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Research Article

Biomineralogy of Paradentosis

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Abstract

Biomineralogical studies were conducted on teeth removed due to paradentosis and on attached micro fragments of gums.

Dentine dysfunction was found in the teeth, accompanied with mineralization of the channel in the roots where nerves and blood vessels enter. Observed phenomena resulted in changes within teeth structure and on their surface.

Studies of the gums affected by paradentosis revealed their partial biomineralization. It involves presence of elevated levels of calcium and phosphorus in various parts of the gum.

Mineralization in gums was also found within micro vessels. In the examined samples it was represented by micro crystals of cholesterol, among others. Those crystals cause narrowing or even complete blockage of vessels. The consequence is malnourishment of gums and teeth. The process is similar to malnourishment of skin leading to its aging. In the case of gums, it causes reduction of their volume and height, and weakening of teeth fixation. The eventual result is tooth loss.

Keywords: Paradentosis; Tooth and Gum Biomineralogy

Introduction

The phenomenon of paradentosis and tooth loss affects all elderly people. Ample literature exists that presents research on this phenomenon. It includes microbiological studies [1-7], methods of diagnosing paradentosis [8-19] and recognizing connection between paradentosis and other diseases [20-24]. Many authors focus on describing methods of preventing and treating paradentosis [14,16,25-32] etc.

Modern methods of studies of paradentosis, including mineralogical studies, allow us to reach into the areas of gums and teeth that had been nearly inaccessible until recently. This publication focuses on such studies, conducted on teeth removed due to paradentosis and on micro fragments of gums remaining on those teeth.

Study material consisted of 32 teeth obtained from patients with advancing paradentosis. They were mostly teeth from the middle part of lower jaw. Due to the wealth of obtained results, only some of them were chosen to be presented in this publication.

Study Methods

The following methods were used in the studies: stereoscopic microscopy (binocular magnifier), polarizing transmitted light microscopy, scanning microscopy with an EDS chemical analysis attachment.

In the studies, stereoscopic microscope (PZO binocular magnifier, model 3) was used, allowing us to select samples for further tests. Selected teeth or their fragments were studied in specially prepared microscopic cuts under polarizing microscope. Those tests were conducted with partially crossed polarizers, using magnifications up to 400x.

Hematoxylin-stained histological preparations were made from chosen gum micro fragments. They were also studied using polarizing microscope because it allowed us to recognize areas of atypical fading of polarized light. Those areas connected with tissue mineralization underwent detailed testing.

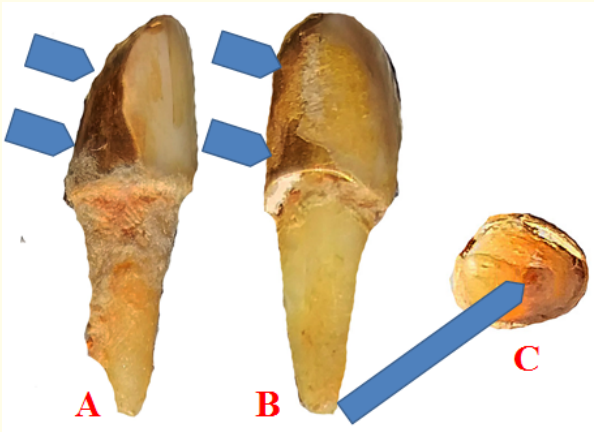
Motic microscope model 07-100477 of Chinese production was used in polarizing microscopy studies. Observed phenomena were documented with micrographs.

The above tests lead to further selection of materials to study using scanning microscope with EDS chemical analysis attachment. In those studies, FEI QUANTA 200 FEG microscope was used.

Determinations of elements contained in the samples were of semi-quantitative character due to difficulties obtaining energy spectra. Only selected energy spectra and micrographs are included.

Test Results

Observations using binocular magnifier (Photo 1) allowed us to choose material for further studies.



In case of teeth, the examination was focused on phenomena observed in the lower part of teeth, in particular on points of contact between the tooth and root cementum, enamel and dentine, the dentine itself, and especially the channel where the nerve and blood vessel enter the tooth (Photo 1C).

