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ZIRCONIA REINFORCED GLASS IONOMER CEMENT- A REVIEW

Dental Science

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ABSTRACT

Many tooth-colored materials have advanced to replace amalgam in the recent past. Zirconomer® and zirconomer improved® (white amalgams) are the latest GIC formulations composed of ceramic and zirconia reinforced glass ionomer cements that could overcome the drawbacks of previously used amalgam as well as other tooth-colored restorative materials. They exhibit the strength of amalgam and at the same time maintain the fluoride releasing capacity of GICs which imparts good anti-cariogenic property. This review article discuss about various properties of this newly introduced material.

KEYWORDS

zirconia, glass ionomer, fluoride release and recharge, zirconomer

INTRODUCTION

Dental caries is a multifactorial, transmissible, infectious oral disease caused primarily by the complex interaction of cariogenic oral flora (biofilm) with fermentable dietary carbohydrates on the tooth surface over time.(1) It is considered as a component of global disease burden. An ideal restoration should have properties like adequate compressive strength, decreased solubility in oral fluids, no marginal leakage, caries preventing ability etc. But, none of the materials till date have satisfied all this ideal properties.(2) Amalgam is used in dentistry since 150 years. Despite having good compressive strength, it has many disadvantages like post-operative sensitivity, poor aesthetics, susceptibility of tooth to fracture, environmental pollution, secondary caries etc. GIC and its modifications which have partially replaced amalgam lacks adequate compressive strength, increased solubility etc. Another popular material with adequate strength is composite but it is highly prone to develop secondary caries as a result of polymerisation shrinkage.

Zirconia reinforced GIC (Zirconomer and Zirconomer improved) is a recent modification of GIC introduced by SHOFU in which zirconia is incorporated.(3) They are also known as white amalgam. Zirconia is a high-strength ceramic.(4) This review aims in evaluating critically various properties of Zirconia reinforced GIC so as to overcome the drawbacks of previously used amalgam as well as other tooth-coloured restorative materials.

ZIRCONIA

Zirconia, was introduced for dental use as a core material in conventional and resin bonded FPDs and crowns.(5) It is highly rated in terms of esthetics and has several other advantages, including biocompatibility as it is metal-free and has a low degree of bacterial adhesion, high flexural strength, and acceptable optical properties, such as adaptation to the basic shades.(6)

The accessible zirconia powders have different grain sizes and additives, such as yttrium oxide and alumina, which are distributed homogeneously throughout the whole material or higher concentration at grain borders.(4) The grain-size variety affects the porosity as well as the translucency of the material.(7) Exclusive characteristic of zirconia called transformation toughening gives it higher strength, toughness, high hardness, and corrosion resistance.(7)

ZIRCONOMER AND ZIRCONOMER IMPROVED

The inclusion of zirconia fillers in the glass component of **Zirconomer** increases the structural integrity of the restoration. It imparts superior mechanical properties for the restoration of posterior load bearing areas where the conventional restorative of choice is amalgam. Properties like outstanding strength, durability and sustained fluoride protection deems it ideal for permanent posterior restoration in patients with high caries incidence as well as cases where strong structural cores and bases are required.(8)

Zirconomer Improved is strong, durable and fluoride rich, it is ideal as a bulk fill restorative for structural cores and bases as well as cases with high caries risk. Novel nano-sized zirconia fillers augment material translucency for a closer shade match to natural tooth with superior handling characteristics for a simple, easy and fast bulk placement.(3)

INDICATIONS

It is used in restoring Class I & II cavities. It can be used as a structural base in sandwich restorations, all classes of cavities where radiopacity is a prime requirement, as a core build-up under indirect restorations, on root surfaces where overdentures rest, in pediatric and geriatric restorations, as a long-term temporary replacement for fractured cusps, fractured amalgam restoration, also suitable for ART techniques.(3)

MECHANICAL PROPERTIES

Compressive strength

The glass component of Zirconomer is exposed to controlled micronization, to acquire optimum particle size and characteristics. (9) Zirconia is homogeneously incorporated in the glass component, it reinforces the material for lasting durability and high tolerance to occlusal load.(10)

