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FLUORIDE RELEASING DENTAL MATERIALS - AN UPDATE

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ABSTRACT

Fluoride releasing materials prevent secondary caries because of stable dimensional property. Today, there are several fluoride-containing dental restoratives available in the market including Glass-ionomer cement, resin modified Glass-ionomer cement, Polyacid-modified composites (composers), composites and amalgams. Due to their different matrices and setting mechanisms the product varies in their ability to release fluoride. Fluoride ions on enamel caries - acrylic resin, acrylic restorative products were developed. The aim of this research is to provide knowledge and to present short review of recent literature available on various fluoride releasing dental materials. A detailed study was done by reviewing several literatures on various fluoride releasing materials. Thorough search of articles was carried out on the database like google scholar and pubmed. All Fluoride containing materials release fluoride in an initial burst and

reduce exponentially. Caries inhibition and remineralisation potential have been shown. Fluoride release and uptake characteristics depend on the matrices, fillers and fluoride content as well as on the setting mechanism and environmental conditions. Fluoride releasing materials, predominantly glass-ionomers and composite have shown cariostatic properties.

Keywords: Cariostatic, fluoride-release, glass ionomer, remineralization

INTRODUCTION

Fluoride is well documented as an anticariogenic agent. A variety of mechanisms are involved in the anticariogenic effects of fluoride, including the reduction of demineralisation, the enhancement of remineralisation, the interference of pellicle and plaque formation and inhibition of microbial growth and metabolism **[1–4]**. Today, there are several fluoride-containing dental restoratives available in the market including glass-ionomer cement, resin modified glass-ionomer cement, polyacid-modified composite and amalgams. Due to their different matrices and setting mechanisms the product varies in their ability to release fluoride. However, it is assumed that the antibacterial and cariostatic properties of restoratives are often associated with the amount of fluoride release. Early observation in the 1930s linked fluorosis in patients with low levels of tooth decay **[5]**. The principal role of fluoride in inhibiting decay is now considered to be its effect on the remineralisation process **[6, 7]**. The presence of lactic acid at the tooth surface alters this balance, enhancing the rate of demineralisation relative to that of remineralisation **[8]**. The aim of this review is **t**o provide knowledge and to present a short review of recent literature available on various fluoride releasing dental materials.

Previously our team had conducted numerous studies evaluating the properties and effects of various substances used regularly on the tooth structures and clinical trials **[9, 10]** as well as reviews **[11–15]** and surveys **[16, 17]** and in-vitro studies **[18–23]** as a step towards discovering new technologies as well as newer innovations in existing literature. The aim of this study is **t**o provide knowledge and to present short review of recent literature available on various fluoride releasing dental materials.

1. Modern Restorative materials

Modern dental restoratives are based on either composite resin or glass-ionomer systems **[24]**.

Composite resins:

These are based on large organic monomers, mainly bid-GMA or UDMA, plus other low viscosity monomers, such as TEGDMA .

Composite resins are not inherently fluoride releasing, but can be made so by adding fluoride compounds **[15, 16]**.

Compomer:

These materials were developed in an attempt to make a composite resin with the fluoride releasing capability of conventional Glass-ionomer cement **[25]**.

They are composed of the same type of components as conventional composite resins i.e, larger molecules, diluents and particulate inorganic fillers.

Glass- Ionomer cement:

Conventional Glass-ionomer cement are based on calcium fluoro-amino silicate glass powder, which is reacted with polyalkenoic acid, typically poly (acrylic acid) to make a cement **[24–26]**. They are tooth-coloured restorative material that bonds chemically to the tooth and can release fluoride for a longer duration **[27]**.

It is often mainly used in paediatric dentistry, where their ability to release fluoride is considered particularly advantageous. There are two mechanisms in which fluoride is released from conventional GIC - short term reaction and long term reaction. Short-term reaction: rapid dissolution from the outer surface into the solution.Long-term reaction: sustained diffusion of ions through the bulk restorative cement **[28]**. When powder and liquid are mixed together, an acid-base reaction occurs in which the acid attacks the glass components of fluoroaluminosilicate glass network and releases cations namely aluminium, calcium or strontium. These cations form bridges with polyacid components and this later forms hydrogel by a gelation mechanism **[21]**.

Resin modified Glass-ionomer cement:

It is similar to conventional Glass-ionomer cement in that they contain a basic ion-leachable glass powder, and also a water soluble polymeric acid. Resin-modified GIC is a conventional GIC with hydroxyethyl methacrylate (HEMA). HEMA is the main accelerator in RM-GIC which slowly absorbs the water and allows for diffusion of fluoride ions into the medium **[29]**.

They also contain the water soluble organic monomer 2-hydroxyethyl methacrylate, (HEMA).

It has been suggested that the presence of HEMA in these materials compromises their biocompatibility **[30]**.

2. Fluoride release patterns

Fluoride release from restorative materials is relied on exposed surface area and not on weight of the restorative material **[31]**.

Fluoride release is generally influenced by the ionic strength, pH of the oral environment, nature of fluoride incorporation in the restorative material and composition of saliva **[32, 33]**. A higher surface of porosity allows a deeper diffusion of the agent into the restorative material and results in more storage and release of fluoride content. Fluoride release is considered one of the important clinical advantages of Glass-ionomer cement of both types (conventional and resin modified). This release has been shown, for conventional Glass-ionomer cement to last for at-least 5 years. Release occurs by two mechanisms, a relatively rapid dissolution process from the surface layers and a slower process that relies on diffusion of the fluoride ions through the bulk cement **[34]**. Composite resins are not inherently capable of releasing fluoride, but may become, so if appropriate fluoride containing compounds are added to them. These include inorganic salts, fluoridated glasses or organic fluoride compounds. Fluoride release from the substances requires water to diffuse into the composite resin, a process that is slower due to the hydrophobic nature of the resin polymer system. It is, however, accelerated by the presence of hydrophilic or ionic additives.

