Abstract

Dentin demineralization inhibition analysis of divalent metal ions using the in-air micro PIXE/PIGE analysis method

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[Abstract]

According to the 2016 Survey of Dental Diseases, an increase in the number of remaining teeth and caries prevalence in the elderly was reported, and caries in the elderly is characterized by frequent occurrence on the exposed root surface due to gingival recession. Although the demineralization inhibitory effect of fluorine is already widely known, the demineralization inhibitory effect of trace elements such as strontium has also been reported.

In order to evaluate the inhibitory effects of trace elements on dentin demineralization, elemental analysis within the tooth is essential. In particular, there is a need for a method capable of simultaneously analyzing a plurality of elements, including fluorine, which is a light element, with high sensitivity. In-air micro proton-induced X-ray and Gamma ray emission (In-air micro PIXE/PIGE) analysis has been used to analyze fluoride and calcium in the tooth, but other trace amounts have been analyzed. Simultaneous elemental analysis was not possible. In this study, we improved the conventional technique and established a method for simultaneous analysis of trace elements. In addition, in order to perform absolute quantification, we prepared standard samples that can be efficiently calibrated by using substances with a composition ratio of a plurality of trace elements, and performed their verification.

Zinc chloride has anti-inflammatory and astringent effects due to protein coagulation, and in addition to its antibacterial properties, it has been reported to have the effect of suppressing the activity of (MMP) matrix metalloproteinas, and the possibility of protecting the nucleus of remineralization. Zinc and copper are commonly compounded and used in the dental field, and we thought that if their demineralization inhibitory effects were recognized, they would lead to the prevention of root caries associated with gingival recession.

Therefore, we used an automatic pH cycler that can simulate intraoral pH changes, a newly developed In-air micro proton-induced X-ray and Gamma ray emission (In-air micro PIXE/PIGE) analysis method, and standard samples. Therefore, we

investigated the demineralization inhibitory effect of zinc and copper. The root surfaces of bovine teeth were exposed by polishing, demineralized, and immersed in 2% zinc chloride, 2% copper sulfate, 2% zinc sulfate and 2% magnesium chloride. After 24 hours, it was sliced and polished to prepare a dentin sample. These were performed before and after 2 weeks of loading with an automatic pH cycler. In the study of remineralization-promoting effects, the roots of bovine teeth were sliced, demineralized, and immersed in 1% zinc chloride, 1% copper sulfate, 1% zinc sulfate, 1% magnesium chloride, and 1% sodium fluoride for 72 hours after immersion. Afterward, they were immersed in the remineralizing solution for one week to prepare remineralized specimens. The obtained samples were subjected to In-air micro PIXE/PIGE measurements to determine the distribution of calcium, zinc, copper, and magnesium. In

-air micro PIXE/PIGE analysis revealed uptake of zinc, copper and magnesium in the surface layer before pH cycling. In addition, both the amount of calcium loss and the depth of demineralization were significantly lower in the dentin group to which zinc chloride, copper sulfate, and zinc sulfate were applied than in the control group. Those with added fluoride showed even lower calcium loss and demineralization depth. Compared to the control group, the analysis of calcium content in demineralized dentin showed predominant increases in calcium content in zinc chloride, copper sulfate, zinc sulfate, and magnesium chloride.
From these results, it was thought that zinc chloride, copper sulfate, and zinc sulfate acted as divalent cations when absorbed into the tooth, and worked to suppress demineralization and calcium loss. The prepared standard samples showed generally good correlation numerically and could be applied to future research.