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SCANNING ELECTRON MICROSCOPIC OBSERVATION OF THE HUMAN THYROID FOLLICLES

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Abstract

The luminal surface of the follicular cells in the human thyroid was observed by scanning electron microscope. The results obtained were as follows:

1. The internal form of the follicles is mostly spherical, and the walls are generally made out of hexagonal flat-surfaced epithelial cells.

2. The apical surface of the follicular epithelium is covered with the irregularly oriented numerous microvilli.

3. One or two central cilia are located at the central portion of the follicular cells. The length of the cilia is usually constant. However, the length of the microvilli is variable depending upon individual cells.

4. The pseudopods appear scatteringly on the surface. Basically their shape is spherical with or without indentation at the vertex.

INTRODUCTION

The scanning electron microscope (SEM) provided good three-dimensional pictures of free surface of the thyroid follicles. Although many ultrastructural studies of the thyroid using a transmission electron microscope (TEM) have been reported, observations by SEM are new and scarce, especially in man. The purpose of the present paper is to report the result of observations of the apical surface of human thyroid follicles by SEM.

MATERIALS AND METHODS

For the purpose of this study the normal thyroid tissue was removed from surgical cases of adenoma. For the confirmation of normal tissue, the specimen was examined under the light microscope. The fresh specimen was removed before ligation of the vessels and was cut with a razor into pieces, approximately $3 \times 2 \times 5$ mm, and rapidly rinsed with

Millonage's phosphate buffer for the removal of the colloid in the follicles. After fixation with 2.5 % glutaldehyde for 90 minutes and post-fixation with 1 % osmium tetroxide for 60 minutes, dehydration was carried out in graded alchohol solution. After critical point drying from isoamyle acetate, the pieces were glued to holders and thinly coated with carbon and gold in a vacuum evaporator. A Hitachi HHS-2R and a Hitachi SSM-2 scanning were operated at 20 KV in the secondary electron mode.

OBSERVATION

Under low magnification transected follicles appear as dome shapes which have different depth and diameter depending upon their initial size and the plane and the level of the section (Fig. 1). They are paved with the follicular cells which are hexagonal or pentagonal in shape. There is a tendency that the larger is the cell, the more polygonal. The length of a side of a polygon measures from 2 to 7 μm. The boundary of adjacent cells is well defined by levee-like protrusion with dense microvilli. The luminal surface of the cell is flat or in some cases slightly convex and covered with irregularly oriented numerous micro-

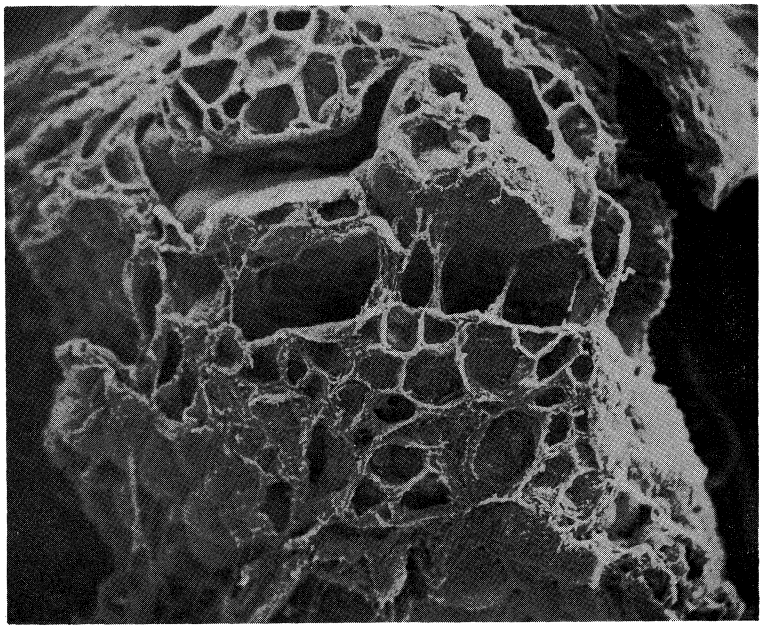

Fig. 1. A low magnification view of the transected follicles appear semispherical. ×60

villi. However, the density of the microvilli in individual cells is not always constant even in a follicle. Two or three neighboring cells having sparse and short microvilli exist sporadically in a follicle. In general the longer are the microvilli, the denser over the surface and vice versa (Fig. 2). The shape of microvilli varies mainly depending upon the length; they are globular in appearance in the short microvilli and rodbar or club-shaped in the long microvilli. One or two, rarely three, central cilia are located around the central portion of the cell. The length of cilia is usually constant, approximately 1.2 μm. Generally the radix is thicker than the apex but some of the apex are swollen spherically (Fig. 3).

