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PATHOGENESIS OF DISTURBANCES OF THE HARD TISSUES OF THE TEETH IN THYROTOXICOSIS

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In thyroid hyperfunction lesions of the hard tissues of the teeth, classified as erosion, become more frequent [1, 3]. However, the mechanism of development of these lesions has not been discovered; moreover, data on the surface ultrastructure of the tooth and its mineral phase in thyrotoxicosis are not available. The investigation described below was undertaken to study these problems.

EXPERIMENTAL METHOD

Experiments were carried out on 150 female albino rats weighing 120-180 g, receiving the ordinary animal house diet. Thyrotoxicosis was produced in 75 animals by daily injection of a solution of the sodium salt of L-thyroxine in a dose of 400 μg of the dry powder/100 g body weight. Control animals received injections of 0.2 ml of physiological saline. The rats were killed at different times after the beginning of the experiment — 5, 10, 15, 20, and 30 days. After sacrifice the incisors were extracted and one batch of them (400 teeth) was dried to constant weight whereas the other (200 teeth) was fixed in 12% neutral formalin.

The dried teeth were ground in an agate mortar to a powder, from which samples weighing 100 mg were prepared, mixed with 100 mg buffer (calcium phosphate), homogenized on an amalgam mixer, and pressed into tablets 1 cm in diameter by means of a press under a pressure of 10.13×10^4 GP. The surface of the tablets was smooth and flawless. The tablets thus prepared were placed in the cuvette compartment of an x-ray fluorescence instrument (VRA-2, from Carl Zeiss, East Germany), then irradiated for 100 sec, after which the intensity of emission for the elements copper, zinc, iron, and cobalt was determined and the background level deducted.

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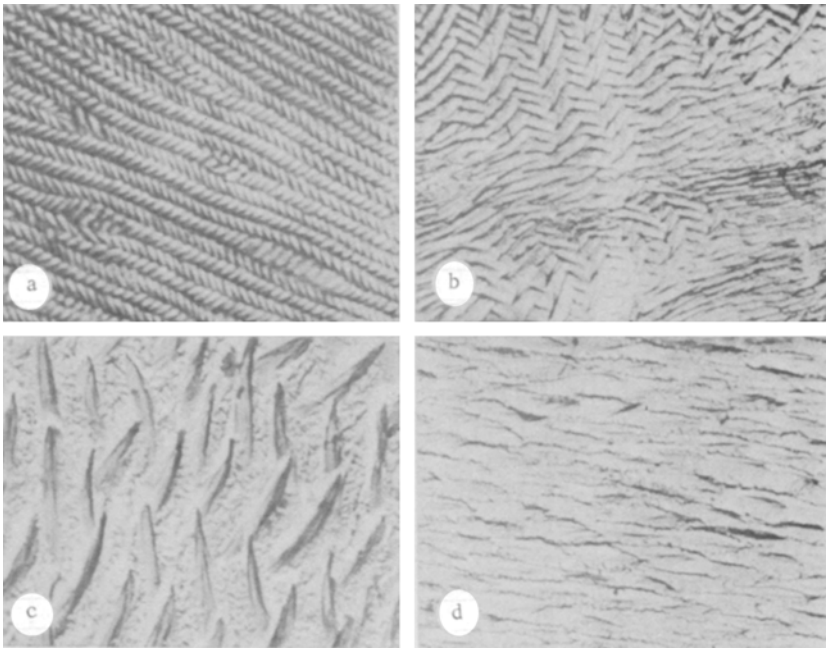

Fig. 1. Structure of enamel surface in rats of experimental group. a) Unchanged structure of enamel surface. Scanning electron microscopy, 1000 ×; b) 5-10 days of experiment: disturbance of orientation of prisms in middle part of tooth crown. Transmission electron microscopy, 2100 ×; c) 15 days of experiment: ends of prisms on unerupted part shaped like slender cones against background of granular structure. Transmission electron microscopy, 3500 ×; d) 20-30 days of experiment: considerable change in structure with disturbance of shape of prisms and their superposition one above the other on enamel surface. Transmission electron microscopy, 2100 ×.

The content of the elements tested was determined by means of five prepared standard samples using calibration graphs. The numerical data were subjected to statistical analysis by Student's test.

The enamel of the incisors fixed in formalin was studied after removal of the soft deposit and the organic membranes by boiling in antiformin solution. The investigation was carried out by the carbon replica technique [2] in a JEM-100S (Japan) electron microscope and JSM-15 (Japan) scanning electron microscope. The ultrastructure of the surfaces of erupted and unerupted parts of the teeth was studied.

