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Hydration characteristics of Biodentine and Theracal used as pulp capping materials

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ABSTRACT

Objectives. Investigation of the hydration and characterization of Theracal and Biodentine used for pulp capping.

Methods. The setting mechanism and characterization of set Biodentine and Theracal after immersion in Hank's balanced salt solution (HBSS) for 28 days was investigated by scanning electron microscopy (SEM) of polished specimens and X-ray diffraction (XRD) analysis. The bioactivity and surface microstructure of cements immersed in HBSS or water was also assessed by similar techniques together with leaching in solution investigated by ion chromatography (IC).

Results. Biodentine hydration resulted in the formation of calcium hydroxide which was present in the material matrix and also on the material surface. Theracal was composed of large cement particles which showed some evidence of reaction rims on hydration. The material matrix included a barium zirconate phase as radiopacifier and also a glass phase composed of strontium, silicon and aluminum. This phase could not be detected in XRD analysis. Formation of a calcium phosphate phase was demonstrated on Theracal immersed in HBSS. Both materials leached calcium ions in solution.

Conclusions. The presence of a resin matrix modifies the setting mechanism and calcium ion leaching of Theracal. The clinical implications of these findings need to be investigated.

1. Introduction

Calcium hydroxide has been the material of choice as a pulp capping material. More recently mineral trioxide aggregate (MTA) has been suggested for use as a pulp capping material [1]. MTA mixed with water hydrates to form calcium silicate hydrate and calcium hydroxide [2–4]. The clinical success rates of MTA and calcium hydroxide used as pulp capping materials have been shown to be comparable [5,6]. MTA is composed mostly of tricalcium silicate. Tricalcium silicate cement exhibits a similar hydration profile to MTA [7].

The main disadvantage of using MTA as a pulp capping material is its extended setting time. MTA utilized as a pulp capping material needs to be layered with other materials while still fresh. Layering of MTA with zinc oxide eugenol cements and glass ionomer cements has been shown to affect the setting of the material [8]. Zinc is taken up by MTA from the adjacent zinc oxide cement and retards the hydration further. On the other hand MTA causes micro-cracking of glass

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ionomer cement at the interface [8]. Materials based on tricalcium silicate with a reduced setting time have thus been introduced. Biodentine, which is composed of tricalcium silicate, zirconium oxide and calcium carbonate mixed with water, chloride accelerator and water-soluble polymer exhibits a clinically acceptable setting time and physical properties [9]. It hydrates also in a similar way to MTA [10,11].

Biodentine has been investigated clinically and it elicits dentin bridge formation over the dental pulp in a similar manner as MTA [12]. Layering of Biodentine with composite resin without any surface treatment resulted in an adequate seal [13]. Biodentine exhibited micro-leakage and surface erosion when etched with 37% phosphoric acid used under composite resin restorations [14]. Acid etching has also been shown to affect the compressive strength and surface micro-hardness of ProRoot MTA [15].

Light curable tricalcium silicate-based materials are indicated for use as liner under composite restorations aiming to achieve a bond between the different layers of materials thus reducing micro-leakage. Theracal, a light curable resin modified Portland cement-based material has been investigated and it was shown to release significantly more calcium than ProRoot MTA and Dycal and thus was able to alkalinize the surrounding fluid [16]. Regardless the calcium ion release contact of Theracal with pulp cells resulted in a reduction in cell metabolism and reduced protein expression [17].

Although calcium release has been shown in Theracal, the setting mechanism and characterization of set material is still not known. The aim of this research was to investigate the setting mechanisms and characterize Theracal and compare it to Biodentine, which is also proposed for use as a pulp capping material.

2. Methodology

The materials used in this study included:

TheraCal™ (Bisco, Schaumburg, IL, USA) and
Biodentine (Septodont, Saint Maur-des-Fosses, France)

Biodentine was mixed according to manufacturer's instructions. The Theracal was dispensed from the syringe and light cured with a LED light-curing unit for 20 s per increment. Cylindrical specimens 10 mm in diameter and 2 mm high were prepared and immersed in Hank's balanced salt solution (HBSS; H6648, Sigma–Aldrich, St. Louis, MO, USA) for 28 days at 37 °C. For surface morphological analysis and ion chromatography additional specimens immersed in water were also prepared.

