Relationship between root resorption and individual variation in the calcium/phosphorous ratio of cementum

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Introduction: The purpose of this study was to investigate whether individual variation in the hardness and chemical composition of the cementum in the root apex affects the degree of root resorption. **Methods:** In a previous study, we evaluated the Vickers hardness scale of 50 extracted teeth. For this study, we classified the 50 extracted teeth into soft, moderate, and hard groups according to the Vickers hardness scale. Then, we randomly selected 7 teeth from each group and measured the resorbed areas of the apical cementum in vitro using human osteoclast precursor cells. We also investigated the calcium/phosphorous (Ca/P) and magnesium/calcium ratios of these 21 extracted teeth using energy-dispersive x-ray microanalysis studies to determine the chemical composition of the cementum in the root apex. **Results:** In the pit formation assay, the resorbed area in the soft group showed a greater extent than it did in the moderate and hard groups ($P < 0.01$). A correlation was noted between the Vickers hardness and the resorbed area of the cementum in the root apex ($r = -0.714$; $P < 0.01$). The Ca/P ratios in the soft and moderate groups were lower than the ratio in the hard group ($P < 0.01$ and $P < 0.05$, respectively). A correlation was noted between the Vickers hardness and the Ca/P ratio of the cementum in the root apex ($r = 0.741$; $P < 0.01$). **Conclusions:** These results suggest that the hardness and Ca/P ratio of the cementum may be involved in root resorption caused by orthodontic forces. (Am J Orthod Dentofacial Orthop 2017;152:465-70)

Orthodontically induced inflammatory root resorption is one of the most difficult accidental symptoms to predict in patients having orthodontic tooth movement; this undesirable result can cause permanent loss of the dental structure of the root apex. In most cases, patients experience mild root resorption. In exceptional cases, however, excessive root resorption may occur. Lund et al[1] reported that nearly 7% of orthodontic patients had at least 1 tooth with root shortening exceeding 4 mm. The causes of this phenomenon have been reported to include use of a heavy force,[2] length of treatment,[3] type of root,[4] and the patient's genetic predisposition.[5] It is therefore critical for orthodontists to anticipate this phenomenon and prevent it when possible.

The cementum is a nonuniform mineralized connective tissue that surrounds the root dentin of teeth and provides the interface through which the root surface is anchored to the collagen Sharpey's fibers of the periodontal ligament. The cementum is less densely mineralized than dentin or enamel, contains no blood vessels, and does not undergo physiologic remodeling.[6-8] The chemical composition of the cementum may display individual and morphologic differences. The cementum is classified as both cellular and acellular.[9] The apical cementum is predominately cellular and less densely mineralized, and has lower hardness values than the more densely mineralized acellular cementum in the middle and cervical thirds of the root.[9] The hardness of the cementum therefore depends on the direction of the structural arrangement and the mineral content of the cementum.[10-12] Several studies have reported that the hardness of mineralized tissues is positively correlated with the extent of mineralization.[13-15] According to Srivicharnkul et al[16] and Rex et al,[17] the hardness and elastic modulus of the cementum may be involved in the amount of root resorption and may alter the mineral content in the cementum.

