ORIGINAL ARTICLE

CONTENTS

Morphological studies of changes in dental hard tissues following different methods of dental deposit removal

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ABSTRACT

Aim: To study structural changes in hard tooth tissues after manual, ultrasonic, and sonic methods of removing dental deposits and identifying the most rational method for various supragingival deposits.

Materials and Methods: Eight patients with supragingival deposits were examined, and eight teeth planned for extraction due to orthodontic or surgical indications: three teeth with dental plaque, three with mineralized deposits, and two with smoker's plaque. Of the three patients with dental plaque, one underwent manual scaling, another ultrasonic scaling, and the third sonic scaling. Similarly, among the three patients with dental calculus, manual, ultrasonic, and sonic scaling were performed. In the two patients with smoker's plaque, ultrasonic and sonic scaling were applied. After tooth extraction, morphological studies were conducted.

Results: Manual scaling of dental plaque left residual deposits and damaged enamel surfaces. For dental calculus, minimal residual deposits and relatively intact enamel were observed. Ultrasonic scaling caused microscopic changes: destruction of enamel prisms, partial fragmentation of the reticular layer in teeth with plaque, partial destruction of superficial enamel layers, thickening of the reticular layer with PAS-positive vegetations in teeth with calculus. In teeth with smoker's plaque, enamel prism destruction, hyperplasia, and reticular layer fragmentation were observed. Sonic scaling caused more pronounced destructive changes.

Conclusions: Manual scaling is the most rational method for supragingival mineralized deposits, while the air-abrasive method is preferred for non-mineralized deposits and smoker's plaque. The destructive changes caused by ultrasonic scaling limit its clinical applicability. Sonic scaling is unsuitable for removing dental debris due to its aggressiveness.

KEY WORDS: dental plaque, dental calculus, manual scaling, ultrasonic scaling, sonic scaling, microscopic study

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INTRODUCTION

It is well known that professional oral hygiene plays a significant role in the comprehensive treatment and prevention of dental caries and periodontal diseases [1, 2]. One of its important components is the removal of non-mineralized and mineralized dental deposits (soft dental plaque, dental biofilm (plaque), dental calculus) as well as smoker's plaque [2, 3].

It should be noted that the majority of studies by national and foreign authors are devoted to examining the structure and characteristics of subgingival dental deposits [4, 5], their impact on tooth and periodontal tissues [6, 7], and the methods for their removal [8]. However, studies on supragingival dental deposits are rare [9]. In this regard, we have previously carried out morphological studies of extracted teeth with various types of supragingival dental deposits [10]. The identified different nature in the structural changes of enamel and its covering tissues, the amelo-dentinal junction, and dentin during the formation of non-mineralized and mineralized dental deposits, as well as smoker's plaque on the tooth surface was an important argument in the search for the most rational methods of dental plaque removal.

Currently, dentists have access to a huge arsenal of various types of instruments, allowing for effective removal of dental deposits with minimal discomfort to patients and without damaging the soft tissues surrounding the teeth. At the same time, the choice of a particular method of dental plaque removal (chemical, abrasive, sonic, ultrasonic, or manual scaling) is often made arbitrarily, based on the practitioner's experience, without considering the nature

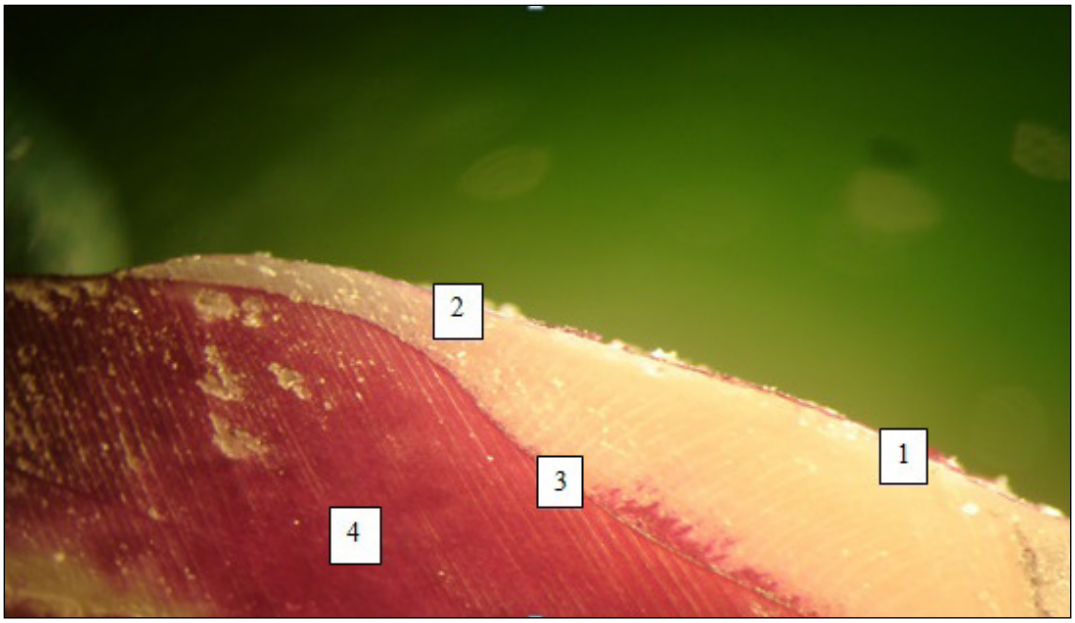

Fig. 1. Changes in tooth enamel after manual scaling of dental plaque: 1 – "eroded" enamel surface; 2 – remnants of dental plaque; 3 – amelo-dentinal junction; 4 – dentin. Staining: PAS-Alcian blue. Magnification: x16.