In case of lower part of a tooth including the root, microscopic observations were focused on root cementum (Photo 2A). In the point of contact between the root and gum, calcium-enriched concentrations were observed, characterized by lower transparency (Photo 2B). Tartar of clearly layered structure was also observed, confirming the cyclical nature of its crystallization (Photo 2C). In some teeth affected by paradentosis, structural changes within the cementum were noted (Photo 2D). They manifest themselves in microscopic images as visible thinning, and in polarized light they show interference colors characteristic of carbonates. It indicates at least partial transformation of tooth hydroxyapatite into carbonates – calcite.

In microscopic examination of some teeth affected by paradentosis, changes on the surface of both roots and enamel are observed, especially in parts close to the root. They are visible as a color change of the surface layer of the enamel (Photo 2E and 2F).

In addition to surface changes in the enamel, its structural changes were also noted in some teeth. They were seen in microscopic images as regular darkening running to dentine through enamel, sometimes reaching the tooth surface (Photo 2G).

In the dentine of examined teeth, blocked channels were often observed. Even though they are blocked only in small sections, it undoubtedly hinders circulation of fluids and nourishing the tooth (Photo 2H).

Examination of selected teeth was conducted using scanning microscope with EDS chemical analysis attachment, focusing on lower parts of teeth, especially the channel where nerves and blood vessels enter the teeth.