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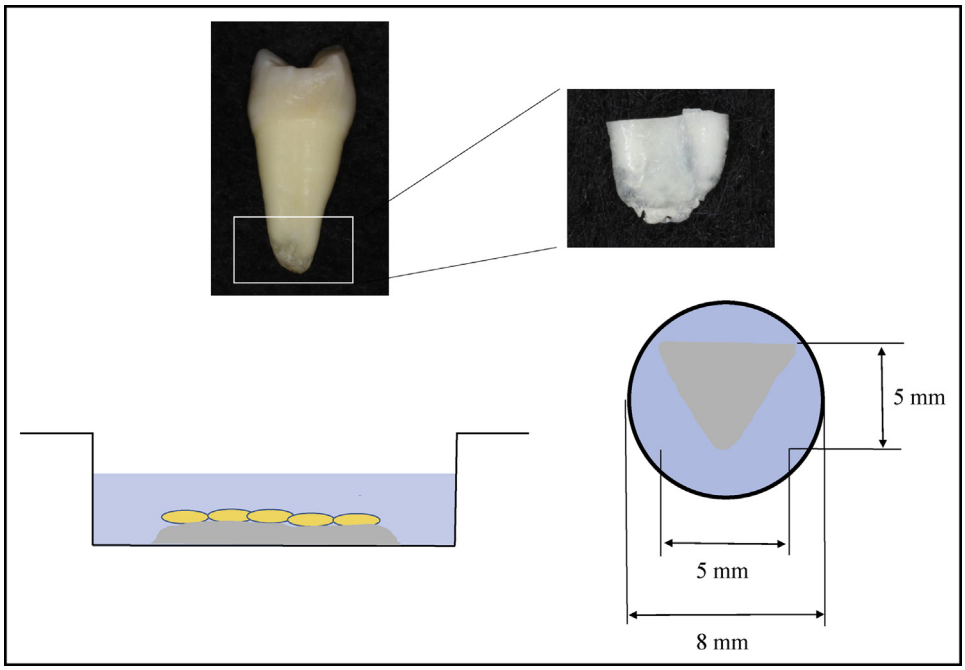

Fig 1. Schema of the pit formation assay. The roots of the apical third were sectioned. In all samples, the area of cementum in contact with the dish surface was equalized. Osteoclasts (1.0×10^4 cells/well) were cultured on the samples in culture medium at 37°C for 14 days.

We examined whether there was individual variation in the Vickers hardness values of the cementum of 50 first premolars in a previous study.[18] The results demonstrated that the hardness of the cementum decreased from the cervical to the apical regions on the root surfaces. Chutimanutskul et al[19] supported the results of this study. Furthermore, individual variations were observed in the hardness of the cementum, and the Vickers hardness value of the hard group was approximately 2 times higher than that of the soft group. In previous studies, the inorganic chemical composition of the root cementum was reported to consist of elements such as calcium (Ca), phosphorous (P), and magnesium (Mg).[20] Thus, individual variations in the hardness of cementum may be related to the chemical composition of Ca, P, and Mg, and may influence whether a patient has resistance or susceptibility to root resorption.

To examine whether individual variation in the hardness of the cementum affects the degree of root resorption, we measured the resorbed areas of the apical cementum in 3 groups (hard, moderate, and soft) using human osteoclast precursor cells in vitro. Furthermore, we performed energy-dispersive x-ray microanalysis studies to determine the Ca/P and Mg/Ca ratios to investigate the chemical composition of the cementum in the root apex.

MATERIAL AND METHODS

We measured the Vickers hardness of the apical cementum of 50 extracted teeth in a previous study.[18] The mean value of the Vickers hardness was 19.00 (range, 10.69-30.92). The extracted teeth were classified into soft, moderate, and hard groups according to their Vickers hardness values. The soft group was more than 1 standard deviation (SD) below the mean, the moderate group was within 1 SD of the mean, and the hard group was more than 1 SD above the mean. In this study, teeth were randomly selected from each group. This study was approved by the ethics committee of Nihon University School of Dentistry at Matsudo in Japan (EC 15-001).

For the pit formation assay, we randomly selected 7 extracted teeth from each group. The teeth were sectioned buccolingually down the long axis of the tooth through the apex with a diamond blade (Isomet; Buehler, Tokyo, Japan) under irrigation with distilled water. Next, the roots of the apical third were sectioned. In all samples, the area of the cementum that was in contact with the dish surface was equalized (Fig 1).

Osteoclasts (Takara Bio, Shiga, Japan) were cultured on the apical cementum in human osteoclast culture medium (Takara Bio) for 14 days. Next, the apical cementum was washed 3 times with phosphate buffered saline. The apical cementum was placed for 30 minutes