RESEARCH ARTICLE OPEN ACCESS

Microtomography of Deciduous Teeth Enamel

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ABSTRACT
Purpose: To develop an in vitro model of de- and re-mineralization with an etching gel (i-Gel) and with a mineralization varnish - Clinpro ™ White Varnish with TCP (3M).
Methods: The material used is from 20 temporary intact teeth. They are first applied throughe preparation of the smooth temporary enamel surfaces with a 30 second demineralization with 37% phosphoric acid (i - gel - etching gel). Then the samples are washed and dried with water and airflow. Demineralized surfaces of the temporary teeth go through a remineralization with application of varnish - Clinpro ™ White Varnish with TCP. The measurement was done with a desktop X-ray microtomography scanner SkyScan 1272 produced by the company Bruker.
Results: Representative images of the observed tooth sample are shown in Figure 3. Figure 1 shows the outer surface of the tooth on which there are visible specific roughness. Clearly differed are two areas; a lighter one, i. e. denser, which is on the outside – the tooth enamel, and a darker one – from the inner side of the tooth – dentin. These two areas are visible on all transverse (software) sections. Such a section is shown in Figure 1. The enamel thickness of a test sample varies between 300 and 500 μm.
There are noticeable defects on the tooth enamel, which represent dark areas, i.e. areas of reduced density. Such areas in the depth of the enamel are presented in Figure 3 and 5 and Figure 4, clearly shows their volumetric nature.Monitoring of the area with "damage" of dental caries, i.e. darker areas of enamel in Figure 4 show that the larger of the two, which is located closer to the tooth surface in fact does not go out of it. It is covered by a layer with a thickness between 10 and 14 μm, whose density is very close, and perhaps a bit higher than that of tooth enamel.
Conclusions:
1. CT has observations that result in such a direction that the tooth surface is uneven as there are areas with varying degrees of unevenness. In the uneven areas, their height, potentially that of the crystals from remineralizing coverage, is between 6 and 14 μm, with a horizontal size 14-40 μm.
2. In the tooth enamel monitor an area is observed that is "sealed" with a layer of a density close to that of healthy dental enamel and a thickness of 10-14 μm. In cutting of a sample such layer has also emerged on its surface. This leads to the hypothesis of the presence of the enamel coating layer whose density is very similar to that of the enamel.
***Key words*-** remineralization, mineralization varnish, tomography

I. INTRODUCTION

Established classical methods of diagnostics and treatment of caries of deciduous teeth require rethinking and changes imposed by the approach of treatment in medicine [1].

Purpose: To develop an in vitro model of de- and re-mineralization with an etching gel (i-Gel) and with a mineralization varnish - Clinpro ™ White Varnish with TCP (Tri-Calcium phosphate) (3M).

Materials and Methods: The material used is from 20 temporary intact teeth, extracted due to physiological change with permanent teeth, with a completely preserved structure and anatomy of crowns and fully physiologically resorbed roots. They are first applied throughe preparation of the smooth temporary enamel surfaces with a 30 second demineralization with 37% phosphoric acid (i - gel - etching gel). Then the samples are washed and dried with water and airflow. Demineralized surfaces of the temporary teeth go through a remineralization with application of varnish - Clinpro ™ White Varnish with TCP (Tri-Calcium phosphate) (3M).

The measurement was done with a desktop X-ray microtomography scanner SkyScan 1272 produced by the company Bruker. The reconstruction of the 3D images included the following adjustments: adjustment for a fine/thermal displacement of the sample; adjustment for change of the spectrum of radiation (beam hardening) and adjustment for circular interferences (ring artifacts).

II. RESULTS

Representative images of the observed tooth sample are shown in Figure 3. Figure 1 shows the outer surface of the tooth on which there are visible specific roughness. Clearly differed are two areas; a lighter one, i. e. denser, which is on the outside – the tooth enamel, and a darker one – from the inner side of the tooth – dentin. These two areas are visible on all transverse (software) sections. Such a section is shown in Figure 1. The enamel thickness of a test sample varies between 300 and 500 μm.

There are noticeable defects on the tooth enamel, which represent dark areas, i.e. areas of reduced density. Such areas in the depth of the enamel are presented in Figure 3 and 5 and Figure 4, clearly shows their volumetric nature.

Surface layer of the deciduous tooth

Characterization of the roughness on the surface of the enamel in Figure 3 shows a height of between 6 and 14 μm and a horizontal size of 14-40 μm. At these sizes of possible crystals faceting can not be observed it the current resolution, which is determined by the focal spot of the X-ray tube - ~ 5 μm. The sharp crystal edges are smoothed as the CT image is a convolution of the research object and of the intensity profile of the focal spot. However, the study does not reject the possibility that these irregularities had a crystalline appearance.

