Development of glass ionomer cement: 1980-2000

Glass Ionomer Cement 1980-2000

Between 1980 till 2000 two variations of the glass ionomer cement from 1969 was developed: light polymerised liquid resin component and glass ionomer cement modified by metal inclusion [1] .

Second generation glass ionomer – 1980

Water-hardening GIC

WHGIC are supplied as Polyacid liuid or powder. The presence of polyacid wither increases viscosity or molecular weight of the liquid, making the material harder to manipulate. Thus, instead of using of polyacid in solution, water or aqueous solution of tartaric acid. This provides low viscosity in early mixing and improved shelf life. Examples of WHGIC: Chem-fil nd Ketac-Chem [6] .

Reinforced glass – ionomer cements:

RGIC is used to fill aesthetic cavities with low stresses due to their low tensile strength and thus makes them unsuitable for high stress areas especially in sites with lack of cavity wall support. Thus, to improve strength of GICs the chemical composition of original glass powder is changed [6] .

Disperse GIC

Prosser invented in 1986 the disperse GIC by creating large concentrations of dispersed phase containing strengthening crystals in order to improve strength. Examples of dispersed phase: corundum (Al2O3), rutile (TiO2), baddeleyite (ZrO2) and tielite (Al2TiO $_5$) [6] .

Fibre reinforced glasses

The addition of alumina, silica, glass and carbon fibre to glass powder increased flexural strength of GIC. But due to difficulty with mixing fibres with glass powder and a decrease in abrasion resistance because of the absence of fibre and matrix bonding, FRG are not used in dentistry [6] .

Metal reinforced GIC

In 1984 Sced and Wilson improved flexural strength of GIC by adding metal fibres. At the same time Simmons added amalgam alloy to the glass cement (Miracle Mix). However, MRGIC had poor aesthetic qualities (grey colour) and they didn't take burnish. Furthermore, they failed at the polyacrylate/metal matrix interface. But this cement did show improved resistance to abrasion compared to regular GIC.

Cermet – ionomer cements

In order to further improve abrasion resistance Cermet GIC were developed by McLean and Gasser in 1985 by adding elemental silver (cermet) with glass powder by high-heat fusion (sintering). The sintering provides better bonding between glass and metal [6] . The added silver increases the radiopacity of the GIC [1, 2] which allows the detection of marginal micro leakage and inaccuracy [3] as well as the wear resistance and abrasion resistance to some extent compared to the traditional GIC [1, 2] . Furthermore, the packaging density and handling properties improved since the metal powder is rounder compared to original GIC powder due to silvers lubricating effect. This lubricating effect is also responsible for improving the abrasion resistance of metal modified GIC [3] .

However, the fracture toughness and resistance of the material was too low to be used in stress-bearing area of teeth. Even though the Ketac-Silver had many undesirable disadvantages it was still used for several years in pediatric dentistry as a replacement for silver amalgam substitute for primary tooth Class 1 restoration until the introduction of resin-modified glass ionomers in 1990s [1, 2] . It was also used for “ tunnel” restorations, core build up material and endodontic filling material due to their good properties [4] .

Resin-modified glass ionomer liner/base – 1990 (RMGI liner/base)

The resin-modified GI base/liner, also known as Vitrabond, was invented in the late 1980s and is a combination of resin based composites and GIC. It comes in as liquid/powder or liquid/paste format which has to be spatulated by hand. The liquid component (polyacid) contains photopolymerisable resin that hardens when a light beam is exposed to the material. Afterwards, the glass-ionomer continues to harden which is now protected from overdrying and moisture because of the framework of hard resin. This “ on demand” rapid light-hardening makes the Vitrebond a valuable and practical dental replacement.

The Vitrebond had been continuously being used for over 13 years as a result of following properties:

- Postoperative sensitivity is prevented when directly applied under resin-based composite restorations, thus providing protection of dentinal tubules against bacteria
- Release of internal fluoride ion
- Antimicrobial qualities [1, 2]
- Good adhesion, adaptation and aesthetics

But due to the use of light for curing, the depth of cement layers is limited since the light can only penetrate the material up to 3 mm depth. This restricts the use the liner/base to incisal edges and cavity linings [4] .

Resin-modified glass ionomer restorative cement (RMGIRC; light-hardened) – 1990

The light-hardened RMGURCs were introduced in 1990s. The concept of RMGIRC was to combine the composite resin with glass ionomer cement in order to combine both of their properties [4] . These materials were used as a predisposed capsule (Fuji II and Photac-Fil) or in bottles for spatulation by hand (Vitremer). The setting reaction of light-hardened RMGIC is the same as the RMGI liner/base. The adding of resin components to glass ionomer decreases the handling difficulties as well as the initial hardening time but considerably increase the physical strength and wear resistant. The major advantages of glass ionomer are retained such as biocompatibility favourable thermal expansion and fluoride ion release [1, 2] . Furthermore, the light-hardened glass ionomer is much easier, quicker to use and more practical compared to its forerunner [1, 2] .

Glass ionomer luting cement -1994

They were used stainless steel crown cementing as well as orthodontic bands. The advantage of fluoride ion release, high physical strength, adhesive bonding, easy-to-use and virtual insolubility allowed the use in preventive dentistry [1, 2] .

Glass ionomer stratification

Highly viscous conventional glass ionomer cement – 1995

HVCGICs were developed in 1995 as an alternative for amalgam posterior restorations. Fuji IX and Ketac Molar, examples of HVCGIC, set due to neutralisation reaction but have far exceeding properties compared to RMGIC. They have reduced moisture sensitivity, low solubility in oral fluids and rapid setting time. The high viscosity is a result of adding polyacrylic acid to the powder as well as finer distribution of grain. This leads to higher abrasion resistance compared to conventional GIC. But they show similar surface hardness and moderate polishing ability as well as lower flexural resistance and premature degradation without a covering bonding agent [5, 6] .

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1980 Second generation (KetacTM Cem, KetacTM Fil, Fuji IITM)

1985 Cermet cements (KetacTM Silver)

1990 Resin-modified GICs (VitrebondTM, PhotacTM Bond, Fuji LCTM)

1994 RMGI luting cements (RelyXTM Luting, formerly VitremerTM Luting)

1995 High viscosity GICs (KetacTM Molar, Fuji IXTM)