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Micro Topographical Analysis of Enamel of Human, Bovine and Goat Incisors-An Atomic Force Microscopic Study

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ABSTRACT

Background: The enamel surface features have not been much explored when compared to its sectional features. The microanalysis can provide information to characterize and devise better restorative materials and also to detect diseases.

Aim: To examine the 3-D atomic force microscopy (AFM) images of human, bovine and goat teeth and look into their micromorphology to micro characterize the surface features of their enamel.

Materials and methods: The enamel of the tooth samples are limited into single layers using Isomet 1000 precision Saw manual. The quantitative examination of the enamel surface roughness is analyzed using the non-contact mode of Atomic Force microscopy(AFM). The generated Three dimensional image of enamel is used for the study of variations from the nano to micro scale.

Result: The surface roughness was determined using three-dimensional 30 um scan images of the tooth samples and were visualized using Atomic Force Microscopy (AFM). The surface roughness parameters of the membranes were expressed in terms of the mean roughness (Sa), Root mean square of the surface (Sq), the mean difference between the highest peaks and lowest valleys (Sz) of the membrane surface were calculated using Nanosurf C300 software, based on mathematical expressions.

Conclusion: AFM investigated the topography of dental tissues in a typical healthy tooth using stereometric analysis and provided quantitative information about surface *shape* and roughness.An accurate understanding of surface micromorphology related to interface morphology, thermodynamic properties, nanoscale surface-fluid interactions, surface energy, biochemical potential gradients, heat transfer, and surface flaws can be gained from stereometric and fractal analyses of human, bovine and goat incisor teeth.

Keywords: *surface, quantitative, Topographical, Microscopic*

INTRODUCTION

Enamel, dentine, and cementum are the three main dental tissues that make up the irregular structure of teeth (Gutiérrez-Salazar and Reyes-Gasga, 2003). Enamel, the outermost layer of a human tooth, is made up of enamel rods that are gathered by interprisms and is said to be the hardest substance in the human body (*Website*, no date a). Human hard tissue's biological, mechanical, micromorphological, and structural characteristics have received a lot of attention recently and can help with illness diagnosis, tissue growth, and the development of better restorative materials (*Website*, no date a).

Several current dental nanotechnological studies introduce creative approaches to resolving problematic mechanisms that result in new therapy focuses (González-Nilo *et al.*, 2011). In this way, 3-D models are utilized for computer-aided dental disease diagnosis and design, simulation, and visualization of 3-D dental geometry (*Website*, no date b). The tooth surface can be studied stereo metrically or via fractal and multifractal analyses of AFM micrograph samples, despite the complex and uneven bio-structure and tiny anatomic details revealed by 3-D morphology(Sharma *et al.*, 2010).

The aim of the study is to examine the micro morphology of human, bovine and goat incisor teeth by AFM Images and Stereometric analysis. Enamel surface features have not been much explored when compared to its sectional features. This microanalysis can provide information to characterize and devise better restorative materials.

Our team has extensive knowledge and research experience that has translate into high quality publications (Chellapa et al. 2020; Kumar et al. 2020; Ramesh Kumar et al. 2011; Ganapathy et al. 2022; Anita et al. 2020; PradeepKumar et al. 2021; Barabadi et al. 2021; Mathivadani et al. 2020; Subramaniam and Muthukrishnan 2019; Felicita 2017)

MATERIALS AND METHODS

The human, bovine and goat central incisors were extracted. For transmission to the lab, the removed teeth were submerged in 0.9% phosphate buffered saline (PBS; pH 7.4). After that, each tooth was brushed for two minutes with a regular toothbrush and toothpaste and rinsed with distilled water. The teeth were kept in distilled water for the first four hours of the experiment so as not to affect tooth structure. The extracted teeth were longitudinally cross-sectioned by a slow speed diamond disc under vigorous water irrigation in order to gain access to the healthy enamel surface.

