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Surface roughness and topography of dentin characterized by AFM

N. Pecikozić[1], T. Lainović[1], L. Blažić[1,2], Z. Bobić[3], P. Terek[3], B. Škorić[3]

[1]*Faculty of Medicine, School of Dental Medicine, University of Novi Sad, Novi Sad, Serbia*
[2]*Dental Clinic of Vojvodina, Novi Sad, Serbia*
[3]*Faculty of Technicial Sciences, University of Novi Sad, Novi Sad, Serbia*
e-mail: nevena_pecikozic@uns.ac.rs

INTRODUCTION

Dentin is a mineralized tissue constituent of a human tooth, which, in addition to the mineral component, contains an organic matrix organized into tubules, surrounded by the peritubular and intertubular dentin. Various dental treatments lead to changes in dentinal surface properties. The modern adhesive dental protocol involves etching the dentin with orthophosphoric acid, which is used to remove the smear layer and open the dentinal tubules in order to achieve the conditions for adequate adhesion of the restorative material [1].
Atomic force microscopy (AFM) is proven as a valuable tool for characterizing the dentinal surface at the nanoscale after any chosen dental conventional or experimental surface treatment methods [2,3]. It can be used after different chemical treatments, as well as after physical methods used for surface preparation in laser dentistry [4].

AIM

This study aimed to analyze the influence of conventional orthophosphoric acid treatment on dentinal surface topography and 3D roughness parameters using AFM.

MATERIAL AND METHODS

Dentin samples have been prepared from human teeth extracted for orthodontic reasons, cut into horizontal and longitudinal slices using a diamond saw. The samples were polished by polishing rubber disks and then etched with orthophosphoric acid for 15 seconds and stored in a moist medium until examination. The structure of the dentin was examined by Veeco CP-II Atomic Force Microscope. The sample's surface was scanned in contact mode with symmetrically etched silicon tip at 0.5 Hz scan rate. Square areas of 100 x 100 μm^2, 20 x 20 μm^2 and 6 x 6 μm^2 were scanned with resolution of 256x256 pixels. The obtained topography data were processed by image analysis software (SPIP, Image metrology) and the following 3D roughness parameters were calculated: average surface roughness (Sa), root mean square height (Sq), maximum height (Sz), and surface skewness (Ssk).

RESULTS

Topography of dentinal surface is presented by 2D and 3D AFM images (Fig. 1-4). It could be seen that conventional orthophosphoric acid treatment on dentin removes the smear layer and opens dentinal tubules. The results of measured quantitative AFM surface parameters are given in Table 1.

Table 1 The AFM surface roughness parameters of dentin treated with orthophosphoric acid

	100 x 100 μm^2		20 x 20 μm^2		6 x 6 μm^2	
	horizontal	longitudinal	horizontal	longitudinal	horizontal	longitudinal
Sa (nm)	479.56	559.1	246.53	372.2	256.17	164.22
Sq (nm)	596.64	685.68	307.23	450.49	354.55	198.42
Sz (nm)	4410.7	4380.9	2047.8	2518.5	2199.4	917.4
Ssk	0.098952	-0.0301	-0.0431	-0.0628	-1.6146	-0.3341

Calculated surface roughness parameters (Sa and Sq) showed that average dentinal roughness treated by orthophosphoric acid is around 500 nm (100 x 100 μm^2). Sz demonstrated the existence of deep open tubular structures and etched intertubular dentinal parts. The Ssk had mainly negative values, which indicates a negative surface dominated with holes and canals, which is considered as a favourable functional surface property for better load-bearing and dentin-adhesive lubrication properties (Table 1).

CONCLUSION

The results show that the dentin surface treated in this way is well prepared to accept dentin-adhesive systems. AFM is a valuable tool for quantitative functional roughness characterization and 3D presentation of the dentinal topography. The presented results of conventionally treated dentin could be used as a reference point for future comparison and investigation of structural changes in dentin caused by other surface modifications, such as cold atmospheric plasma (CAP) or experimental laser treatments.
Future perspectives offer potential new possibilities of ''site-matching'' analysis, by means of AFM-IR, which is a perspective of our further research.