EXPERIMENTAL RESULTS

Animals receiving L-thyroxine were much smaller than the controls in weight. The mean weight of the rats of the two groups after 15 days differed by 25-30%, evidence of the development of marked thyrotoxicosis.

The surface of the enamel of the incisors from rats of the control group had a prismatic structure, and in most cases the ends of the prisms emerged on the surface in the form of cones, resembling a herringbone pattern or "parquet" floor, and they formed horizontal rows on the vestibular and, to some extent, on the contact surfaces. Morphological changes in some animals of the control group consisted of separate foci in which the orientation of the prisms was disturbed and their shape altered. The ends of the prisms were stretched out along the length of the tooth, superposed one above the other or, joined together to form sometimes crystal-like aggregations of different sizes, oriented in the vertical direction on the vestibular surface. These focal changes in structure usually were arranged along the midline of the crown of the tooth or slightly eccentrically. In other areas of the surface of the teeth no structural changes were seen.

TABLE 1. Effect of Thyrotoxicosis on Content of Trace Elements (in μg/g dry weight) in Hard Tissues of Rats' Teeth (M ± m)

Group of animals	Duration of experiment, days	Trace element			
		Cu	Zn	Fe	Co
Control	5	5,57±0,17	5,54±0,21	4,41±0,15	5,04±0,19
Experimental		5,42±0,10 (97,3)	5,50±0,16 (99,3)	4,73±0,04 (107,3)	5,99±0,32 (118,8)
Control	10	4,94±0,08	5,21±0,11	4,46±0,04	4,44±0,21
Experimental		4,93±0,07 (99,8)	6,37±0,53 (122,2)	4,66±0,03 (104,5)	5,58±0,59 (130,6)
Control	15	4,99±0,19	4,98±0,13	4,45±0,06	5,41±0,75
Experimental		5,12±0,12 (102,6)	6,14±0,24 (123,2)	4,64±0,06 (104,2)	4,92±0,42 (90,9)
Control	20	4,94±0,25	4,48±0,40	4,56±0,10	5,56±0,25
Experimental		5,33±0,09 (107,9)	5,06±0,65 (112,9)	4,60±0,03 (100,9)	5,52±0,23 (99,3)
Control	30	5,35±0,18	6,43±0,40	4,78±0,04	5,39±0,91
Experimental		5,07±0,08 (94,8)	6,11±0,24 (95,0)	4,47±0,06 (93,5)	4,84±0,50 (89,9)

Legend. Figures in parentheses indicate percent of control.

Characteristically changes in enamel structure on the unerupted part of the tooth were not present in any rats of the control group.

In rats with experimental thyrotoxicosis changes in the structure of the surface enamel were found: the ends of the prisms were considerably elongated and their orientation was changed; around the edges of the focus the structure was unchanged (Fig. 1a).

The degree and distribution of the changes described above depended on the duration of the experiment. On the 5th-10th day of the experiment structural disturbances appeared in the form of a narrow strip (Fig. 1b), only in the midline of the crowns of the teeth, nearer to the cutting edge. With an increase in duration of the experiment the structural changes increased and spread both in the length and breadth of the tooth. Starting with the 15th day of the experiment, morphological structural changes also were observed not only on the erupted, but also on the unerupted part of the enamel (Fig. 1c). This process progressed on the 20th-30th day of the experiment, when nearly the whole surface of the dental enamel had a modified structure on both unerupted and erupted parts (Fig. 1d).

Disturbances of the structure of the dental enamel surface were accompanied by changes in the content of trace elements (Table 1). A distinct tendency toward an increase in the content of trace elements, especially zinc, was observed in the hard tissues of the teeth of the experimental animals over a period of 15 days. Later no difference could be found between the trace element levels.

As a result of thyrotoxicosis the ultrastructure of the enamel surface of the incisors is thus disturbed in rats. In the first 2 weeks changes were located in the erupted part of the tooth crown, but later they spread also to the unerupted part of the incisors. These results can be explained on the assumption that in experimental thyrotoxicosis the properties of the mouth fluid are changed and this has an unfavorable action on the dental enamel in the region of the middle part of the crown.

Under these conditions it is possible that destructive changes arise in the enamel, as shown by disorientation of the enamel prisms. In severe thyrotoxicosis these changes spread to the unerupted part of the tooth. The increase in the content of trace elements found in the hard tissues of the tooth is probably due to increased penetration of trace elements from the mouth fluid as a result of disturbance of the ultrastructure of the tooth surface.

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