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Effect of pH and Lidocaine on the Compressive Strength of Calcium Enriched Mixture Cement

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Abstract

Statement of Problem: The pH of the human abscess has been measured as low as 5.0. This low pH could potentially inhibit setting reactions, affect adhesion, or increase the solubility of root end filling materials hence affect the compressive strength. Moreover, root end filling materials might expose or even mix with lidocaine HCL during periapical surgery.

Objectives: The aim of this in vitro study was to evaluate the effect of acidic pH and lidocaine on the compressive strength of calcium-enriched mixture (CEM).

Materials and Methods: CEM was mixed according to the manufacturer's instructions or with lidocaine (L), and condensed into 6 × 4 mm split moulds. The samples were exposed to phosphate buffered saline (PBS) at pH 5 or 7.4 for 7 or 28 days. Cylindrical blocks of CEM (total number = 120 and 15 for each group) were subjected to compressive strength test using a universal testing machine. Data were analysed using three-factor analysis of variance (ANOVA).

Results: Regardless of pH and time, significant differences were not found between lidocaine groups and the groups that were mixed according to the manufacturer's instruction ($p = 0.083$). For both mixing agents, regardless of time, there were no significant differences between the two pH levels ($p = 0.157$). Regardless of the material and pH, there was a significant increase in the compressive strength from days 7 to 28 ($p < 0.001$).

Conclusions: Mixtures with lidocaine and exposure to an acidic environment had no adverse effects on the compressive strength of CEM Cement.

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Introduction

Root end surgery is considered to be the final option for cases in which non-surgical endodontic retreatment has failed or conventional root canal therapyis not possible [1]. In this method, after root resection and root end cavity preparation, a reparative material is applied to fill the root end cavity. Root end fillings are

inevitably exposed to the inflamed tissue or even anaesthetic solutions used for bleeding control. The pH of inflamed tissue has been estimated to be as low as 5.0, and the pH of lidocaine HCL as an anaesthetic solution is estimated to be 4.2 [2]. The low pH of the environment or the anaesthetic solution may potentially affect the physical and chemical properties of root end filling materials. Acidic environments adversely affect the hydration behaviour of mineral trioxide aggregates (MTA) [3,4]. Low pH also reduces the surface hardness [5], and bond strength [6] of this material.

Calcium enriched mixture (CEM) (Bionique Dent, Tehran, Iran) is a tooth-coloured, water-based cement that has been introduced recently. This new cement is composed of different calcium compounds, such as calcium hydroxide, calcium oxide, calcium phosphate, calcium sulphate, calcium silicate and calcium carbonate [7]. High concentrations of water-soluble calcium and phosphate cause the immediate formation of hydroxy apatite during and after setting [8]. CEM cement is compatible for handling and setting in an aqueous environment [8]. It has been shown that this cement exhibits excellent sealing properties [9] and biocompatiblity [10]. The cytotoxicity of this cement is comparable to MTA [11]. Because of these characteristics, CEM is used for management of internal and external resorption [12], furcalperforation [13], and pulpotomy of primary and permanent molars [14,15]. In a recent study on CEM, lower pH values in highly acidic environments (pH = 4.4) adversely affected the force needed for the displacement of this cement, while in higher pH values (6.4) the bond-strength was not affected [16].

Given the uncertain characteristic of CEM cement when exposed to different environments, and the fact that during periapical surgery, CEM might be exposed or even mix with lidocaine HCL. The purpose of this study was to evaluate the compressive strength of CEM cement when mixed with its specific liquid or lidocaine and exposed to an acidic or neutral environment.

Materials and Methods

Twenty-four Custom-made, two-part split Plexiglass moulds were used in this experiment. Each mould had five holes with internal diameters of 4 mm and heights of 6 mm. The moulds were randomly allocated into eight groups, according to the mixing agent, pH, andtime period (Table 1).

For half of the groups, CEM was mixed with its specific liquid according to the manufacturer's instructions (CEM/MI), and for the other half, 2% lidocaine HCL (DarouPakhsh, Tehran, Iran) withepinephrine (1:80000) was substituted for the specific liquid (CEM/L). The experimental CEM mixtures were introduced incrementally into the moulds by amalgam carrier. After gentle packing and compacting with condensers, excess material was removed with wet cotton pellets. A glass slab was secured to one end of each split mould. The moulds were then wrapped into wet pieces of gauze

Table 1: Summary of mean compressive strength and standard deviation (MPa)

Material	Number of Samples	pH	Time(days)	Mean ± SD
CEM/L	13	5	7	1.55 ± 0.38
CEM/MI	14	5	7	2.29 ± 0.84
CEM/L	12	7.4	7	2.09 ± 0.32
CEM/MI	15	7.4	7	2.36 ± 0.59
CEM/L	12	5	28	36.06 ± 7.44
CEM/MI	15	5	28	36.88 ± 10.14
CEM/L	14	7.4	28	36.23 ± 10.21
CEM/MI	15	7.4	28	44.24 ± 10.94

saturated with PBS titrated to pH 5.0 or 7.4, and kept in an incubator at 37 °C for 24 hours, to ensure preliminary set. Next, the moulds were wrapped into new wet pieces of gauze saturated with the same solutions for a total of seven or 28 days. On each testing day, the moulds were split and CEM blocks were removed carefully by applying a light force, taking care not to damage the CEM samples. After removal, the blocks were evaluated for voids or cracks.