Table 1 showing comparison of mechanical properties of zirconomer improved with amalgam

Mechanical Properties	ISO Limit for Amalgam	Zirconomer Improved
Compressive strength at 1 hour (MPa)	> 80 MPa	149
Compressive strength at 24 hours (MPa)	> 300 MPa	326
Creep	< 2%	0.01%
Dimensional stability	-0.10% to +0.20%	0.06%

In a study, highest compressive strength was for Zirconomer followed by Zirconomer Improved. The least compressive strength value was exhibited by Ketac Molar. The superior mechanical property is attributed to the inclusion of zirconia.

Homogeneity of glass particles also reinforces both Zirconomer and Zirconomer Improved creating a compressive strength above 300 MPa.(11)

In another study, which compared the compressive strength and diametrical tensile strength of Zirconomer, conventional GIC and amalgam results concluded that Zirconomer and amalgam had no statistically significant difference in compressive strength and diametrical tensile strength but had more compared to GIC. However the study concluded that combination of outstanding strength, durability, and sustained fluoride protection makes it ideal for permanent posterior restorations in patients with high caries incidence as well as in cases where strong structural cores and bases are required.(12)

In a study, different levels of sorption, solubility, and compressive strength of three different glass ionomer cements in artificial saliva – type IX glass ionomer cement, silver-reinforced glass ionomer cement, and zirconia-reinforced glass ionomer cement were evaluated. Zirconia-reinforced glass ionomer cement has the highest compressive strength, followed by silver-reinforced glass ionomer cement and the least value of compressive strength is seen with glass ionomer cement. Solubility was least for Silver-reinforced glass ionomer cement followed by zirconia-reinforced glass ionomer cement, and the highest sorption and solubility rates was for glass ionomer cement type IX-Extra.(13) Compressive strength of Miracle Mix was much greater than conventional glass ionomer cement as silver particles increased gelation of the cement, but was less than zirconomer due to the fact that mixtures of metal powders failed at the metal and poly-acrylate matrix interface and this was the weak link.

Setting time and working time

It has a P/L ratio of 3.6 : 1.0 i.e. two scoops powder : 1 drop liquid. Working time is 1 minute 30 seconds. Setting time is 3 minutes.(3)

Hardness and abrasion resistance

Incorporation of various fillers like silver, gold, titanium, palladium, zirconia, stainless steel powder and SiC into glass-ionomers has been investigated in order to improve their mechanical properties, but poor aesthetic and low abrasion resistance are their important limitations.

In a study, microhardness of Zirconomer and RMGI and their mixture with 0, 5, 15 and 25 wt% of microhydroxyapatite were evaluated. It concluded that, addition of 5 and 15 wt% of microhydroxyapatite into RMGI and Zirconomer improved the surface microhardness.Also, incorporation of 25% microhydroxyapatite into Zirconomer and RMGI decreased hardness values less than the groups without microhydroxyapatite.. Microhydroxyapatite. was chosen in this study because hardness value of this is similar to that of natural teeth. Highest Vickers hardness number (VHN) was found in the RMGI group with 5 wt% of microhydroxyapatite.

In this study, the hardness values of RMGI groups were higher than the Zirconomer groups. It might have been the larger glass particles sizes and less voids and cracks of RMGI that resulted in higher hardness values. Due to resin cross-linking and rapid setting, it seems that RMGI was more resistant to being dissolved in water after a day of water storage but Zirconomer is self-curing and therefore chemically similar to glass-ionomers, resulting in more dissolution in water.(14)

Microleakage

In a study which compared microleakage, surface roughness and hardness of three glass ionomer cements – Zirconomer, Fujii IX Extra GC and Ketac Molar it concluded that sealing property of Zirconomer is lower than Ketac Molar & Fujii IX Extra GC. It may be due to large size of the filler particle in Zirconomer prevents proper adaptation of this material to the tooth surface and it's poor working consistency, longer setting time, and rough surface texture. Zirconomer showed least polishability. This might have been due to large filler particle incorporated in the cement. Increase in surface roughness results in alterations in light reflection and material surface also turn opaque. Fuji IX Extra GC exhibited high hardness and excellent shade matching at buccal surface of the cervical third of the tooth. Zirconomer did not match with the shade of the tooth at the cervical region.(15)

