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Morphological characterization and permeability of attrited human dentine

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ABSTRACT

Objective: Dentine is a vital tissue that can be changed by physiological and pathological condition. The purpose of this study was to clarify the morphology and permeability of dentine that changed by wearing process.

Methods: Twenty extracted human molars with enamel attrition and dentine was exposed and 20 intact human extracted third molars that had not reached occlusion were used. Ten teeth per each group were observed under light microscope (LM) and transmission electron microscope (TEM). Remaining 10 teeth per each group were subjected for evaluation of dentine permeability.

Results: Under LM, the transparent dentine and reactionary dentine were found in the attrition group but were not found in the group unaffected by attrition. When the transparent dentine were examined under the TEM, it was found that dentinal tubules were partially or completely occluded by growth of peritubular dentine or by precipitation of needle-like or rhombohedral crystals in transparent dentine. In reactionary dentine, tubular dentine structures that were comparable to those in secondary physiologic dentine were observed whereas atubular dentine demonstrated occlusion of tubules by high mineral substances or by peritubular dentine under the TEM. Permeability of dentine from worn teeth was less than those from unoccluded teeth significantly.

Conclusion: Change in dentine by wear resulted in the formation of reactionary dentine and transparent dentine that illustrated various types and degrees of tubular occlusion. These decrease the dentine permeability.

1. Introduction

Increase human life span calls for increasing attention to geriatric dentistry.[1,2] Excessive wear may cause of tooth loss in elderly patients.[3,4] Tooth wear is a normal physiological process. However, when self-adaptive capabilities are exceeded, the physiological process becomes a pathological problems[5–7] and restorative treatment is requirement.

The attrition of teeth allows changes in morphological characterization of dentine such as transparent dentine formation and production of reactionary dentine.[8–12] These morphological changes might affect the permeability of dentine. Few studies have been published on the morphology of dentine and its permeability during the progression of wear. Such knowledge is important for understanding dentine reaction under clinical condition.

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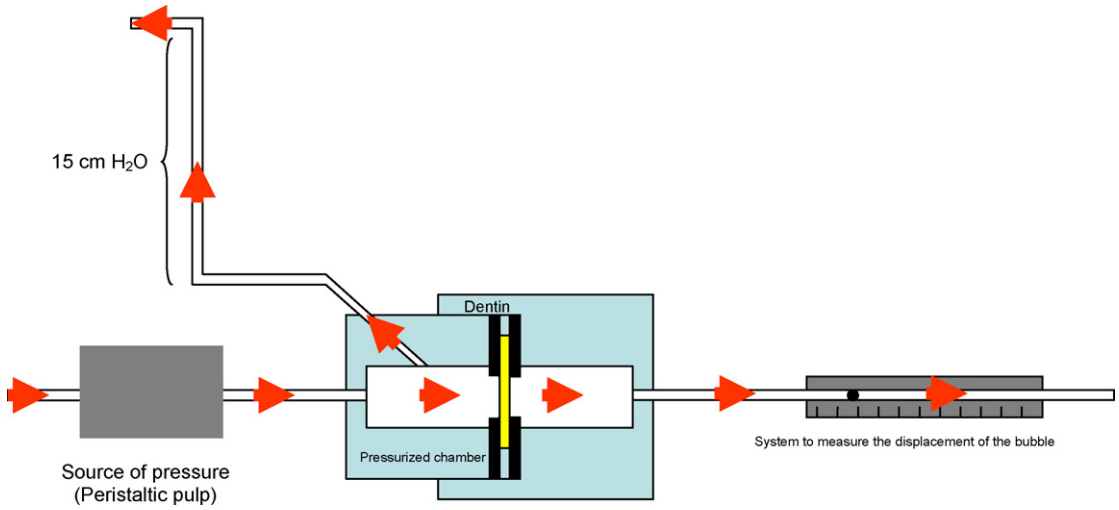

Fig. 1 – Experimental apparatus for dentine permeable test. Red arrows demonstrate the direction of fluid flow. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

2. Materials and methods

2.1. *Morphological study*

Twenty human teeth were included in this study; 10 extracted molars from elderly individuals with enamel attrition and exposed middle 1/3 of dentine and 10 extracted intact third molars that had not reached occlusion were used in this study. These intact teeth will be referred as unaffected teeth. All teeth were extracted and the patients were informed and agreed that their teeth will be used for this investigation. The ages of subjects ranged from 55 to 65 years for elderly patients (worn teeth) and 18 to 25 years for adolescent patients (intact teeth). The extracted teeth were kept in physiological saline solution at 5 °C within 2 months prior to processing.

The teeth were sectioned axiobuccolingually with a high-speed diamond saw (Leitz 1600, Leica Instruments, Heidelberg, Germany) to create a 150 μm thick section from the centre of teeth. The 150 μm thick slabs were reduced to approximately 100 μm with silicon carbide papers by hand lapping. The specimens were examined under a transmission light microscope (Vanox AHBS3, Olympus, Tokyo, Japan). The morphological structures identified were mantle dentine, globular dentine, primary and physiologic secondary dentine, transparent dentine, and tertiary reactionary dentine.[13]

Based on the light microscope examination, small areas were dissected out and processed for a transmission electron microscopy. Ultrathin sections were cut with a diamond knife and collected on carbon-coated grids. The section were examined under a transmission electron microscope (TEM) operated at 80 kV (Hitachi 300 TEM, Hitachi Co., Tokyo, Japan)

2.2. *Dentine permeable study*

The dentine permeability was measured by the means of hydraulic conductance. Additional 10 extracted molars from elderly individuals with enamel attrition and exposed dentine and 10 extracted intact third molars that had not reached occlusion were used. Flat dentine discs with 0.7 mm thick from outer 1/3 of occlusal dentine were prepared by cutting with a low speed diamond saw (Isomet, Buehler, IL, USA) perpendicular to long-axis of teeth and polished with wet silicon carbide papers (600 grit down to 1000 grit). The smear layers created by polishing were removed with 10% phosphoric acid for 10 s. The test method and apparatus (Fig. 1) were derived from the study of Puapichartdumrong et al.[14] The rate of fluid movement pass through circular areas with 6 mm diameter of the dentine disc was measured by monitoring the movement of a small air bubble under the pressure that was comparable to pulpal pressure (1.47 kPa or 15 cm H_2O)[15] at the rate of 0.2 mL/min. The system used in the present study consisted four parts: a source of pressure, a pressurized chamber, a system to measure the displacement of bubble (50 μL micro-syringe), and a specimen holder. The data were converted into the hydraulic conductance (Lp; $\mu L\ cm^{-2}\ min^{-1} 15\ cm\ H_2O^{-1}$):

$$Lp = \frac{Jv}{P}$$

Jv ($\mu L\ cm^{-2}\ min^{-1}\ cm\ H_2O^{-1}$) is the fluid flux that was calculated by $Jv = Q/At$ [Q (μL) is the fluid shift, A (cm^2) the area of dentine and t (min) is the diffusion time]. P (cm H_2O) is the applied hydrostatic pressure.[14]

3. Results

3.1. *Morphological study*

Morphological features of dentine of worn and unaffected teeth were studied by examined ground sections under the transmission light microscope. The attrition resulted in various changes in dentine. Globular dentine was observed normally in unaffected teeth (Fig. 2A), but was rarely noted