To test for compressive strength, the CEM blocks were placed lengthwise between the platens of a universal testing machine (Zwick/Roell Z020 Zwick, CombH & Co, Germany) and compressed using a cross-head speed of 1 mm/min [6]. The load at fracture was recorded and plotted on a graph in megapascals (MPa). Differences between the groups were statistically analysed using three-factor analysis of variance (ANOVA). The Statistical Package for Social Sciences, version 16 (SPSS Inc., Chicago, IL, USA) was used to analysed the data.

Results

Some CEM blocks, mainly from the lidocaine groups, fractured during the removal of the sample from the moulds. The number of samples, mean compressive strengths and standard deviations of the eight experimental groups, are presented in Table 1. The highest and the lowest compressive strength values were recorded in the CEM/MI in the pH 5/day 28 group, and CEM/L in the pH 5/day 7 group, respectively. Regardless of the pH and time, there were no significant differences between the lidocaine groups and the groups prepared according to the manufacturer's instruction (p = 0.083). For both mixing agents, regardless of time, there was no significant difference in regard to pH (p = 0.157). Regardless of the mixing agents and pH, there was a significant increase in the compressive strength

Table 2: The results of three – way ANOVA

Source	Type lll Sum of squares	df	Mean Square	F	Sig
Corrected Model intercept	35875.724a	7	5125.103	101.871	.000
	41109.940	1	41109.940	817.140	.000
Material	154.289	1	154.289	3.067	.083
Ph	102.480	1	102.480	2.037	.157
Time	33162.097	1	33162.097	659.161	.000
Material* ph	72.791	1	72.791	1.447	.232
Material* time	94.566	1	94.566	1.880	.174
Ph* time	77.269	1	77.269	1.536	.218
Material* ph* time	90.493	1	90.493	1.799	.183
Error	4880.028	97	50.310		
Total	833668.659	105			
Corrected Total	40755.752	104			

from days seven to 28 ($p < 0.001$). The results of three-way ANOVA tests have been presented in Table 2.

Discussion

The clinical relevance in testing for compressive strength of the root end filling material is considered not only to ensure that they can stand the forces caused by tooth function or operative procedures, but also to verify that they are completely set [6,17]. Although mechanical tests are unable to reflect the clinical situation, they can show the effects of different mixing liquids and setting conditions on different cement types.

According to ISO 9917-1 (2003) standards, for the compressive strength test, a split mould design made of a material that will not be affected by the cement has been advised. In a study on the compressive strength of MTA, plastic split moulds [18] have been used. In this study, two-part split Plexiglass moulds were used to form CEM samples. A pilot study conducted prior to this study showed that samples required a light force to allow for removal.

The results of the present study showed that mixing CEM cement with lidocaine HCL did not have adverse effects on the compressive strength of this material. However, these results should be interpreted with caution because despite using two-part split moulds that required only light force for removal of the CEM samples, nine samples from the lidocaine groups versus one sample of CEM/MI were fractured during removal from the moulds. Therefore, one may assume that mixing CEM cement with lidocaine has deleterious effects on the physical properties of this cement.

The present study also showed that acidic environments did not adversely affect the compressive strength of CEM cement in pH 5, which is similar to an infectious environment.

On the other hand, the present study is not in agreement with Watts *et al*.'s study that reported mixture with lidocaine and also exposure to pH 5 caused a significant decrease in the compressive strength of both white and grey MTA [6]. Saghiri *et al*. also showed that acidic environments can drastically affect the compressive strength of nano white MTA, WMTA and bioaggregate (BA) [19]. Other studies also reported the adverse effect of acidic environments on the sealing ability and bond strength of MTA [20,21].

These discrepancies could be attributed to the different experimental setups that have been used in these studies. For example, Watt *et al*. removed the MTA samples from the moulds after three days and immersed them in PBS with different pH for a total of seven and 28 days [6] while in the present study the CEM samples were exposed to different pH levels within their respective moulds therefore the exposure area to the acid was lower than in watts *et al*.'s study. The different chemical composition and particle size of different cements might also explain the differences in the results of different studies. The chemical composition of CEM used in this study is different from that of MTA and BA [9]. CEM cement also has a smaller particle size compared to MTA, which might cause it to be less affected by acidic environments [7,22]. In the case of BA, it has been shown that BA has a very similar composition with MTA, but it is aluminium-free and has different opaquers [23].

Only few studies have evaluated the effect of time on the compressive strength of CEM. In the present study, the time intervals caused significant increases in the compressive strength of all groups.

The results of the current study are in agreement with those of Rahimi *et al*. who reported an increase in the bond strength of CEM cement from 24 hour to seven days [24]. Another study also showed that the bond strength of this cement increased from day 3 to day 21 [25-26]. Watts *et al*. showed an increase in the compressive strength of white MTA and grey MTA when mixed with sterile water from day 7 to 28. But when WMTA and GMTA were mixed with local anaesthetic, the time intervals caused a significant decrease in their compressive strength, which was not in agreement with the findings of the present study [6].

Conclusions

The most important factor in the increase of CEM cement compressive strength is time. Although mixing with lidocaine and exposure to acidic environments had not statistically affected the compressive strength of CEM, it is not recommended in clinical situations until further studies are conducted.

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Conflict of interest

The authors deny any conflicts of interest related to this study.

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