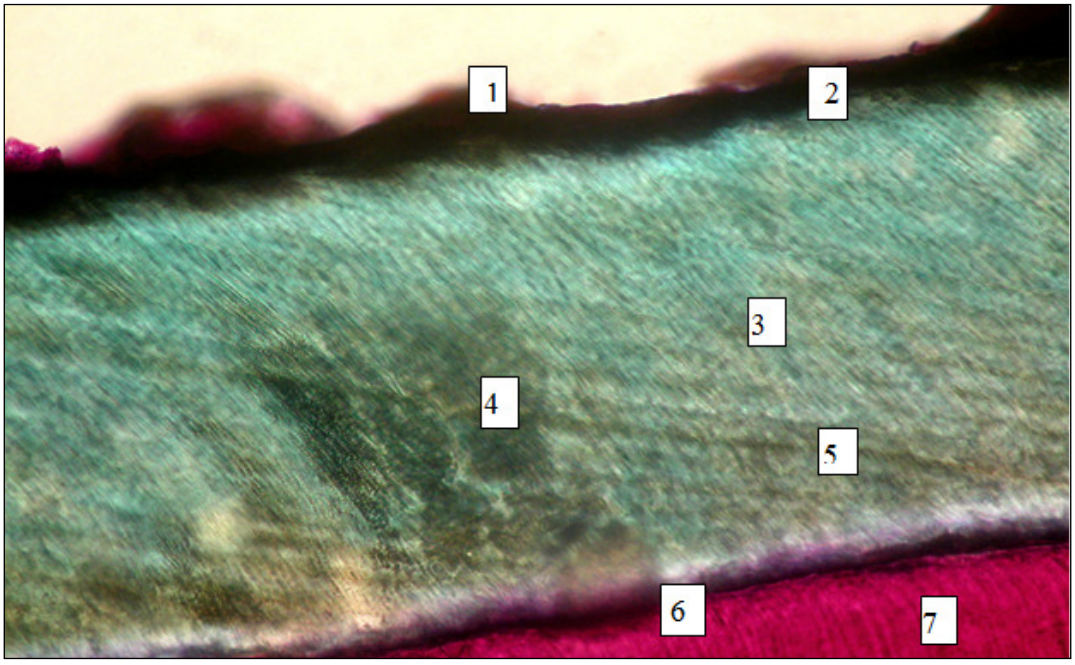

Fig. 2. Remnants of soft dental plaque after manual scaling: 1 – remnants of dental plaque; 2 – cuticle; 3 – preserved bundles of enamel prisms; 4 – partially destroyed bundles of enamel prisms; 5 – Retzius lines; 6 – amelo-dentinal junction with structural disruptions; 7 – dentin. Staining: PAS-Alcian blue. Magnification: x400.

of the dental deposits [8]. However, everyone is convinced of the need to achieve an ideally smooth tooth surface to prevent the recurrence of plaque formation [11]. Most authors believe that achieving a perfectly smooth tooth surface after removing dental deposits is impossible [12]. There is no unanimous opinion regarding the effects of the most commonly used manual, ultrasonic (piezoelectric and magnetostrictive), and sonic instruments on the tooth surface. There are conflicting opinions in the literature about the surface roughness and damaging properties of ultrasonic, sonic and manual scaling. Some researchers believe that ultrasonic scaling is the most sparing method [13], while others consider manual scaling is preferable [14], and the use of sonic scalers is recommended only for long-standing hard dental deposits [13].

Therefore, to date, there is no study in the literature that would allow creating a differentiated approach to selecting a method for removing supragingival dental deposits depending on the nature of dental deposits and structural changes in adjacent tissues, as well as the

