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ORIGINAL ARTICLE

Comparative evaluation of the calcium release from mineral trioxide aggregate and its mixture with glass ionomer cement in different proportions and time intervals – An *in vitro* study

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Abstract *Background:* Addition of glass ionomer cement (GIC) has been suggested to improve the setting time and handling characteristics of mineral trioxide aggregate (MTA). This study evaluated the effect of adding GIC to MTA in terms of calcium release, an issue that has not been previously studied.

Materials and methods: The study comprised four groups with five samples each: a control group of MTA alone and experimental groups I (1MTA:1GIC), II (2MTA:1GIC), and III (1MTA:2GIC) based on the mixture of MTA and GIC powders in the respective proportions by volume. Calcium release from the samples was measured by atomic absorption spectrophotometry at 15 min, 6 h, 24 h, and 1 week after setting. The level of statistical significance was set at $p < 0.05$.

Results: Groups I (1MTA:1GIC) and III (1MTA:2GIC) released significantly less calcium than the control group at all time periods, except at 15 min for group I. Group II (2MTA:1GIC) showed no significant difference in calcium release compared to the control at any time period. Group II exhibited greater calcium release than group I or III at all time periods, with significant differences between groups I and II at 1 week and between groups I and III at 24 h and 1 week. There were no statistical differences in calcium release between groups I and III.

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Conclusions: Adding GIC to improve the setting time and handling properties of the MTA powder can be detrimental to the calcium-releasing ability of the resultant mixture, depending on the proportion of GIC added. Adding MTA and GIC at a proportion of 2:1 by volume did not impact calcium release from the mixture. These findings should be verified through further clinical studies.

1. Introduction

Mineral trioxide aggregate (MTA) has many favorable biological properties for endodontic usage (Torabinejad and Parirokh, 2010). These properties are related to the formation of calcium hydroxide and subsequent release of calcium ions by MTA, as these actions modulate cytokine production and promote an alkaline pH, hydroxyapatite formation, and cementum deposition (Sarkar et al., 2005; Torabinejad et al., 1997; Zarrabi et al., 2010). However, despite these favorable properties, MTA has several drawbacks, including a prolonged setting time and difficult handling characteristics (Torabinejad et al., 1995). In this regard, the addition of accelerators and other vehicles to MTA has been recommended (Bortoluzzi et al., 2006; Gandolfi et al., 2008; Kogan et al., 2006; Wiltbank et al., 2007).

Combining glass ionomer cement (GIC) powder with MTA powder recently has been proposed as a means to overcome the drawbacks of MTA (Jeong et al., 2010; Oh et al., 2010). However, very few studies of this process have been conducted. One study evaluated the physical and chemical properties of experimental mixtures of MTA and GIC powders mixed at three different proportions. The experimental mixtures showed improved setting times but poor compressive strength and pH when compared to MTA powder alone (Jeong et al., 2010). Another study found that the biocompatibility of an experimental mixture of MTA and GIC was similar to the biocompatibility of MTA or GIC individually (Oh et al., 2010). Nevertheless, further studies have been recommended to determine the proper mixing ratio of GIC and MTA and the effect of different mixing ratios on various properties (Jeong et al., 2010).

The setting reaction of MTA results in the formation of calcium hydroxide, which subsequently dissociates into calcium and hydroxyl ions. The biological response to MTA is suggested to be based on its alkaline pH and calcium ion release (Camilleri and Pitt Ford, 2006; Holland et al., 1999, 2001; Massi et al., 2011; Yoshiba et al., 1996). Takita et al. (2006) confirmed that the proliferation of human dental pulp cells in contact with MTA is related to the continuous release of calcium ions. Therefore, any modification of MTA should not affect its calcium ion-releasing ability.

Because calcium ion release is the basis for the biological properties and applications of MTA, understanding the calcium ion-releasing abilities of GIC–MTA mixtures is of crucial clinical importance. However, no studies of this aspect have been conducted to date. Therefore, the purpose of this study was to compare calcium ion release among different GIC–MTA mixtures. The null hypothesis was that there would be no difference in calcium ion release from MTA–GIC mixtures containing different proportions of powders or measured at various times after setting.

2. Materials and methods

This study was designed to evaluate and compare the effect of combining GIC and MTA powders in three different proportions in terms of the calcium ion release from the mixture at different times after setting. The study included four groups with five samples each. Control group samples were prepared by mixing MTA powder (Angelus, Londrina, PR, Brazil) with distilled water. Samples in experimental groups I, II, and III were prepared by mixing MTA and GIC powders (Fuji II, GC Corporation, Tokyo, Japan) at proportions of 1:1, 2:1, and 1:2 by volume, respectively. Considering the powder/liquid ratio recommended by the manufacturer, the MTA and GIC powders were proportioned separately by using an automated weighing machine (Essae Teraoka Ltd., Singapore). Finally, powder mixtures in groups I, II, and III were mixed with liquid component of GIC, instead of distilled water provided with MTA, in order to fulfill the purpose of adding GIC to MTA.

Composition of MTA and GIC used in the study

MTA	GIC
Powder – silica, potassium oxide, alumina, sodium oxide, iron oxide, sulfur trioxide, calcium oxide, bismuth oxide, magnesium oxide and insoluble residues of calcium oxide, potassium sulfate, sodium sulfate and crystalline silica	*Powder* – silica, alumina, aluminum fluoride, calcium fluoride, sodium fluoride, aluminum phosphate
Liquid – distilled water	*Liquid* – tartaric acid, co-polymers of itaconic, maleic or tricarboxylic acid

Study samples were prepared in a Teflon mold. After setting, samples were placed in polypropylene tubes containing 10 ml of distilled water that had been confirmed to be free of calcium ions and to have a neutral pH of 6.8. Tubes containing the samples were closed and maintained at room temperature during the study.

Calcium ion release from the samples was measured at 15 min, 6 h, 24 h, and 1 week after sample setting by using an atomic absorption spectrometer (Varian, Model No. AA240) that was equipped with a specific cathode lamp for reading. The instrument was calibrated and used in accordance with the manufacturer's instructions. The amount of calcium ions that were released was measured as follows. First, the sample was removed, and the distilled water from the tube was emptied into the spectrometer flask. Lanthanum solution was added to prevent possible interference by other alkaline metals. The amount of released calcium ions (in parts per million, ppm) was measured. Finally, the distilled water was