH, and SR of Amalgomer CR and GS.80 after 1 day and 1 week water storage are shown in Table 3.

Table 3: Means, standard deviations, t-value and p-value of CS, DTS, SH AND SR of the tested materials after each storage period

Storage time	Test	Amalgomer CR	GS.80	t-value	p-value
1 day	CS (MPa)	340.7(2.303)	313.1(1.334)	22.963	0.000
1 week	CS (MPa)	382.5(1.857)	374.0(0.893)	9.160	0.000
1 day	DTS (MPa)	27.7(0.03)	23.7(0.368)	24.268	0.000
1 week	DTS (MPa)	31.4(1.45)	33.9(3.03)	-1.691	0.129
1 day	SH (VHN)	35.1(1.16)	32.4(2.02)	2.057	0.109
1 week	SH (VHN)	39.4(1.5)	40.2(4.5)	-.0292	0.785
1 day	SR (µm)	1.12(0.25)	2.56(0.49)	-4.480	0.011
1 week	SR (µm)	1.23(0.05)	2.91(0.22)	-12.860	0.000

Wang Y, Darvell BW et al investigated the development of the load-bearing capacity of a ceramic reinforced glass-ionomer cement (GIC), stored dry or wet, using Hertzian indentation. From their study it was concluded that the failure load was relatively stable for air-stored specimens but showed a significant decreasing tendency for AS-stored specimens. *Significance:* Zirconia-reinforced GIC is sensitive to moisture. Artificial saliva storage has a detrimental effect on the failure load of ceramic-reinforced GIC that may indicate long-term deterioration in service [2].

Deepa Gurunathan & Shobha Tandon et al compared the clinical performance of two glass ionomer cements, Amalgomer CR and Fuji IX in small and medium cavities prepared using Atraumatic restorative treatment approach in India. It was found that the survival rate of Amalgomer CR for class I, class II cavities, small sized class II restorations and medium sized class I and II restorations- 97.4%, 95.1%, 94.2%, 100% respectively was greater than Fuji IX restorations. It was concluded that the clinical performances of both materials were satisfactory at the end of 1 year and ART is suitable procedure to be done in a dental clinic for children [4].

Navaneetha Cugati, Sham S Bhat, Sundeep K Hegde compared the anticariogenic effect of Amalgomer CR, Fuji VII and Heliomolar Refill in the cavosurface margin. Cavity with a dimension of 2mm x 3mm x 1.5mm was prepared in buccal / lingual surface of 40 extracted sound human premolars. It was concluded that the anticariogenic efficacy of Amalgomer CR was very highly significant followed by Fuji VII, Heliomolar Refill and the least by Fusion Alloy [5].

1. Fluoride Release

The cariostatic effect of fluoride ions on enamel caries had been well demonstrated by many researchers. Incorporation of fluoride to many restorative materials led to a major revolutionary change in restorative dentistry. It has been suggested that fluorides from restorative material retain its cariostatic efficacy, which however may be altered by variability in the oral environment.

The coarse ceramic particles reinforced in glass-ionomer of Amalgomer CR may contribute to its high fluoride release. This is supported by DeSchepper and Others (1991) who observed that the coarse silver alloy particles in Argion (a metal reinforced glass ionomer), which are not bound to the cement matrix, result in an increase in the microporosity of the cement, thus increasing the effective surface area available for elution of fluoride. Hence it could be concluded that The Amalgomer CR releasing higher concentration of fluoride may be advised for the restoration of tooth in highly susceptible child patients to dental caries [6].

Study was done to evaluate the fluoride release of the various restorative materials such as Amalgomer CR, Fuji II, Fuji IX, Beautifil II, Dyract extra, Coltene Synergy at different pH (4.3, 4.6, 5.0, 5.5 and 6.2.), in order to simulate variability in oral environment. The Amalgomer CR showed the maximum fluoride release, the release of it was found to be 2.3, 1.3, 4.7, 2.1 and 7.0 fold more respectively than the respective release of Fuji IX, Fuji II, Beautiful II, Dyract extra and Coltene synergy. The result showed that the fluoride release rate was significantly higher in first day and reduced after third day to a nearly constant level. Hence it was concluded that Amalgomer CR showed the highest fluoride release among all the experimental dental restorative materials [6].

Table 4: Indications

1. Class I and Class II Cavities
2. Repair of amalgam restored tooth or # restoration
3. As a Base under composite restorations
4. Classes of cavity were radiopacity is prime concern
5. As core build up under crowns
6. On the root surfaces for locating over-dentures
7. Long term temporary replacement for cusp(s) and Repair to crown margin

2. Conclusion

From the reviewed article, it can be concluded that Amalgomer CR can be used as an effective restorative material due to its higher physico-mechanical properties and fluoride releasing capacities. However further *in-vivo* studies are needed justify the above results in clinical practice.

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