The enamel of the tooth samples are limited into single layers using Isomet 1000 precision Saw manual. The quantitative examination of the enamel surface roughness is analyzed using the non-contact mode of Atomic Force microscopy(AFM). AFM provided quantitative data on surface morphology and roughness in addition to stereometric analysis that looked at the topography of dental tissues in a normal healthy tooth. The generated Three dimensional image of enamel is used for the study of variations from the nano to micro scale.

RESULT

To determine the surface roughness three-dimensional 30 um scan images of the tooth samples were visualized using Atomic Force Microscopy (AFM). The surface roughness parameters of the membranes were expressed in terms of the mean roughness (Sa), Root mean square of the surface (Sq), the mean difference between the highest peaks and lowest valleys (Sz) of the membrane surface were calculated using Nanosurf C300 software, based on mathematical expressions.

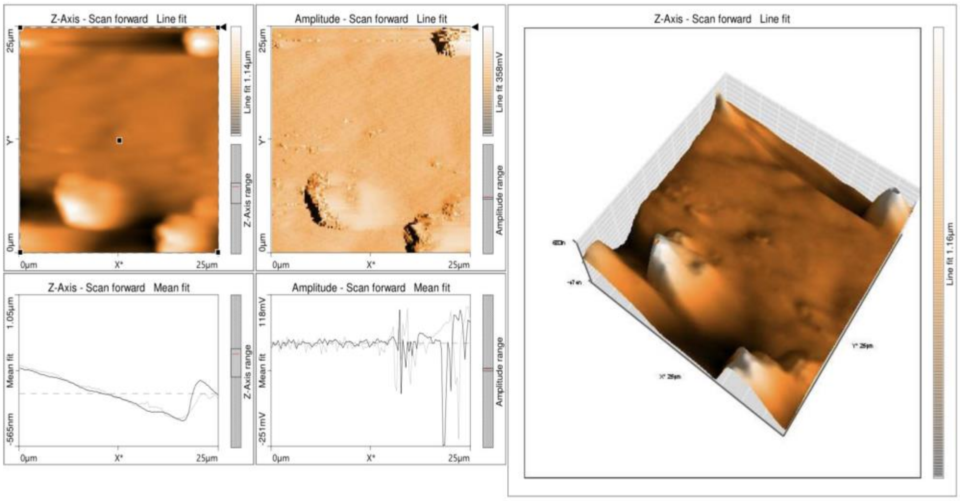

FIGURE 1: Bovine

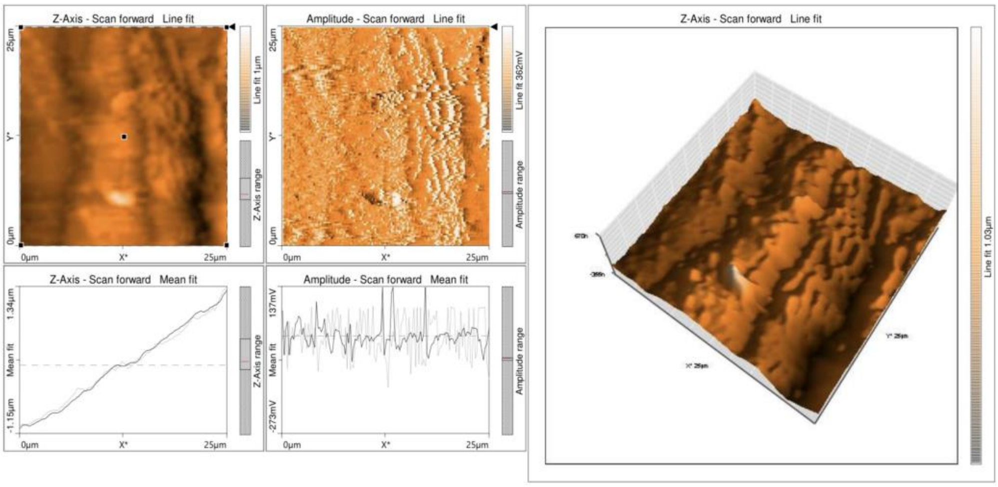

FIGURE 2: Human

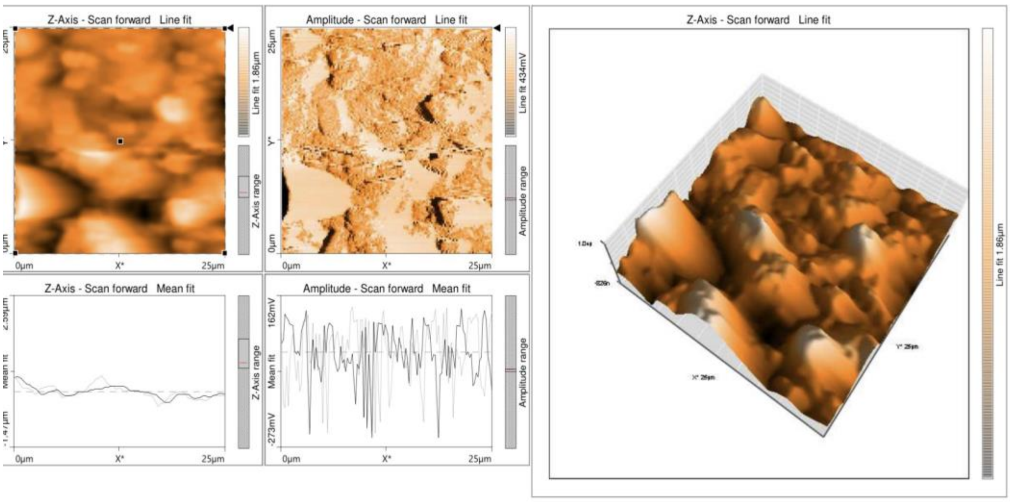

FIGURE 3: Goat

DISCUSSION

The advantage of using AFM in non-contact mode is that any surface dragging from the tip on the surface is avoided (Silikas *et al.*, 1999). This is crucial because fragile structures could be created by processes like tooth whitening. AFM is also a widely used technology for characterizing surface roughness. When enamel surface AFM 2-D images are analyzed by AFM at a nanoscale resolution, significant differences can be seen (Silikas *et al.*, 1999; Feninat *et al.*, 2001).

The accompanying table provides a summary of the stereo metric findings from AFM pictures of enamel, the toughest tooth tissue. The height histogram was also displayed, with the area material curve superimposed on the histogram and the number of components on the surface associated with a particular peak height. The highest growth of root mean square in the incisor is indicated by the largest and smallest arithmetic means of vertical deviations in from the mean surface (Sa) and the largest and lowest root mean height (Sq).

