ABSTRACT

The aim of restorative dentistry is the successful restoration and maintenance of the health of the tooth by an adequate reconstructive treatment to re-establish the function of damaged pulp. The potential cytotoxicity of specific materials used in restorative dentistry has been widely studied, and the aim of this review article is to summarise and discuss the cytotoxicity of glass ionomer cements when they are in direct or indirect contact with the pulp tissue. Resin modified and metal reinforced glass ionomer cements, in comparison to conventional glass ionomer cements, showed higher cytotoxic effects on pulp cells in vitro. In vivo, the dentin barrier between toxic glass ionomer cements and the pulp cells may prevent pulp cell damage. Potentially toxic resin modified and metal reinforced glass ionomer cements should not be applied directly to the pulp tissue.

Keywords: cytotoxicity, pulp cells, glass ionomer cements

INTRODUCTION

The aim of restorative dentistry is the successful restoration and maintenance of the health of the tooth by an adequate reconstructive treatment to re-establish the function of damaged pulp (1).

The main role of pulp is dentin formation and nutrition as well as the innervation of teeth. The primary function of pulp is dentin formation, which begins when the mesenchymal cells differentiate into odontoblasts and ends when the tooth is completely formed. The channels created by the odontoblasts function in dental nutrition; the continuous transport of nutrients and fluids maintains the vitality of the pulp. Throughout an individual’s lifetime, pulp continuously produces dentin in physiological condition as well as in response to physical and chemical injuries. Pulp also serves as a defence barrier. Increased dilatation and permeability of blood vessels and intensive migration of inflammatory cells are usually results of pulp response to different noxious stimuli (2).

In restorative dentistry, the protection of the dentin-pulp complex consists of the application of one or more layers of specific materials (e.g., varnishes, calcium hydroxide-based products, glass ionomer cements (GICs) and adhesive systems) between the restorative material and dental tissue to avoid additional damage of pulp tissue caused by operative procedures, toxicity of restorative materials and bacterial penetration due to microleakage (1, 3).

The potential cytotoxicity of the specific materials used in restorative dentistry has been widely studied, and the aim of this review article is to summarise and discuss the cytotoxicity of GICs when they are in direct or indirect contact with the pulp tissue.
THE CHARACTERISTIC AND CLASSIFICATION OF GLASS IONOMER CEMENTS

Glass ionomer cements (GICs), invented and originally described by Wilson and Kent (4), consist of a basic glass powder (calcium or strontium aluminofluorosilicate) and a water-soluble acidic polymer, such as polyacrylic acid (5). GICs are classified into three categories: conventional, metal-reinforced and resin modified [6-7]. Metal-reinforced GICs are strengthened by the inclusion of finely divided metal powders, typically the silver-tin alloy of dental amalgams (8).

Although conventional GICs, because of their similarity to dentin in terms of biocompatibility, elasticity and ability to release fluoride, have advantages in comparison with other materials used in restorative dentistry, they have several limitations, such as susceptibility to dehydration and poor physical properties (i.e., high solubility and slow setting rate) (1, 9-10).

The incorporation of polymerisable water-compatible monomers such as 2-hydroxyethyl methacrylate (HEMA) led to the introduction of hybrid versions of conventional GICs, known as resin-modified GICs (RMGICs) (1, 8). In comparison with conventional GICs, RMGICs show enhanced flexural strength, diametral tensile strength, elastic modulus and wear resistance, but they are not as biocompatible as conventional GICs (11).

THE CYTOTOXIC EFFECTS OF GLASS IONOMER CEMENTS

The main disadvantage of metal-reinforced GICs and RMGICs is their higher cytotoxicity in comparison with conventional GICs (1, 12).

The cytotoxicity of RMGICs could be due to their constituent HEMA which, because of their hydrophilicity and low molecular weight, can easily diffuse through the dentinal tubules; reach dental pulp cells; damage pulp cells by suppressing cell growth and proliferation; and induce apoptosis of dental pulp cells (12).

