SOLUBILITY OF CALCIUM SILICATE BASED CEMENTS – A COMPARATIVE STUDY

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Abstract. *Calcium silicate based cement is a group of biomaterials, based on Portland cement. Its physicochemical properties such as solubility are of the utmost importance. It should have low solubility in tissue fluid since the dissolution of materials may lead to treatment failure. The aim of this study is to evaluate the solubility of five calcium silicate cements after being placed in distilled water for a period of 28 days. Material and methods:* The purpose of this study was to compare solubility of a four new calcium silicate-based cements, such as: gray MTA Angelus; white MTA Angelus; BioAggregate and Biodentine with conventional mineral trioxide aggregate White ProRoot. Solubility is evaluated using standardized samples of materials, which are weighed before and after 28-day immersion in distilled water. **Results:** The lowest solubility is found at White ProRoot and the significantly highest solubility – at Biodentine.

Key words: new calcium silicate based cements, solubility, conventional mineral trioxide aggregate.

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INTRODUCTION

Calcium silicate based cements are a group of biomaterials, based on Portland cement. Mineral Trioxide Aggregate (MTA), such as ProRoot MTA (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA) was introduced in the 1990s [1] followed later by MTA Angelus (Angelus, Londrina, Brazil). The new materials have been claimed to have all the advantages of conventional MTA without any of its drawbacks. More recently materials based on calcium silicate cement have been introduced in dentistry. Biodentine (Septodont Ltd., Saint Maur des Fossés, France) is a new tricalcium silicate based inorganic commercial cement [2, 3]. Bioaggregate (Innovative BioCeramic, Vancouver, Canada) is a relatively new product containing calcium silicate hydrate, calcium hydroxide [4]. These products are used for repair of iatrogenic root perforations occurring during clinical root canal

procedures [5]. Hermetic sealing ability is a basic requirement for this group of materials. It is a complex result of several factors – marginal adaptation, adhesion, solubility and dimensional changes [6]. Its physicochemical properties such as solubility are of the utmost importance. It should have low solubility in tissue fluid since the dissolution of materials may lead to treatment failure [5]. Slightly contradictory is the available information in the literature on the solubility of calcium silicate based cements [9, 10, 13].

The aim of this study is to evaluate the solubility of five calcium silicate cements after immersion in distilled water for a period of 28 days.

MATERIAL AND METHODS

This study was performed using five calcium-silicate cements: group 1 – white ProRoot MTA (Dentsply, Maille-

fer, Suisse); group 2 – gray MTA-Angelus (Angelus, Londrina, Brazil); group 3 – white MTA-Angelus (Angelus, Londrina, Brazil); group 4 – BioAggregate (IBC, Canada); group 5 – Biodentine (Septodont, France).

All calcium silicate cements were mixed according to the manufacturer's instructions in ratio 3:1 powder-to-liquid on a glass slab with cement spatula to produce homogeneous paste and inserted into cylindrical molds in internal diameter 15 mm and height 4mm. The surface of the samples was smoothed with Mylar strip. On this surface a wet cotton pellet was placed in contact with cement for 4 hours to provide the necessary additional humidity for the normal course of the hydration and setting process.

Biodentine is prepared by adding the liquid to the powder present in the capsule. These components are then triturated with an amalgamator for 30 s at 4000 rpm leading to the formation of a paste of creamy consistency.

The specimens were placed then in a vacuum desiccator for 3 days to evaporate excess moisture. The samples were weighed in an analytical balance Sartorius with accuracy of $\pm 0,0001$ g. Then they were placed in 20 ml distilled water for 28 day.

After this period the test samples were removed from the distilled water and evaporated in a furnace at a temperature below the boiling point. The weight of the crucible with the residual dry matter was measured with the balance. It takes away the weight of the empty crucible. The solubility was calculated as a percentage by weight of the dry matter divided by the initial weight of the samples and multiplied by 100.

The solubility of each tester was determined by the following formula

$$\text{Solubility \%} = \frac{\text{weight of the dry matter}}{\text{the initial weight of the samples}} \times 100$$

Statistical analysis

All data was processed with a IBM SPSS Statistics 19.0. For a significance level in which the zero hypothesis was rejected, $p < 0.05$ was selected. The following methods have been applied: 1) descriptive analysis – when tabulated the frequency distribution of the studied groups, rare anatomical variations; 2) alternative analysis – for comparing relative shares.

RESULTS

The results are presented in Table 1.

The different digits are a sign of a statistically significant difference

The lowest solubility was recorded in ProRoot – 2.90% and the highest in Biodentine – 18.72%. A statistically significant difference was seen with ProRoot and gray Angelus, on the one hand, and white Angelus and Bioaggregate, on the other. There is also a statistically significant difference between Biodentine and all other cements.

DISCUSSION

The solubility of calcium silicate materials is of particular importance because they are expected to provide hermetic sealing ability in contact with blood and tissue fluids [7]. According to ANSI/ADA (American National Standards Institute/American Dental Association) specification 57, the requirements for the solubility of the root-filling agents are not to exceed 3% [ANSI/ADA]. The ISO 6876 standard is also 3% [8].

The results found by us show only such solubility in ProRoot – 2.90% and in all other materials the solubility is increased. The highest solubility in Biodentine is 18.72%. There is a statistically significant difference between different materials.

Unlike us according to Grech and et al [9] Biodentine and Bioaggregate have very low solubility, with no

Table 1

Solubility Materials	The initial weight of the samples	The weight of dissolved material	% dissolved material
ProRoot MTA	1,0360	0,0301	2,90a
W MTA Angelus	1,0400	0,0562	5,40b
G MTA Angelus	1,0037	0,0394	3,92a
Bioaggregate	0,8126	0,0471	5,82b
Biodentine	1,1119	0,2082	18,72c

statistically significant difference between them. A Saghiri et al. reported that the solubility of Bioaggregate is 2.15% and white ProRoot MTA is 0.87% [10].

The literature reports that ProRoot has low or no solubility [11]. However, it has been observed in some studies that the solubility increases with time [12].

Similar to our results, Singh et al [13] reported that Biodentine have significantly higher solubility than ProRoot for 30- and 60-day immersion periods. Likewise, similar data reported Kumari, et al [14].

Roberti Garcia et al [15] found that white MTA-Angelus (6.65%) had a higher solubility than the gray formulation. Similar data is reported from Borges [16]. Moreover, Borges also noted that the white ProRoot MTA was also more soluble than the gray one. Comparing white and gray MTAs, the white version of the cement exhibited greater solubility [17]. Although bismuth oxide is an insoluble substance, the presence of this substance in the composition of MTA may be responsible for the solubility of the cement due to the fact that bismuth oxide causes a deterioration of the mechanical strength and it increases the relative porosity of the material [1].

Water absorption studies of materials are related to their solubility. According to Bortoluzzi et al [19] one of the disadvantages of MTA is its tendency to wash off or disintegrate in early contact with blood and other tissue fluids.

CONCLUSION

The solubility of five calcium-silicate cements in distilled water for a period of one month is compared. After analysis of our solubility results we can make the following conclusions: 1. ProRoot has the lowest solubility at the end of the first month – 2.90%. 2. Biodentine has shown the highest solubility – 18.72%.

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