According to the method used for data analysis, the enamel surfaces following bleaching treatment differ in morphological wave lengths but not in roughness metrics. Despite being useful tools for comparing various surface morphologies, the roughness RMs and Ra only provide information along the vertical direction, making them unable to properly characterize the surface texture (Pedreira De Freitas *et al.*, 2011).

The intermittent contact AFM technique was effective for characterizing the micro morphology of tooth enamel. The Ra and RMS readings could not be utilized to draw any conclusions, per the research protocol, but the iSD could distinguish between enamel that had been bleached and enamel that hadn't. The contribution of each morphological wavelength might be quantified using PSD analysis on a nanometer scale (Moldes *et al.*, 2009).

CONCLUSION

An accurate understanding of surface micromorphology related to interface morphology, thermodynamic properties, nanoscale surface-fluid interactions, surface energy, biochemical potential gradients, heat transfer, and surface flaws can be gained from stereometric and fractal analyses of human, bovine and goat incisor teeth. A variety of physical nano scaled events were studied from both the theoretical and experimental perspectives using specific mathematical techniques in order to get more understanding of structural features (crystalline structure, local composition, and mechanical information). In addition, a base model for further mathematical study of physical and mechanical phenomena, such as cracks and fracture, was introduced. It can also be used to analyze the evolution of nanocrystalline human, bovine, and goat incisor teeth for fatigue loading and computer graphics.

CONFLICT OF INTEREST

The authors report no conflict of interest. The authors alone are responsible for the content and writing of the paper.

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