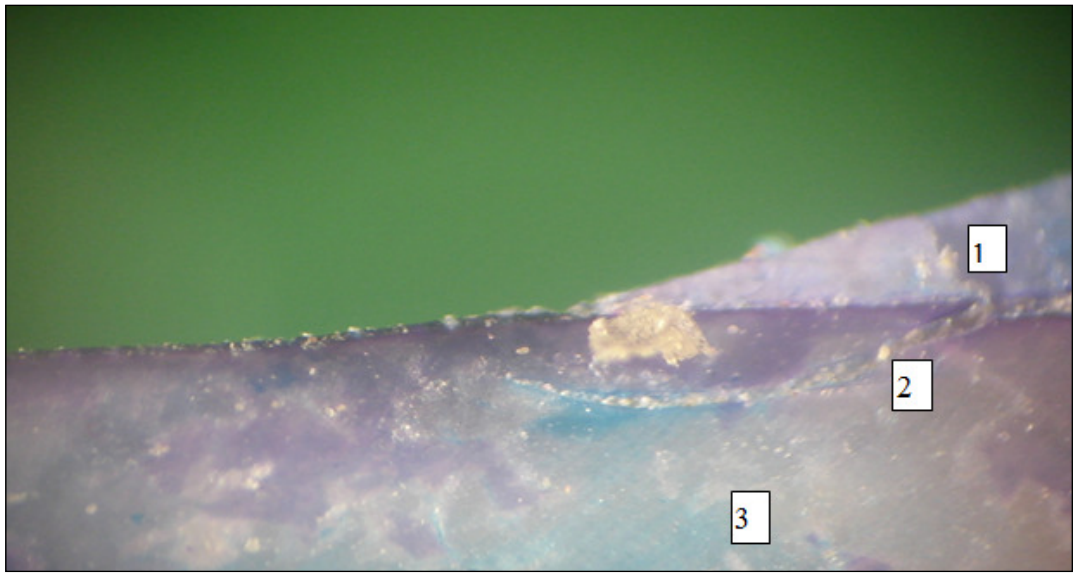

Fig. 3. Remnants of dental calculus in the cervical region of the tooth after manual scaling: 1 – preserved enamel; 2 – enamel invagination into root dentin; 3 – interglobular dentin. Staining: PAS-Alcian blue. Magnification: x16.

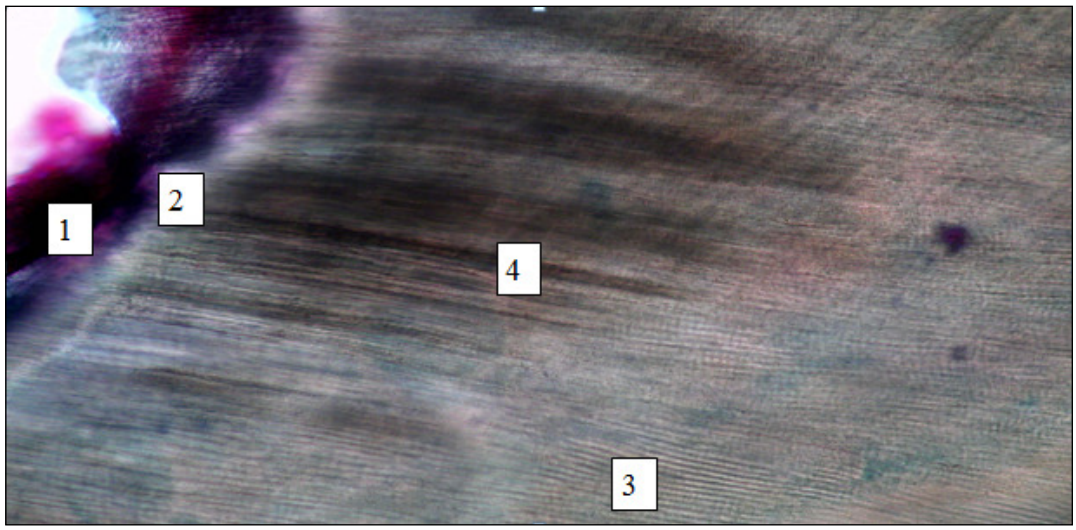

Fig. 4. Microscopic changes in enamel adjacent to dental calculus after manual scaling (equatorial region): 1 – remnants of dental calculus; 2 – the boundary between dental calculus and adjacent enamel; 3 – preserved enamel prisms; 4 – partially or completely destroyed enamel prisms. Staining: PAS-Alcian blue. Magnification: ×400.

effect on the tooth surface of mechanical and physical methods of their removal.

AIM

The aim of this work was to study the structural changes that occur in the hard tissues of the tooth after performing manual, ultrasonic, and sonic methods of removing dental deposits and to determine the most rational method for various supragingival deposits.

MATERIALS AND METHODS

To achieve the study's objective, an examination of 8 patients with various types of supragingival dental deposits was carried out. These patients were scheduled for the removal of 8 teeth due to orthodontic and surgical indications: 3 teeth with dental plaque, 3 with mineralized dental deposits, and 2 with smoker's plaque. In one of three patients with dental plaque, dental deposits were removed using the instrumental method (manual scaling) [15], in the second – with the ultrasonic scaler Cavitron Select SPS (Dentsply, USA), and in the third – with the sonic scaler TopMed TM-AS2000, M4 (China). Similarly, scaling of teeth was performed in patients with mineralized dental deposits. In two patients with smoker's plaque, the removal of supragingival deposits was performed using the ultrasonic and sonic scalers, respectively. Manual scaling of smoker's plaque in patients was