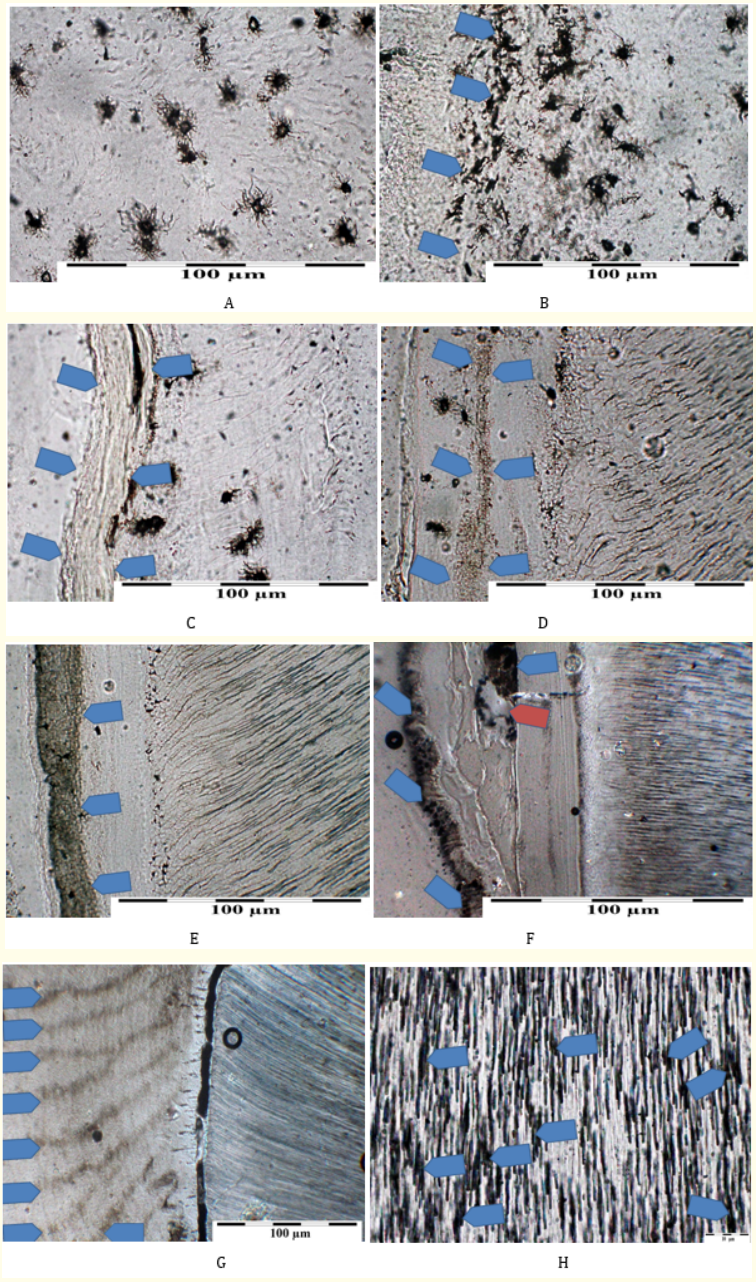


Photo 2: *A- Structure of cementum in a tooth affected by paradentosis (man, age 55). B- Image of the point of contact between the tooth and its surroundings, in root area. Visible concentration of carbonates and opaque substances on contact - arrows (man, age 62). C- Layered structure of tartar (arrows) built up on the root of a tooth affected by paradentosis (woman, age 50). D- Changes within root cementum (arrows). E, F- Topical, surface darkening on the enamel (man, age 66). G- Cyclical darkening in the enamel of a tooth affected by paradentosis (woman, age 59). H- Microscopic image of dentine of a tooth removed due to paradentosis, with blocked channels (arrows). Photos taken in polarizing microscope, polarizers partially X.*

This area of removed teeth was covered with fragments of tissues (Photo 3A, Figure 1) that were cleaned off mechanically for scanning, and especially for chemical tests (Photo 3B). In such prepared teeth, SEM examination was focused on the walls of the channels in the lowest part of the tooth root. Due to the morphology of that spot, taking a micrograph and, in particular, conducting chemical analysis of the walls turned out to be difficult, because the signal from inside the channel was weak and significantly different in particular places.

In spite of the difficulties, images from inside the channel were obtained. Phosphate crystals were recognized on its walls (Photo 3C and 3D) and conducted chemical analyses (EDS) indicated the presence of calcium carbonates, mainly calcite, in addition to calcium phosphates (Figure 3 and 4). These compounds were accompanied by trace amounts of other elements, which was confirmed by presented energy spectra.