3. Clinical features of fluoride release

The fluoride releasing ability is different in one restorative material to the other and also rely on oral environment, such as pH of saliva **[35]**. It also depends on other factors such as, powder liquid ratio, constituents of restorative cement and ability to releasing of fluoride from the final set in oral environment of a patient **[36]**. Some of the restorative materials have the ability to release fluoride in the oral environment, which can help in inhibiting the recurrent caries. Restorative materials therefore contribute only a little amount of fluoride, compared with fluoridated toothpastes and drinking water. In principle, fluoride may have antibacterial properties and there is certainly evidence that, even at low concentrations, sufficient is released from restorative material to reduce bacterial growth and interfere with bacterial metabolism **[37, 38]**. In general, it seems that the level of fluoride release, even from conventional Glass-ionomer cement, is too low to have a consistent effect on the dental plaque, leading to the conclusion that such are minor compared with the effects of fluoride on the material phase of the tooth.

An important consideration in the potential anti-caries effects of fluoride release by restorative material is the occurrence of gaps between the filling material and the cavity

wall **[39]**. In a number of studies, reduced caries experience has been attributed to elevated salivary fluoride levels. It has been stated that a constant supply of low levels of intra-oral fluoride is of most benefit in preventing caries. After a single application of fluoride containing dentifrices salivary fluoride concentration 10-15mins after application increases to approximately 1-3ppm. Insertion of amalgam restorations is mostly accompanied by the applicator of lining cements (such as Glass-ionomer cement), which might increase the fluoride release from the restoration especially when marginal gaps lead to exposition of the liner **[40]**.

Duckworth and Morgan **[37]** have shown that the kinetics of fluoride clearance after tooth-brushing may be divided into two phases: an initial phase, lasting for 40-80 mins while fluoride concentration rapidly decreases due to clearance of topical fluoride. A secondary phase: fluoride concentration is slowly declining likely due to fluoride release from oral fluoride reservoirs, such as tooth surfaces, mucosa and tongue. It was suggested that the caries inhibiting effect of fluoride releasing materials is most likely due to a localised fluoridation of the vicinity of a restoration rather than to an elevation of fluoride levels in saliva.

According to Tviet and Lindh, 1980, a greater concentration of fluoride, about 4000mu gm/ml in Enamel surfaces exposed to fluoride containing amalgams is found in outer 0.05mu m of the tissue **[41]**. In Dentin surface, greater concentration is about 9000mu g/ml is found at the depth of 11.5mu m. According to Forsten, 1977 GIC releases significantly more fluoride than silicate cement and amalgam. These cement shows the evidence of uptaking of fluoride in cavity walls, Enamel and plaque **[42]**. According to Tveit and Gjerdet, 1981, Fluoride release from silicate cement was about five times greater than that of Glass-ionomer. Presence of fluoride in Glass-ionomer cement inhibits the plaque formation. Salivary fluoride concentration is twenty times that of the baseline concentration after a few days of replacement **[43]**.

According to Donly, 2019 Composite inhibits caries at enamel margins that conflict with the inhibition of caries in Dentinal margins.Demonstrated the remineralisation effect of a fluoride releasing composite, also demonstrated the recurrent caries inhibition at enamel margins **[44]**. According to Seppa and Forss, 1991, Fissures sealed with Glass-ionomer sealant are more resistant to demineralisation than unsealed controls **[45]**. According to Wiegand A *et al.*, 2007

Continuous small amounts of fluoride surrounding the tooth, decreases demineralisation of tooth tissues. Fluoride release from Glass-ionomer cement restoration following continuous uptake process increases the fluoride concentration in saliva and in adjacent hard dental tissues **[30]**. According to Al Niami, 2008 Higher fluoride release from Glass-ionomer cement is not able to reduce the amount of bacterial growth and biofilm formation- on the surface of these materials, when stored in natural saliva. Fluoride release due to ion exchange but a degree of "wash out" or dissolution - contributes to higher fluoride release **[46]**. Therefore, fluoride helps to inhibit caries in the oral environment by means of both physico chemically and biologically. The fluoride can enter the microorganisms against a concentration gradient and accumulates intracellularly.

CONCLUSION

This article has reviewed a range of modern restorative materials available to the clinician. They range from those materials that release relatively high levels of fluoride, at least initially that is conventional Glass-ionomer cement and resin modified Glass-ionomer cement to those that release only low levels of fluoride, namely the fluoridated composite resins. Fluoride release has different patterns for each restorative material. Fluoride release from fluoridated restorative materials declines with time, the ability or a restorative material to exhibit non-carious activity will be determined by the material's ability to demonstrate fluoride recharge also. It can be concluded that all fluoride containing materials release fluoride in an initial burst and then reduce exponentially to a much lower steady-state level of release. The steady state release of fluoride is reached after thirty days for most of the materials. Caries inhibition and remineralisation potentials have been shown by these materials.

LIMITATIONS

Adhesion - It occurs naturally for Glass-ionomer cement whereas problematic for composites.

Release of other mineralising ions such as calcium, phosphor.It is repairable.

FUTURE SCOPE

Clinical implementation for cariostatic controls.

AUTHOR CONTRIBUTION

Data collection: V. Vindhiya varshini

Data Analysis and interpretation: V. Vindhiya varshini

Drafting the article: V. Vindhiya varshini

Critical Revision of the article: Dr. Balaji Ganesh

Final approval of the version to be published: Dr. Balaji Ganesh, Jayalakshmi Somasundaram.

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CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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