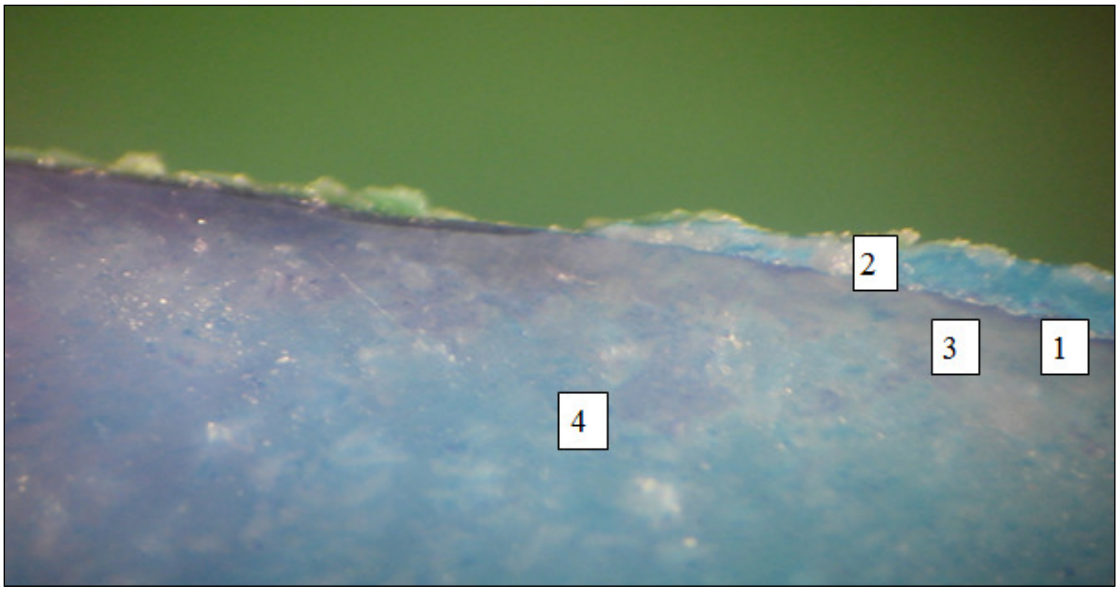

Fig. 5. Condition of hard dental tissues in the cervical area after ultrasonic scaling of soft dental plaque: 1 – amelo-dentinal junction; 2 – "eroded" enamel; 3 – dentin; 4 – interglobular dentin. Staining: PAS-Alcian blue. Magnification: ×16.

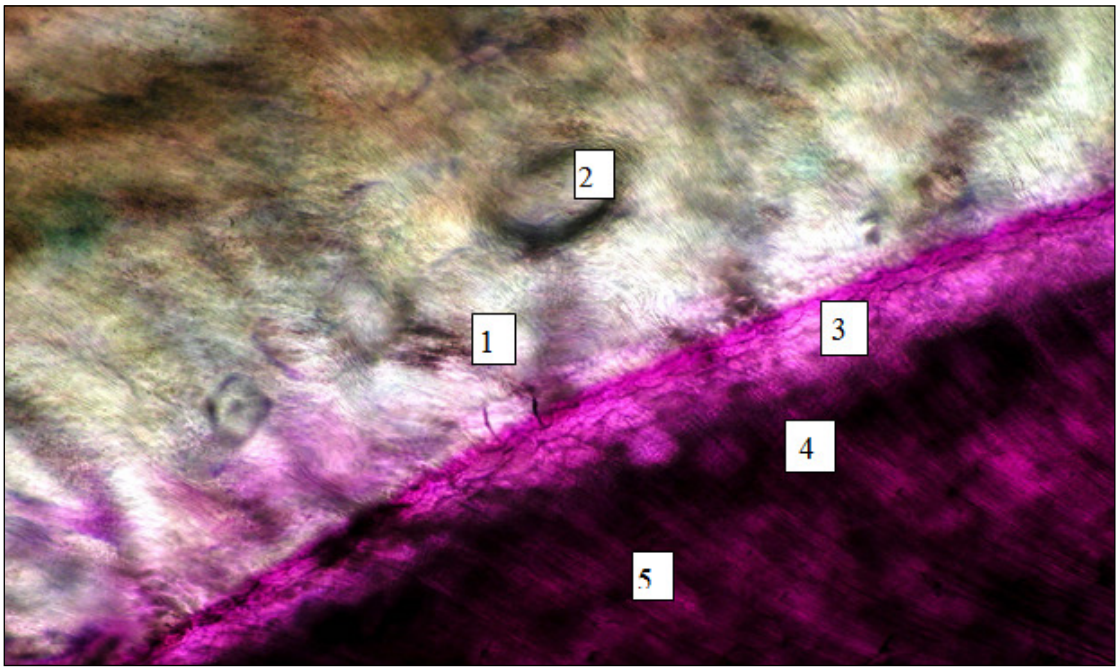

Fig. 6. Condition of hard dental tissues after ultrasonic scaling of supragingival dental calculus: 1 – partial or complete destruction of enamel prism bundles; 2 – granular structures of destroyed enamel; 3 – thickening of the reticular layer; 4 – destroyed layer of odontoblastic terminal processes; 5 – "dead tracts" near the amelo-dentinal junction. Staining: PAS-Alcian blue. Magnification: ×400.

not performed due to the impracticality of using this method in clinical practice. The tooth extraction procedure was carried out the day after the removal of dental deposits.