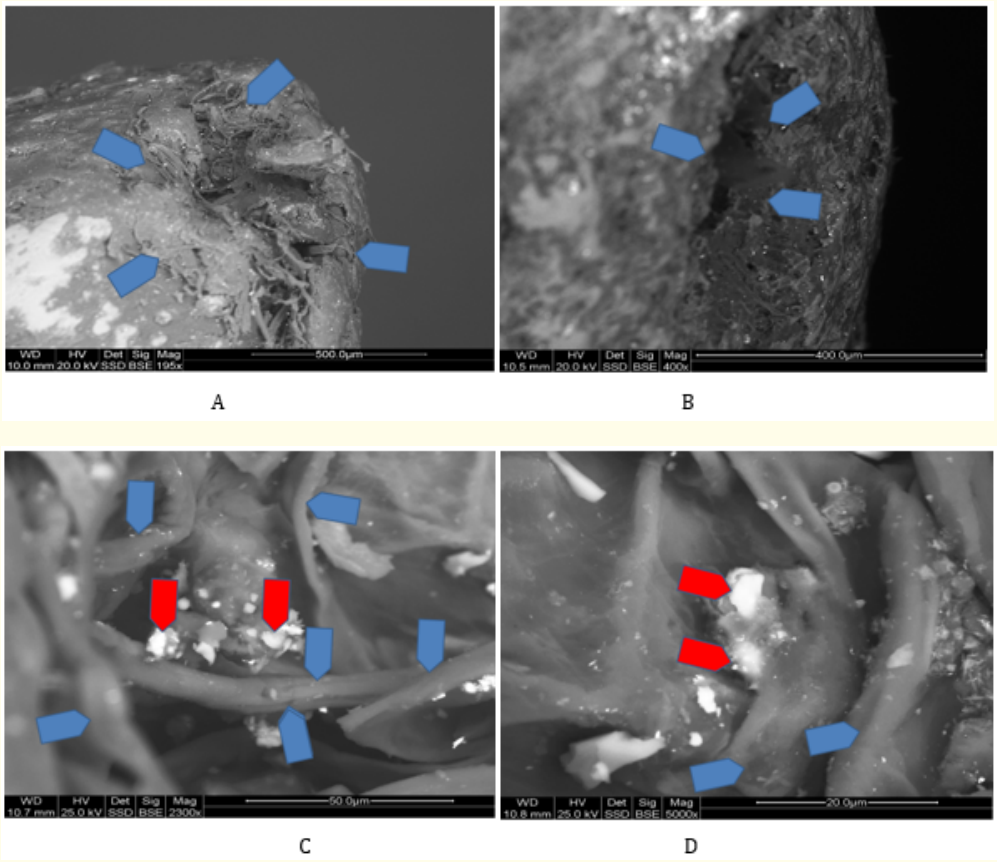


Photo 3: *A- SEM image of the lowest part of a tooth affected by the process of paradentosis, right after its removal (before cleaning). Visible organic shards are gum fragments (arrows). B- Image of the same part of root after removal of organic fragments. Visible root entrance channel (arrows). C- Image of crystals on the walls of root entrance channel of a tooth affected by paradentosis. Blue arrows - calcium phosphates, red arrows - calcium carbonates. A-C - man, age 66. D- Calcium phosphates (blue arrows) and calcium carbonate (red arrows); woman, age 57.*

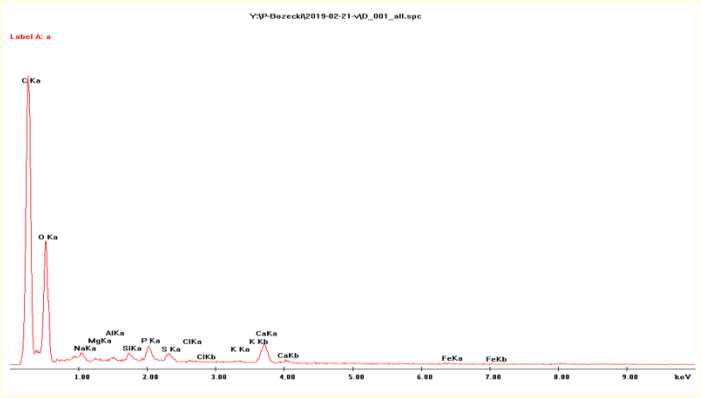


Figure 1: *Energy spectrum (EDS) of tissue remaining on the lower part of the tooth root after its removal (Photo 3A).*

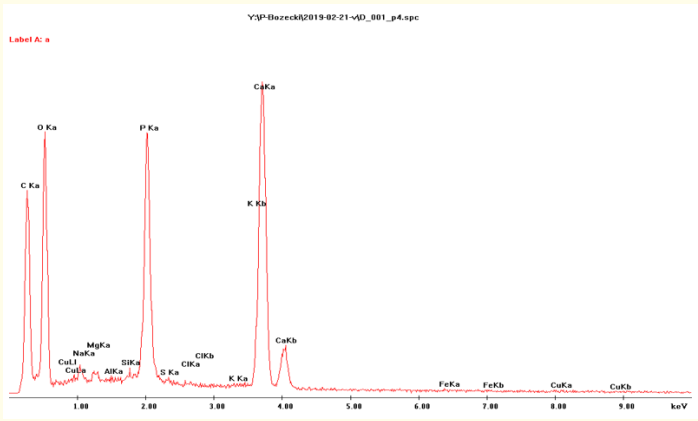


Figure 2: *Energy spectrum (EDS) of the surface of the lower part of the root after removing the gum fragments.*

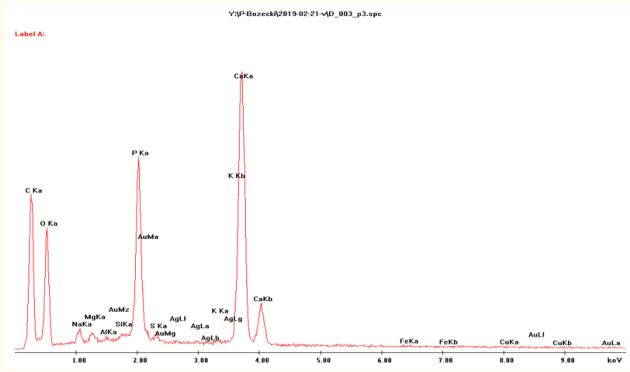


Figure 3: *Energy spectrum (EDS) of hydroxyapatite crystals from the walls of the channel in the lower part of the tooth affected by paradentosis (Photo 3C and 3D).*