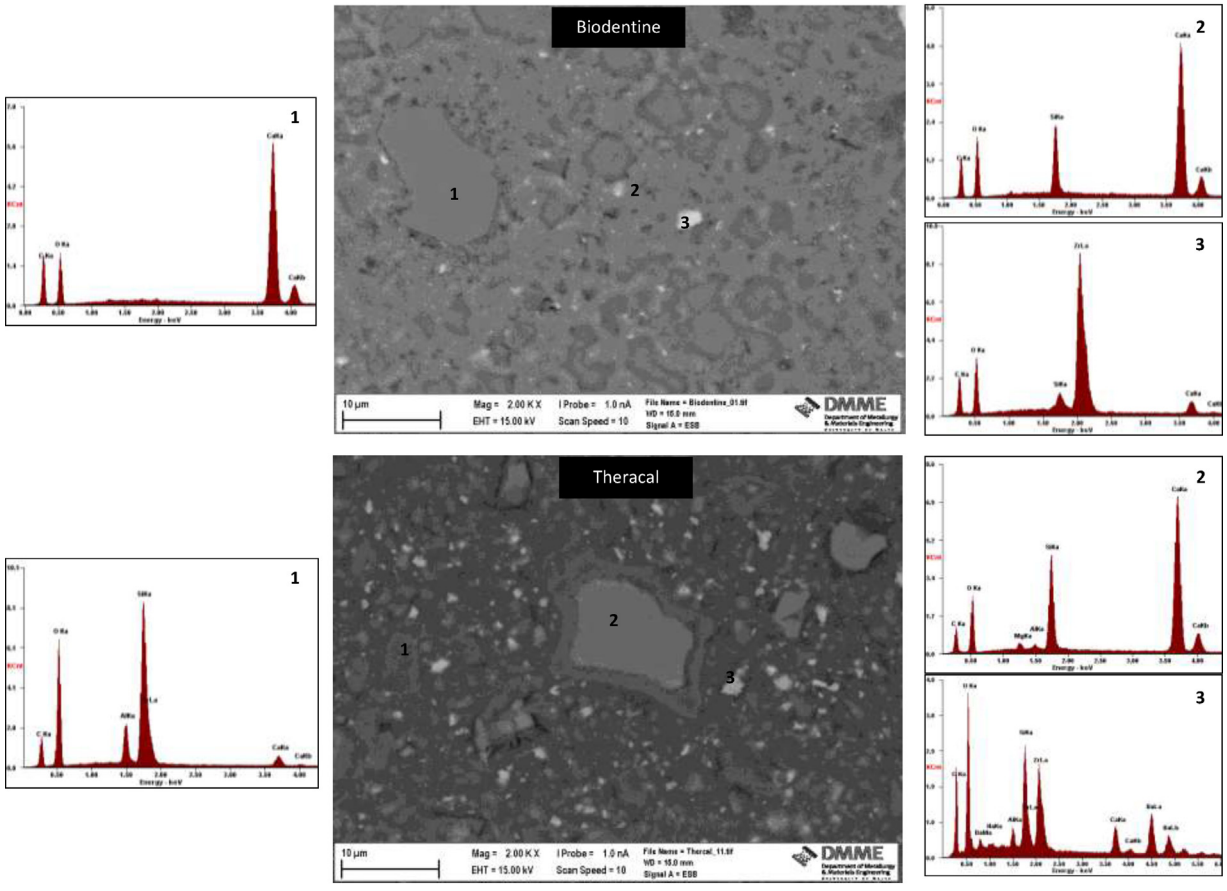

Fig. 1 – Back scatter scanning electron micrographs and energy dispersive spectroscopic analysis of the different microstructural features of set Theracal and Biodentine stored in Hank's balanced salt solution for 28 days at 37 °C.