Figure 3 makes it also noticeable that this type of unevennesses is different in different parts of the surface. In the foreground three is an area with more and larger unevennesses, while in the background and on the right there is are smoother areas. This suggests that if there is some coverage, it is uneven on the surface and may even be missing somewhere. Perhaps this could be established by a comparative testing of the unvarnished part of the same tooth.

Monitoring of the area with "damage" of dental caries, i.e. darker areas of enamel in Figure 4 show that the larger of the two, which is located closer to the tooth surface in fact does not go out of it. It is covered by a layer with a thickness between 10 and 14 μm, whose density is very close, and perhaps a bit higher than that of tooth enamel. It could be assumed that this is an effect of amending the spectrum of the beam as the correction for this effect can only be done for one of the phases in the sample; in this case the enamel has been selected. However, this hypothesis should be rejected because the difference in density between the damaged and the healthy part of the enamel is much smaller than that between the enamel and the dentin, and concerning the dentin effects from the spectrum change of the beam are not observed. Meanwhile, the subsequent images in Figure 5 show that a layer of approximately the same thickness 10-14 μm has emerged upon incision of the sample. The size of 10-14 μm is very close to the height of the irregularities observed on the surface of the tooth. These structures can be fluorapatite crystals.

III. DISCUSSION

The open surface coating of the enamel sample suggests that these models of study correspond to higher fluoride retention after washing and moistening of the samples. Samples pass through a period of re-mineralization, deposition of calcium and phosphate ions from the varnish application. This deposition can saturate (permeate) the microstructures in enamel, making it more resistant to demineralization. When there is an acidic threat, enamel samples lined with varnish are able to be more resistant than the enamel of the deciduous teeth without the temporary application of a ternary fluorine varnish. Applied varnish material was tightly adherent, dry pressed to the deciduous tooth enamel sample, so long as it released fluoride for a slonger period of time [2,3].

The enamel of deciduous teeth without application could not have been or be able to compensate for the loss of minerals. The damaged part of the enamel, however, is located in a smooth region on the surface [3].

IV. CONCLUSIONS

1. CT has observations that result in such a direction that the tooth surface is uneven as there are areas with varying degrees of unevenness. In the uneven areas, their height, potentially that of the crystals from remineralizing coverage, is between 6 and 14 μm, with a horizontal size 14-40 μm.
2. In the tooth enamel monitor an area is observed that is "sealed" with a layer of a density close to that of healthy dental enamel and a thickness of 10-14 μm. In cutting of a sample such layer has also emerged on its surface. This leads to the hypothesis of the presence of the enamel coating layer whose density is very similar to that of the enamel.

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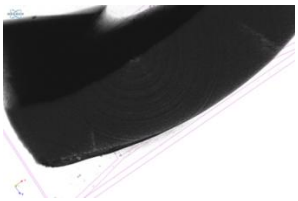


Fig. 1. Microtomography–cross-section of the deciduous tooth enamel. These two areas of enamel and dentin are visible on all cross (software) sections. The thickness of the enamel in the presented sample varies between 300 and 500 μm

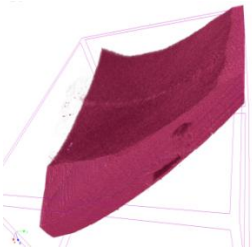


Fig. 2. Tomography of the deciduous tooth enamel-inner surface of the enamel to the enamel-dentin border (presence of two microcavitated caries lesions in the enamel)

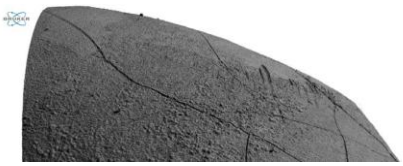


Fig. 3. Outer surface of a deciduous tooth

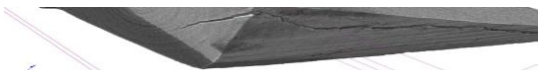
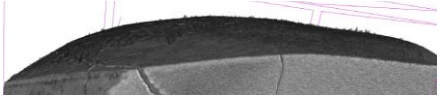


Fig. 4. Volumetric section of a part of the enamel "damaged" by dental caries - dark areas of reduced density



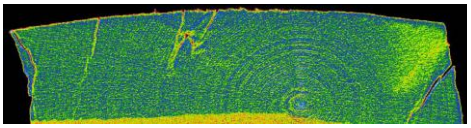


Fig. 5. Over the damaged part of the enamel layer there appears of a thickness of 10-14 μm, which has a density similar to that of the healthy tooth enamel or even slightly higher. In the above mage is clearly visible a denser (lighter) layer above the darker part of the tooth enamel "damaged" by caries. It is also seen that upon cutting of the ample, there outlines a layer of thickness similar to that of the damaged part of the enamel. The same is shown in the cut in the figure below, which is colored so that the higher density are is blue and the enamel caries defect is in yellow-green