The extracted teeth were stored in a 10% neutral formalin solution. Morphological studies were carried out according to the previously described methodology [10].

The research was conducted at the Department of Pathological Anatomy and Forensic Medicine of Poltava State Medical University. All research was performed with the voluntary consent of the participants, in compliance with contemporary requirements for scientific research, as outlined in the "Declaration of Helsinki of the World Medical Association" (ethical principles for medical research involving human subjects) – 6th revision (Seoul, 2008). The study was approved by the Ethics and Academic Integrity Commission (Protocol No. 6/27 dated June 28, 2024).

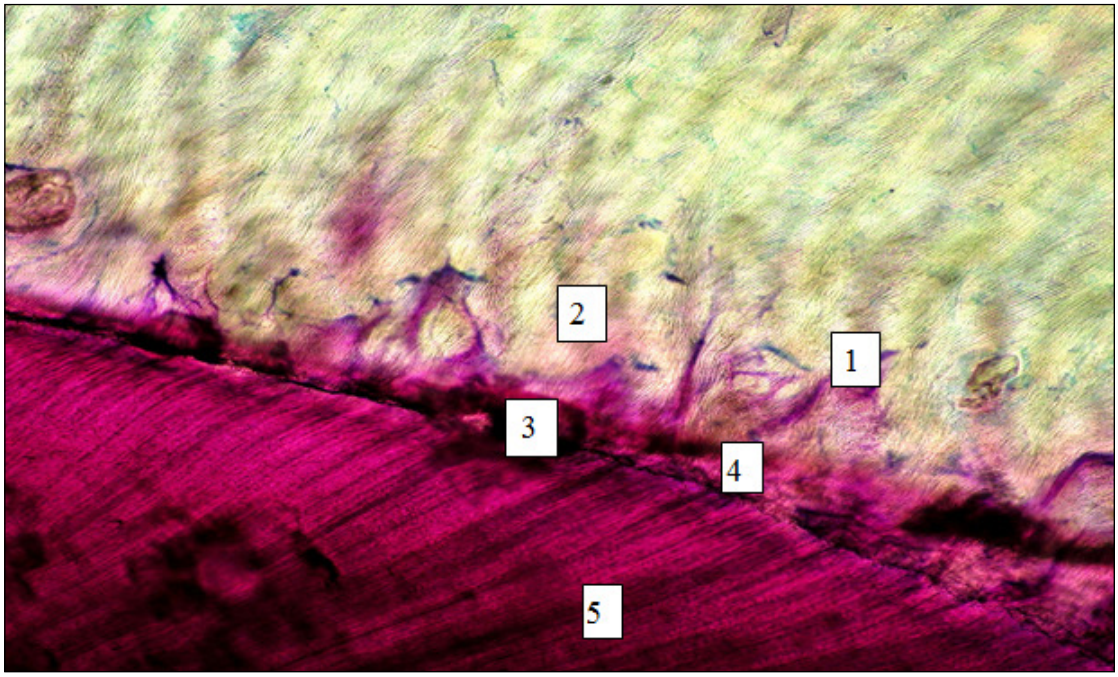

Fig. 7. Condition of hard dental tissues during ultrasonic scaling of smoker's plaque: 1 – destroyed bundles of enamel prisms; 2 – penetration of nicotine pigment into the interprismatic spaces of Hunter-Schreger lines; 3 – fragmentation of the reticular layer; 4 – destruction of the reticular layer with the formation of PAS-positive vegetations; 5 – "dead tracks" in the dentin. Staining: PAS-Alcian blue. Magnification: x400.