It has been shown that methacrylate monomers present in resin-based materials such as Vitrebond (3M/ESPE Dental Products, St. Paul, MN, USA), and Vitremer, (3M/ESPE Dental Products, St. Paul, MN, USA) are incorporated in the lipid bilayers of cell membranes that can cause dysfunction of cellular membranes and consequently induce cell death (13). This was documented by Costa et al. in a study in which the cytotoxicity of several GICs was tested on an odontoblast cell line (MDPC-23) by a 3-(4, 5-dimethyl-thiazol-2-yl)-2, 5-diphenyl-tetrazolium bromide (MTT) assay (13). It was shown that two GICs, Fuji IX GP (GC, Tokyo, Japan) and Ketac Molar (3M/ESPE Dental Products, St. Paul, MN, USA), were the least cytotoxic among the tested materials while two other RMGICs, Vitrebond and Vitremer, caused intense cytopathic effects on the cultured cells by significantly decreasing cell metabolism and by causing remarkable cell death (13). The highly cytotoxic effects of Vitremer on cultured human osteoblastic cells was confirmed by Oliva et al. (14), who showed in vitro that HEMA is mainly responsible for the cytotoxicity of Vitremer.

To compare the cytotoxic effects of different RMGICs and metal reinforced GICs, Stanislawski et al. carried out an in vitro pulp cell viability assay in which metal reinforced GICs were shown to be highly toxic materials. Vitremer was the most toxic material among the RMGICs while the least toxic were Compoglass (Ivoclar Vivadent Ltda., São Paulo, SP, Brasil) and Photac Fil (3M/ESPE Dental Products, St. Paul, MN, USA) (11).

It was documented that HEMA, along with other unmodified monomers like triethylene glycol dimethacrylate (TEGDMA), is responsible for the cytotoxic effects of RMGICs and metal reinforced GICs.

However, the presence of some ions in significant amounts in metal reinforced GICs and also in RMGICs also could be responsible for their cytotoxicities. The ions Cu2+ and Ag+, which were present in toxic concentrations, could be the main elements responsible for the toxicity of the metal-reinforced GICs along with HEMA and TEGDMA (11). Further, the possible cytotoxic effects of F-, Al3+, Zn2+ and Sr2+ ions, which are also present in significant amounts in GICs, were tested. It was concluded that among the tested ions, only the zinc ion was found to be associated with a high enough concentration to induce cytotoxicity of metal reinforced GICs and RMGICs (11).

Conversely, Soheili Madj et al. demonstrated that the cytotoxic effects of GICs might be caused by the metal components, or the small amounts of aluminium and/or iron ions present in their composition, which may cause cytotoxic effects on cultured cells by oxidative stress (15).

The potential toxic effects of the organic components of GICs also have been tested. Leyhausen et al. suggested that the cytotoxicity of Vitrebond may be caused by chlorine benzene, iodine benzene, and bromide benzene, which are decomposition products of the initiator diphenyldiodonium chloride (DPICI) (16).

Complementing the results presented above, the RMGICs and metal reinforced GICs showed higher cytotoxic effects on cultured fibroblasts and osteoblasts in vitro in comparison with conventional GICs. It has been shown that RMGICs are able to cause intense cytopathic effects on the cultured cells by significantly decreasing cell metabolism as well as by causing remarkable cell death (1).

However, it is most important to point out that the toxic effects of GICs were tested mainly in vitro. Although in vitro tests are simple to perform, cost-effective and suitable as an alternative to in vivo experiments, the results of in vitro studies cannot be automatically extrapolated to clinical situations (17-19).

It has been shown that the sensitivity of human pulp cells to cytotoxicity depended on the differences in the content, specifically the component monomers or additives of the tested RMGICs. Additionally, the sensitiv-
ity of human pulp cells to cytotoxicity depended on the concentration of the elutes tested. The cytotoxicities of the tested RMGICs decreased as the dilution concentration of the elutes increased because an increase of dilution concentration of the elutes is followed by a decrease in the content of the monomers or the additives in the dilution (17).

In line with this observation are the results of in vivo studies performed in human teeth, which have demonstrated that the RMGIC Vitrebond, the GIC which showed toxic effects in vitro, caused no inflammatory pulp response when it was applied in vivo as a liner in very deep class V cavities, (18-19). It seems that pulp cell damage documented in in vitro studies is prevented in vivo by the presence of a dentin barrier between the RMGIC Vitrebond and the pulp cells.

CONCLUSION

Based on this literature review, it may be concluded that RMGICs and metal reinforced GICs, in comparison with conventional GICs, showed higher cytotoxic effects on pulp cells in vitro. Monomers (HEMA and TEGDMA) present in resin composites of RMGICs, as well as Cu2+, Ag+ and Zn2+ ions, present in significant amounts in metal reinforced GICs and are the components mainly responsible for the toxic effects of these GICs.

In vivo experiments showed that the presence of a dentin barrier between toxic GICs and the pulp cells may prevent pulp cell damage. Potentially toxic RMGICs and metal reinforced GICs, because of their cytotoxicity, should not be applied directly to the pulp tissue.

REFERENCES