In a study which evaluated the sealing properties ofcomposite , white amalgam (zirconomer), GIC/composite, and zirconomer/composite in sandwich technique by using dye penetration method. The results concluded that all materials showed some microleakage at the cervical margin of restoration. GIC/composite exhibited lowest microleakage followed by zirconomer/composite, then white amalgam (zirconomer) and composite. It also added that the successful placement of a proximal restoration requires a predictable outcome that offers protection from further caries at the cavo margins and RMGIC family of materials should be recommended for use in the open-sandwich technique when cervical margins are placed in dentine.(16)

Sorption and solubility

In a study which evaluated the sorption and solubility of type IX glass ionomer cement, silver-reinforced glass ionomer cement, and zirconia-reinforced glass ionomer cement it was concluded that miracle mix absorbed less water and is less soluble than other cements followed by zirconia-reinforced glass ionomer cement, and the highest sorption and solubility rates in artificial saliva were seen with glass ionomer cement type IX-Extra. Miracle Mix-GC has the lowest sorption and solubility values in artificial saliva, i.e. 55.73 and 10.7 ug/mm3 respectively, with respect to Fuji type IX-Extra and zirconia reinforced GIC. The addition of silver is responsible for lower sorption and solubility of the miracle mix.(13)

Fluoride release and anticariogenicity

Fluoride release from restorative materials play an important role in reduction of caries. Recently, zirconia reinforced GIC has been introduced which promises the protective benefits of glass ionomer while completely eliminating the hazard of mercury.

In a study which evaluated the *in vitro* antibacterial activity and fluoride release from two conventional glass ionomer cements (GC II and GC IX), compomer (Compoglass) and a zirconia reinforced glass ionomer cement (Zirconomer). The antibacterial activity of the cement specimens were evaluated against *Streptococcus mutans* using the agar inhibition test. Zone of inhibition on Mueller-Hinton agar plates were measured after 48 hours. The fluoride release from the cement specimens in ppm were measured at 1, 7, 14 and 21 days using a fluoride ion selective electrode. Statistically significant largest zone of inhibition was observed with Zirconomer group. At all the time intervals maximum fluoride release was detected with Zirconomer and minimum with Compoglass.(17)

Fluoride released from restorative materials effectively protect the tooth tissues from demineralization in the area adjacent to it.(18) Initial release of fluoride reduces the number of viable bacteria and causes remineralization.(19) Fluoride release from the material is mainly by diffusion and is affected by the concentration of the particles and the material matrix. Diffusion of fluoride from the matrix exposed on the surface of the material is very rapid. This phenomenon of "burst effect" seen during the first two days for glass ionomers.(20) Smaller glass particles provide a larger surface area, this in turn increase the acid-base reactivity, and thereby, have increased capacity to release fluoride from the powder more rapidly thereby increasing the fluoride release of the materials.(21)

Recently a study compared the amount of fluoride released from zirconia reinforced glass ionomer cement, high density glass ionomer cement (ketac molar) and packable posterior glass ionomer restorative material (GC Fuji IX GP). Maximum fluoride release was observed by Ketac molar at 24 hrs, 1.584 ppm. Zirconomer showed maximum amount of release of fluoride at 7 hrs, 1.026 ppm followed Fuji IX at 48 hrs, 1.088 ppm. Release of fluoride by Zirconomer was constant from

14 hrs up to 10 day. Thereafter there was a decline in fluoride release.(22)

CONCLUSION

Zirconia Reinforced Glass Ionomer Cement may be considered as a promising material and might be the best alternative to both GICs and it's modifications as well as dental amalgam. Further *in-vitr*o and *in-vivo* research works should be closely followed upon for it to replace other restorative materials used today.

CONFLICT OF INTEREST

None

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