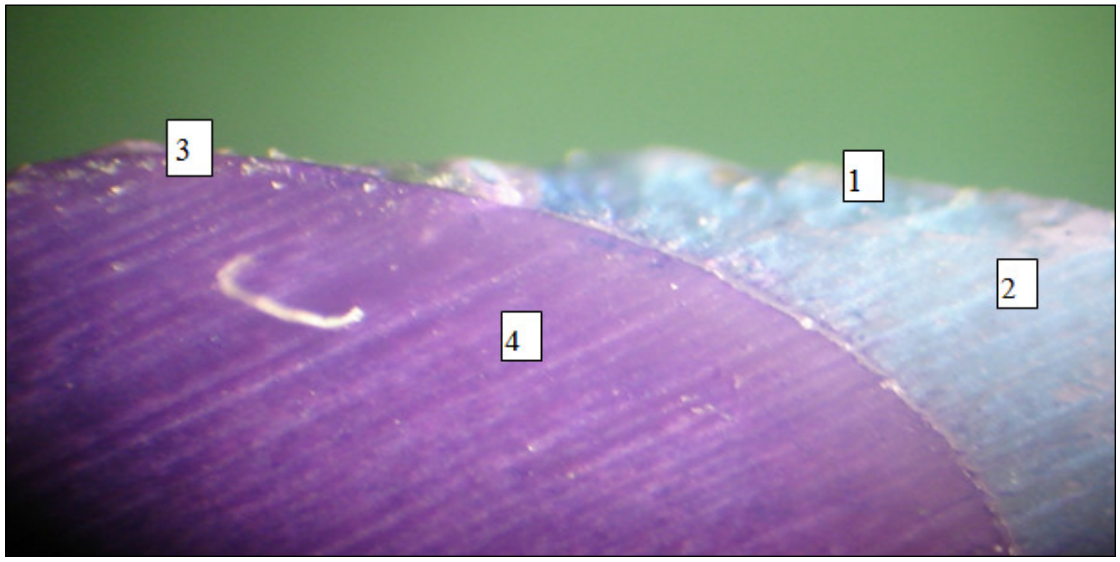

Fig. 8. Condition of hard dental tissues in the cervical area after sonic scaling of dental plaque: 1 – "eroded enamel"; 2 – preserved enamel; 3 – destroyed cementum; 4 – preserved regular dentin. Staining: PAS-Alcian blue. Magnification: x16.

RESULTS

After the removal of dental plaque using a manual method, thick histochemically stained PAS-Alcian blue sections revealed that the enamel surface displays an "eroded" appearance due to the absence of the cuticle. In certain areas near Nasmyth's membrane, represented as a light band, a small amount of PAS-Alcian-positive soft deposits is preserved, which do not penetrate into the enamel's thickness (Fig. 1). In these cases, the enamel is stained in various shades of yellow. The amelo-dentinal junction exhibits a winding course, with single enamel tufts extending from it.

The results of thin-section studies demonstrate the presence of dental plaque remnants across the entire enamel surface as dark pink homogeneous masses (Fig. 2). Alongside preserved bundles of enamel prisms stained blue, well-defined Retzius lines of biomineralization are distinctly visible. In certain areas of the enamel, partial destruction of enamel prism bundles is observed. These prisms are stained a darker shade and are distinctly bordered by lighter lamellae. Near

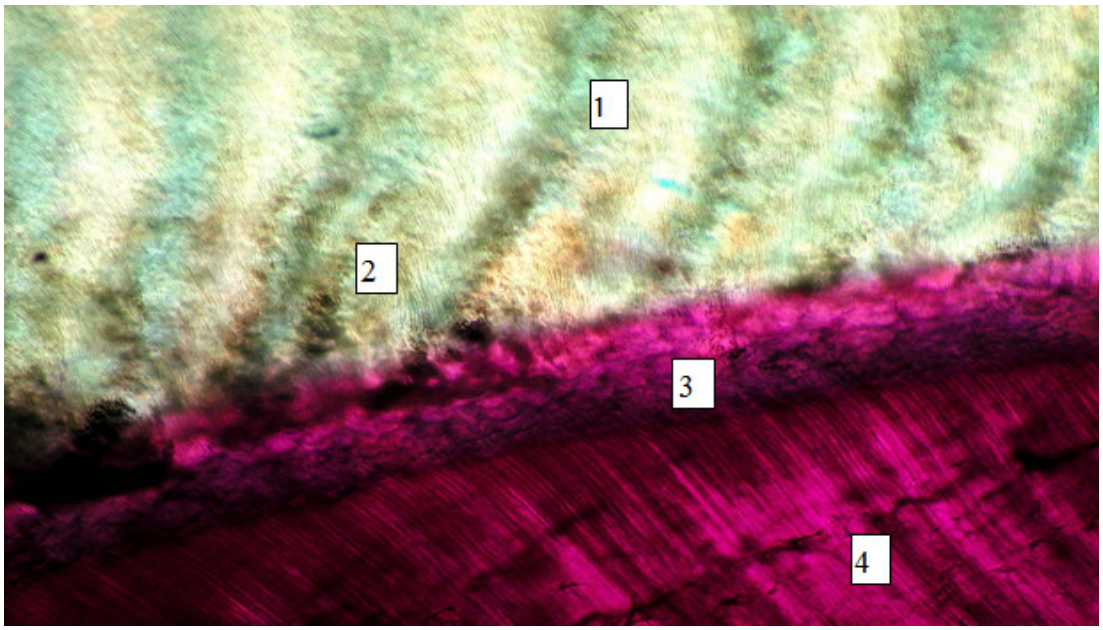

Fig. 9. Condition of hard dental tissues after sonic scaling of mineralized dental deposits: 1 – greenish-blue bands of vertical Hunter-Schreger lines; 2 – yellow-brown bands of vertical Hunter-Schreger lines; 3 – hyperplasia of the reticular layer; 4 – interglobular dentin. Staining: PAS-Alcian blue. Magnification: x400.