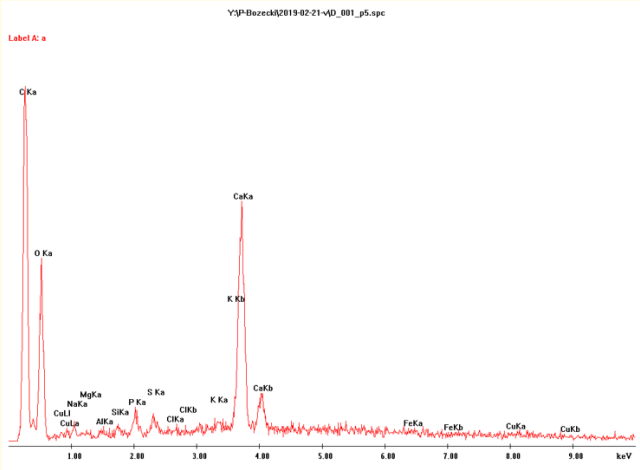


Figure 4: *Energy spectrum (EDS) of calcite from the entrance channel in the lower part of the tooth shown in Photo 3D - red arrows.*

In addition to teeth examination, micro fragments of gums that remained on teeth removed due to paradentosis were also studied. Due to minimal amount of material, only a few histological preparations were made. However, even in those few, it was possible to recognize areas affected by biomineralization, represented mostly by elevated levels of calcium and partially phosphorus.

Observations of the histological preparations allowed us to choose spots for SEM-EDS tests. Particular attention was paid to micro vessels present in the gums.

It was noted that the vessels located closest to the tooth were partially or almost completely blocked by various substances they contained. It caused partial, and sometimes complete occlusion of those vessels, and in result, limited blood flow. Some of the blocked micro vessels were deformed (Photo 4A).

Attempts to observe crystallizing substances in the micro vessels were made. It turned out to be difficult due to the vessels' size, and in particular, problems with obtaining SEM images from within. This difficulty resulted from both the problem with electron beam penetrating the micro vessel and the fact that the resulting signal was very weak. It caused the images of the inside of the micro vessels to look blurry and often smudged (Photo 4B).

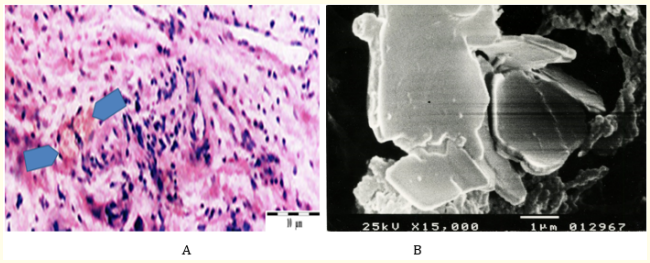


Photo 4: *A- Histological image of a fragment of gum tissues affected by paradentosis. Arrows indicate two micro vessels completely blocked by secondary substances.*
B- Concentrations of cholesterol micro crystals in a micro vessel (artery) of a gum affected by the process of paradentosis (Photo 4A - SEM - scale 1 µm). Effects of electron smudging of the photo connected with very weak signal from inside the micro vessel.

However, observations indicated the presence of flaky crystals of cholesterol, among others, in those vessels. Their maximum size didn't exceed a few micrometers (Photo 4B).

Summary and Conclusions

Conducted studies allowed us to learn some details connected with the phenomenon of paradentosis.

Examination of teeth affected by paradentosis showed that they were worse nourished, which was linked, among other factors, with the blockage of dentine channels and their reduced patency. It was also noted that in the root channel, in addition to phosphate (apatite) crystals, there were also carbonate (calcite) grains which limit the flow of nutrients to the tooth.

Examination of gums affected by paradentosis showed their increased mineralization, manifesting itself in the EDS chemical analysis as elevated calcium level. It was also observed that gum micro vessels affected by this process are partially or completely blocked with substances crystallizing inside, including cholesterol. It limits nourishment of gums and teeth, contributing to lowering of gums and teeth loss.

Gums can be treated as a peripheral area of circulatory system. Gum micro vessels, like vessels under the skin, are the first to get partially blocked, leading to tissue aging. Obtained results suggest that similar phenomenon happens in the gums, resulting in widely defined paradentosis.

This is why fight against paradentosis should focus on preventing the blockage in gum micro vessels. If they are already blocked, it should help in their unblocking and restoration of healthy circulation in gums.

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