Abstract

Setting and biological properties of spherical microparticle-modified MTA cement mixed with Strontium Nitrate solution

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[Purpose] Due to the good sealing ability and biocompatibility, MTA cement is widely used for retrograde fillings and treatment of root perforations. MTA cement possess poor handling properties, especially when used as a retrograde filling because of prolonged setting time. The study aimed to improve mechanical, chemical and biological properties of MTA cement using strontium (Sr) nitrate as a mixing liquid.

[Method] Commercial White TMR-MTA (Yamakin Ltd., Osaka, Japan) cement powder and distilled deionized water (DDW) were mixed at 20% water rate as a control group, and as experimental groups, powder mixed with 1, 5, 10, and 30% strontium nitrate solution. Mixtures were cast in the ring molds, and incubated with 95-100% humidity at 37°C, up to set. Initial (working time) and final (curing time) setting times were determined with a Vicat needle apparatus weighing at 400±2 gr. Compressive strength was measured using universal testing machine (AG-IS, SHIMADZU Corporation, Japan) at 1 and 7 days. Ions concentrations (ICP-OES Optima 5300 DV, PerkinElmer precisely, Shelton, USA) and pH value (pH/ion/cond meter F-55, Horiba, Japan) were measured after soaking in 5 ml of DDW in a sealed bottle at 37 °C for 1, 3 and 7 days. Cell proliferation was assessed with WST-1 assay at 24, 48, 72, and 96 hours in the cell culture with MTA extract divided into 6 groups (1, 10, 100, 1,000, and 10,000 ppm of Sr groups and the control, which was not contained Sr). Mineralization of MC3T3-E1 was evaluated with ALP staining and Alizarin Red S staining in the 1 – 1,000 ppm of Sr groups and the control. The statistical analysis was carried out with one-way ANOVA, adjusted by the post-hoc Tukey's test at a significance level of 0.05.

[Results and Discussions] The final setting time of the cement with all concentrations of Sr-MTA were significantly shorter than that of the control. Among all groups, the 30% Sr-MTA was cured in the shortest time. These results suggested that the Sr^{2+} accelerated setting reactions of MTA. The compressive strength of the 1 and 5% Sr-MTA significantly lower than ($p<0.05$) that of the control within 1 day. The 10 and 30% Sr-MTA were comparable to the control throughout the 1 and 7 days of immersion in DDW. The pH of the test solutions prepared from the 1, 5, 10, and 30% Sr-MTA specimens at 1, 3 and 7 days, were around 11.0, similar to the pH of the solution prepared from MTA. The amount of Sr^{2+} and Ca^{2+} released from various concentrations of Sr-MTA immersed in DDW decreased with time. In the result of *in vitro* experiment, 1 – 1,000 ppm of Sr hasn't affected to the cell proliferation, but 10,000 ppm of Sr significantly decreased. However, the calcification of MC3T3-E1 cells decreased in 100 and 1,000 ppm of Sr within 4 days, increased in 21 days. The mineralized nodule formations in the 100 and 1,000 ppm of Sr, were relatively larger than that of the other groups, described in the Alizarin Red S staining images.

[Conclusion] In conclusion, Sr successfully extended the working time and reduced the curing time without decreasing the compressive strength of MTA. The cement, was mixed with 30% of $Sr(NO_3)_2$ solution, was the most effective according to the results of the setting but it is limit of the safe dose to the cell, confirmed with the results of mineralization assay.