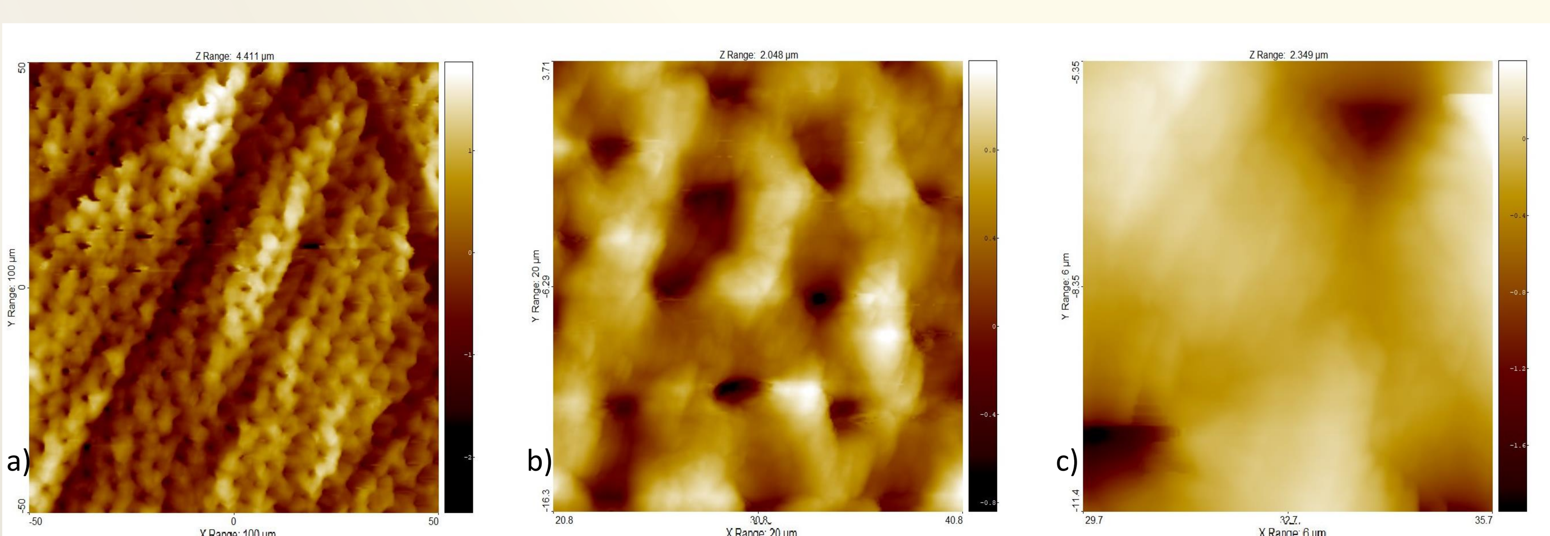

Fig. 1 2D AFM image of the treated dentin topography of the horizontal slice; scan areas of a) 100 x 100 μm^2, b) 20 x 20 μm^2 and c) 6 x 6 μm^2

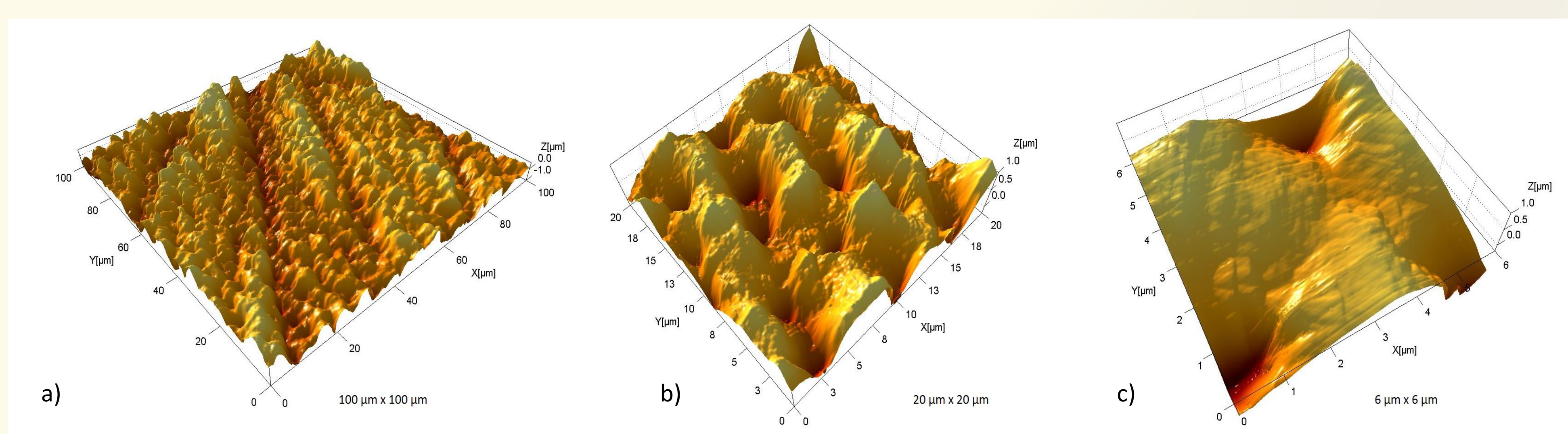

Fig. 2 AFM 3D-view image of the treated dentin topography of the horizontal slice; scan areas of a) 100 x 100 μm^2, b) 20 x 20 μm^2 and c) 6 x 6 μm^2

