Dentinal Tubule Densities in Human and Bovine Coronal Dentin

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Abstract: The purpose of this study was to compare the area number density of dentinal tubules in human and bovine coronal dentin. Six human teeth and six bovine teeth were used in this study. The number of dentinal tubules per mm² was measured in human and bovine coronal dentin using scanning electron microscopy. The mean density of dentinal tubules in human dentin was 27,838±6,700 dentinal tubules per mm² and in bovine dentin was 31,011±1,679 dentinal tubules per mm². These values were compared statistically by one-way ANOVA and Fisher's PLSD tests. There was no significant difference between dentinal tubule densities in human and bovine coronal dentin. Human and bovine dentins were structurally similar as observed by scanning electron microscopy.

Key words: teeth, dentinal tubule, human dentin, bovine dentin.

In the field of dental research, animal teeth have been used in many studies to evaluate the characteristics of hard dental tissues with a view to substituting them for human teeth. These studies have included teeth from rats, cats, dogs, monkeys, goats, horses, pigs and cows. Among these, bovine teeth have been widely used in recent years for studies focusing on the mechanical properties of enamel to dentin because of their large size. Thus, among the animal species evaluated, bovine teeth have been shown to provide the most suitable animal model for human teeth.1,2,3 However, with respect to their ultimate tensile strengths there were marked differences between human and bovine coronal dentin.4,5

Dentin is the most abundant mineralized tissue in teeth, by both weight and volume. It is traversed by tubules that extend from the pulp towards the dentino-enamel junction (DEJ). It has been reported that there is a variation of dentinal tubule density in teeth.6,7 Additionally, the density of dentinal tubules affects the tensile strength of dentin.8,9 Hence, the aim of this study was to compare the number density of dentinal tubules in human and bovine coronal dentin in order to better understand the mechanical properties of the tooth.

Materials and Methods

Materials

Human extracted molars were obtained under informed consent with a protocol approved by the Ethics Committee of Showa University School of Dentistry. Bovine lower central incisors were extracted immediately after sacrifice from animals that were estimated to be 2–2.5 years old based on their dental age. Teeth were frozen within 3 h of extraction and stored at −12°C until analysis. Before processing, the teeth were thawed by immersion in Hank’s balanced salt solution at room temperature for 30 min.

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Preparation of specimens

Six human teeth and six bovine teeth were used in this study. The dentin was fractured and prepared for scanning electron microscopy (SEM) and the number of dentinal tubules was counted according to a previous report. Measurements were made at a mid position on the coronal dentin 1.5 mm from the DEJ in both bovine and human preparations. The surfaces of the specimens were coated with gold using an ion sputtering machine and observed by SEM (S-4700, Hitachi, Tokyo, Japan) at ×1,000 magnification. The numbers of dentinal tubules per mm² were compared statistically by one-way ANOVA and Fisher’s PLSD tests.

Results

Figure 1 shows typical dentinal tubules in human and bovine coronal dentin as observed in the scanning electron microscope.

The numbers of dentinal tubules per mm² are shown in Table 1. In human dentin the mean value was 27,838 ± 6,700 dentinal tubules per mm² and in bovine dentin there were 31,011 ± 1,679 dentinal tubules per mm². These means were not significantly different.

Discussion

It has been reported that dentinal tubule number density is variable depending on the type of tooth and on the specific layer within the dentin. However, no significant difference was found between human and bovine coronal dentin in the densities of their dentinal tubules. A previous report also failed to observe any difference in the numbers of dentinal tubules in human and bovine dentin. Our results were therefore in agreement with that study. Human and bovine dentins were observed to be similar structurally in the scanning electron microscope. Additionally, it has been reported that the percentage of intertubular dentin is similar in human and bovine teeth. The intertubular dentin is mostly composed of collagen matrix. It is known that bovine dentin shows a similar organic matrix to human dentin. Thus, based on the observation that human and bovine patterns at sclerosis are similar, it may be inferred that the intertubular dentins of these teeth are similar.

Slightly, the number of the human dentinal tubules was lower than that of bovine dentin as shown in Fig. 1. Therefore, the net cross-sectional area of the
dentin matrix in a sample of human dentin of total area 1 mm² was actually greater than that in bovine dentin. As tensile fractures usually occur at the plane of minimal cross-sectional area, the tensile strengths of human dentin would be expected to be a little greater than those of bovine dentin.

Additionally, it has been reported that bovine dentin is easier to demineralize than human dentin. Moreover, microleakage is higher on the margins of the restorations of bovine teeth in comparison to human teeth. These differences in the microstructures of human and bovine teeth, and observations that their chemical, structural, anatomical and radiographic characteristics are not always similar, imply that there may be differences in their ultimate tensile strengths. Moreover, age-related changes in tooth structure play an important role in the mechanical and physical properties of dentin. It has been reported that bovine teeth from animals of different ages possess different characteristics. Older human teeth exhibit lower numbers of dentinal tubules than teeth from bovine animals approximately 36 months old but younger human teeth are similar to bovine teeth. This indicates the existence of dissimilarities in the disposition and quantity of dentin tubules, or in the chemical composition of dentin, or a combination of these factors. Thus, in future studies, we will focus on differences in composition between human and bovine dentin with aging.

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