Journal of Biomechanics 44 (2011) 1626–1629

Contents lists available at ScienceDirect

Journal of Biomechanics

journal homepage: www.elsevier.com/locate/jbiomech
www.JBiomech.com

Short communication

Nano- and micromechanical properties of dentine: Investigation of differences with tooth side

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ARTICLE INFO

Article history:
Accepted 4 March 2011

Keywords:
Human teeth
Tooth
Mantle dentine
Dentino-enamel junction
Soft dentine
Nanoindentation
Microhardness
Elastic modulus
Hardness
Atomic-force microscopy

ABSTRACT

The soft zone in dentine beneath the dentino-enamel junction is thought to play an important role in tooth function, strain distribution and fracture resistance during mastication. Recently reported asymmetry in mechanical properties with tooth side may point at a basic property of tooth function. The aim of our study was to test if this asymmetry was reflected in the nano- and micromechanical properties of dentine.

We investigated the mechanical properties of dentine on the buccal and lingual side of nine extracted human teeth using nano- and microindentation. Properties were analysed on the natural log scale, using maximum likelihood to estimate the parameters. Two-sided 0.05-level likelihood ratio tests were used to assess the influences of surface (buccal versus lingual) and dentine depth, measured from the DEJ in crown dentine and from the CDJ in root dentine.

Results showed the well known gradual increase in mechanical properties with increasing distance from the DEJ. Coronal dentine showed higher elastic modulus and hardness on the lingual side of teeth for all measurements, while root dentine was harder on the buccal side. Due to the subtlety of these effects and the small number of teeth studied, results failed to reach statistical significance. Results suggest that dentine nano- and micromechanical properties vary with tooth side in agreement with recent literature using macroscopic methods. They also reveal that buccal–lingual ratios of hardness are in opposite directions in crown and root dentine, suggesting compensatory functions.

1. Introduction

Dentine is situated between the pulp chamber and enamel (coronal dentine) or cementum (root dentine) of teeth, and its microstructure consists of a hydrated type I collagen matrix reinforced with nanocrystalline carbonated apatite (Ten Cate, 1998). Intertubular dentine (ITD) lies between tubules that run from the pulp chamber to the dentino-enamel junction (DEJ); the tubule lumens are about 1 μm in diameter and are surrounded by a 0.5–1.5 μm hypermineralised layer of peritubular dentine (PTD) (Kinney et al., 1999) which seems to be non-collagenous (Habelitz et al., 2007).

Studies of deformation and stiffness of the dentine soft zone near the DEJ showed dentine near the DEJ to be significantly less stiff on the buccal side than on the lingual side of the tooth, suggesting that tooth function relies on this asymmetry, allowing the enamel cap to shift during mastication (Zaslansky et al., 2006a; Wang and Weiner, 1998). The aim of our preliminary study was to determine if this asymmetry in mechanical properties of teeth was reflected in elastic modulus and hardness of dentine near the DEJ, which we investigated using nano- and microindentation.

2. Materials and methods

2.1. Tooth sample preparation

Human maxillary third molars from females aged 19–23 years requiring extractions as part of dental treatment were collected following a protocol approved by the UCSF Committee on Human Research. Teeth were sterilised using gamma radiation (White et al., 1994; Brauer et al., 2008) and stored in Hank's Balanced Salt Solution (HBSS) at 4 °C. Crowns were sectioned parallel to the occlusal plane to obtain 1–2 mm thick discs from directly beneath the occlusal part of the enamel, using a diamond saw (Buehler, Lake Bluff, IL, USA); roots were sectioned bucco-lingually in the centre of the root, perpendicular to the occlusal plane (for illustration see diagrams in Fig. 1). Specimens were polished with SiC papers and diamond suspensions to 0.25 μm and stored in HBSS to minimise surface demineralisation (Habelitz et al., 2002).

2.2. Materials testing

Three types of experiments were performed: measurement of (i) nano-mechanical properties (elastic modulus and hardness) of wet and dry coronal

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0021-9290/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jbiomech.2011.03.004