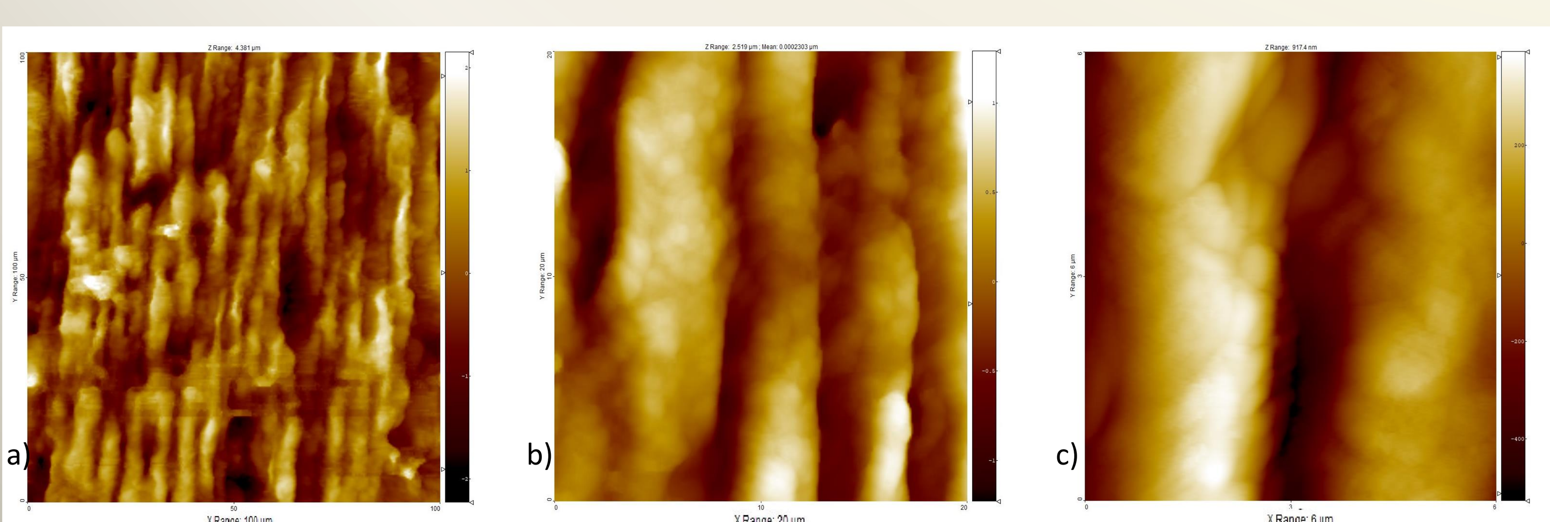

Fig. 3 2D AFM image of the treated dentin topography of the longitudinal slice; scan areas of a) 100 x 100 μm^2, b) 20 x 20 μm^2 and c) 6 x 6 μm^2

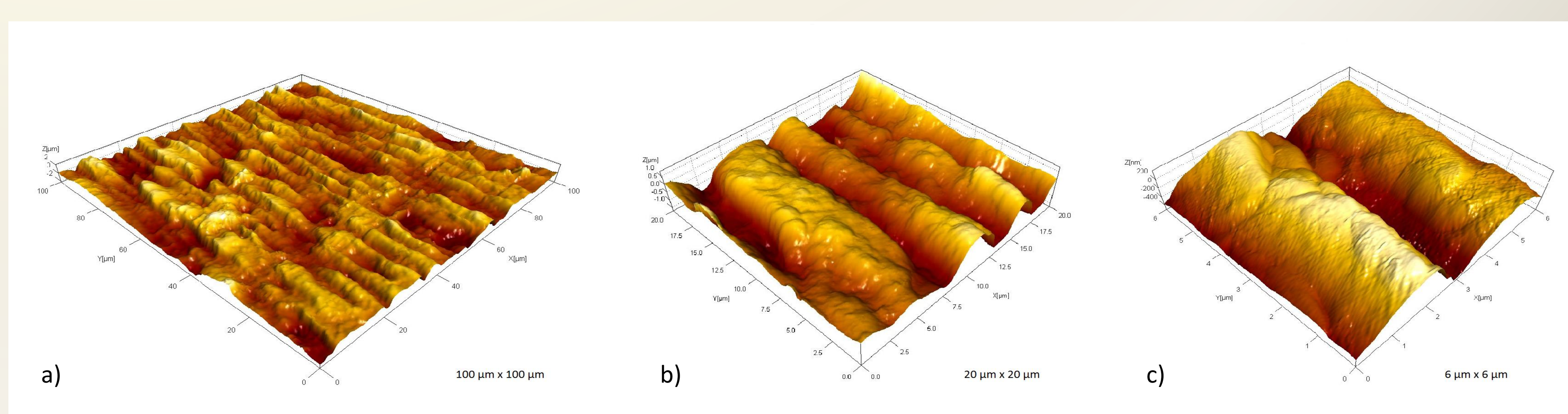

Fig. 4 AFM 3D-view image of the treated dentin topography of the longitudinal slice; scan areas of a) 100 x 100 μm^2, b) 20 x 20 μm^2 and c) 6 x 6 μm^2

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