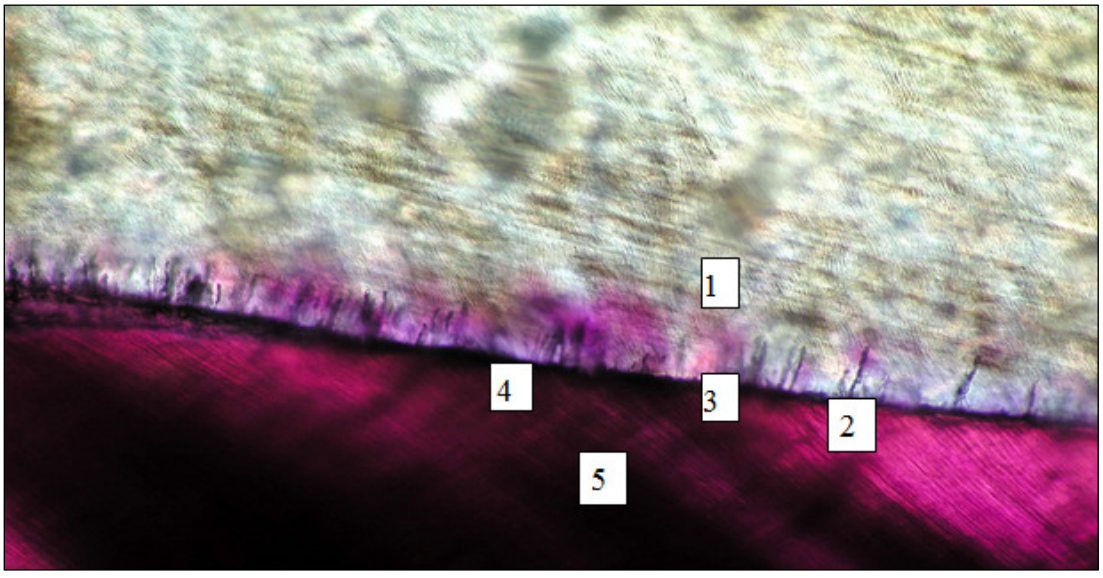

Fig. 10. Condition of hard dental tissues after sonic scaling of smoker's plaque (equatorial part): 1 – enhanced pattern of Retzius lines; 2 – hyperplasia of enamel spindles; 3 – preserved enamel tufts; 4 – reticular layer; 5 – "dead tracks" in the dentin near the amelo-dentinal junction. Staining: PAS-Alcian blue. Magnification: x400.

the damaged enamel prisms, fragmentation of the amelo-dentinal junction and disruption of its structure are noted.

It was established that after manual scaling of supragingival dental calculus in the cervical area, remnants of calculus partially persist (Fig. 3). These remnants exhibit a whitish color due to localized calcification. Preserved areas of enamel invaginate into the dentin and are stained dark purple. The enamel adjacent to the calculus has a triangular shape and is stained light blue. In areas adjoining the calculus, interglobular dentin is present, appearing light lilac against the background of destroyed dentinal tubules.

When examining histochemically stained thin sections, it was found that the calculus remnants exhibit various shades of dark purple (Fig. 4). At its boundary with prismatic enamel, a light homogeneous band can be observed, separating it from the bundles of enamel prisms. The enamel prism bundles display varying colors, ranging from blue to dark gray. The blue color corresponds to intact bundles of enamel prisms, while the dark gray indicates fragmented or entirely destroyed ones.

After ultrasonic scaling of tooth surfaces with non-mineralized dental plaque (dental biofilm), complete removal of deposits is observed. At the same time, the enamel exhibits an "eroded" surface, particularly in the cervical region (Fig. 5). It is noteworthy that two types of altered enamel prism bundles are identified in this area. In the first case, the enamel prism bundles stain blue, with a partially fragmented reticular layer observed. In the second case, the enamel stains light gray, which evidently corresponds to completely destroyed enamel prism bundles. Furthermore, the reticular layer at the amelo-dentinal junction is almost entirely destroyed. The dentin layer adjacent to the enamel stains gray-blue and contains individual layers of interlobular dentin.

After the removal of mineralized debris with an ultrasonic scaler, areas of enamel adjacent to it demonstrated complete removal of supragingival dental deposits. In certain areas, partial or complete destruction of enamel prism bundles was observed, along with small foci of granular structures. In the zones adjacent to the enamel, the reticular layer was thickened and represented by fibrous PAS-positive structures, which separated the enamel from the zone of completely destroyed terminal odontoblast processes. These processes appeared as dark formations extending into the so-called "dead tracts", which, according to Hasiuk A. P. et al. [16], result from fragmentation or complete destruction of odontoblast processes (Fig. 6).

After ultrasonic scaling of smoker's plaque, the enamel exhibits an "eroded" appearance. Significant destructive changes are observed within the enamel structure. Thus, bundles of enamel prisms are stained in various shades ranging from yellow to brown. Individual bundles are demarcated by darker brown stripes and are arranged along the vertical lines of Hunter-Schreger bands, apparently caused by nicotine pigment. The amelo-dentinal junction after ultrasonic scaling shows a wavy course with areas of partial hyperplasia of the reticular layer at the boundary with dentin. At the same time, fragmentation of the reticular layer is noted in the deeper enamel, accompanied by the formation of PAS-positive structures in the thickness of this formation and their vegetation (Fig. 7).

It has been established that when sonic scaling is used to remove dental plaque, the enamel in the cervical area has a pronounced "eroded" surface. Bundles of enamel prisms are partially destroyed and stain in shades ranging from blue to light blue, while the pattern of the amelo-dentinal junction remains intact. However, the layer of cementum adjacent to the enamel is partially or completely destroyed. Partial destruction of the adjacent dentin is also noted, especially in the cervical region of the tooth (Fig. 8).

During microscopic examination of histochemical tooth sections stained with PAS-Alcian blue, after the removal of mineralized dental deposits via ultrasonic scaling, partial destruction of the superficial enamel layers was observed. In areas with preserved enamel, distinct bundles of enamel prisms were noted, appearing as vertical Hunter-Schreger bands. These exhibited either a blue-green or yellow-brown coloration. Ultrasonic scaling revealed thickening of the reticular layer and its hyperplasia due to an increase in PAS-positive fibrous structures within it. Additionally, directly in the zone of regular dentin, which stains red, interglobular dentin bands with a dark cherry color were observed (Fig. 9).

Morphological examination of hard tooth tissues after removal of smoker's plaque using a sonic scaler revealed its absence and a "eroded" enamel surface. The terminal ends of enamel prisms appeared light yellow and brown. In certain areas, the Retzius lines showed intensified patterns, stained in dark color. Preserved enamel tufts and hyperplastic enamel spindles at the interface with the reticular layer also exhibited a dark color, indicating the accumulation of nicotine pigment. In the dentin near the amelo-dentinal junction, "dead tracts" were revealed (Fig. 10).

DISCUSSION

Thus, the analysis of the morphological study results established that after the removal of all types of dental deposits through various scaling methods, the structural changes in enamel, amelo-dentinal junction, and dentin, previously identified by us [10], persist. However, ambiguous changes in hard dental tissues were revealed with different types of scaling of non-mineralized and mineralized dental deposits.

The results of microscopic studies indicate that after manual scaling, dental deposits partially remain on the tooth surface – less so in cases of supragingival calculus and more significantly with dental plaque. This confirms the authors' data [13, 14] regarding the ineffectiveness of manual scaling in patients with soft dental deposits and its advantage in the presence of mineralized deposits.

The established changes in enamel after ultrasonic scaling of different types of dental deposits demonstrate partial or complete destruction of enamel prism bundles. Similar destructive processes were observed at the amelo-dentinal junction and in the superficial layers of dentin. Based on the mechanism of ultrasonic cavitation in biological media [17], it can be argued that the cause of enamel surface damage and destruction of the reticular layer may lie in the differences in micro-

hardness among dental plaque, enamel, and dentin. At the same time, high-frequency microwaves passing through tissues with varying hardness levels may, due to changes in oscillation frequency, cause the rupture of chemical bonds and contribute to defect formation in enamel and degenerative alterations at the amelo-dentinal junction. The ineffectiveness of this scaling method has been confirmed in a few clinical studies [14, 10] and aligns with the results of our microscopic investigations.

Pronounced destructive processes in enamel (damaged surface layers, hyperplasia of enamel spindles) and at the amelo-dentinal junction (thickening of the reticular layer) observed during sonic scaling of non-mineralized and mineralized dental plaque confirmed the clinical observations of the authors [13] regarding the aggressiveness and impracticality of using this method in clinical practice.

Thus, the results of morphological studies suggest that the most rational method for removing mineralized dental deposits is manual scaling, while the removal of non-mineralized plaque and smoker's plaque is best achieved through air-abrasive techniques. The latter method, in our opinion and according to some authors [8, 10, 11], may be the most rational approach; however, this requires further confirmation. Given that destructive changes in dental tissues and deep penetration of nicotine pigment into enamel persist regardless of the type of scaling, there is a need for additional remineralization therapy and teeth whitening using known methods [18].

CONCLUSIONS

1. The conducted morphological studies made it possible to objectively assess the condition of enamel and adjacent tissues, occurring after different methods of supragingival dental calculus removal.
2. It was established that removing non-mineralized dental deposits (dental plaque) and smoker's plaque using sonic, ultrasonic, and manual scaling methods is inefficient. An air-abrasive system may be the method of choice for these types of deposits.
3. Pronounced destructive processes in the enamel (damaged surface layers, hyperplasia of enamel spindles) and the amelo-dentinal junction (thickening of the reticular layer), observed during sonic scaling of non-mineralized and mineralized dental deposits, indicate significant aggressiveness and underscore the impracticality of its use in clinical practice.
4. It has been proven that the most rational method for removing supragingival mineralized dental deposits is manual scaling. Destructive changes in the hard tissues of teeth (partial destruction of surface enamel layers, hyperplasia of the reticular layer with the formation of PAS-positive vegetations) observed (identified) during ultrasonic scaling limit its application in clinical practice.
5. Considering that, regardless of the type of scaling, the enamel surface remains uneven, with destructive changes in the tooth tissues and deep penetration of nicotine pigment, there is a need for mandatory polishing of tooth surfaces as well as additional remineralization therapy and tooth whitening procedures.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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