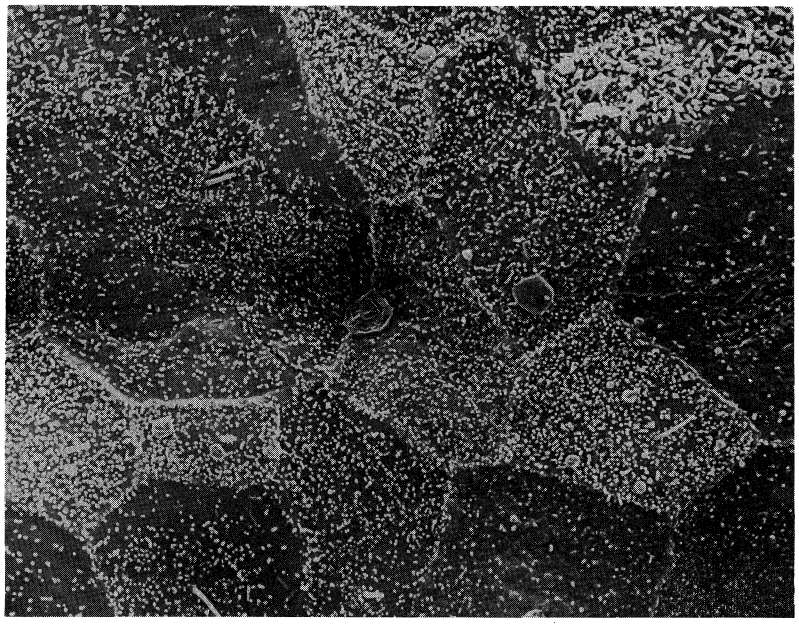

Fig. 2. The follicle of the flat surfaced hexagonal epitherial cells. Their cell borders are distinctly outlined. The number and length of microvilli are not always constant. ×3,000

Conspicuous globular projections which are identified with pseudopods by TEM observation are protruding from any place of the apical surface of the cell into the lumen sporadically. The pseudopods do not have the microvilli but have a fine surface structure. Basically pseudopods appear spherical in shape and are connected to cellular surface with thin and short stalks. However, various modified shapes are also seen; some have an indentation at the apex and some appear to be cups, bowls, and morning glories (Fig. 4-8).

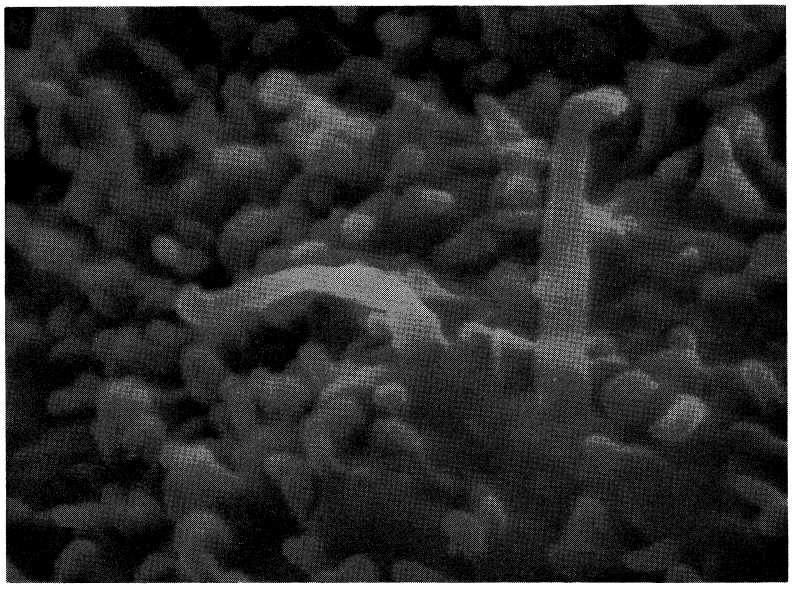

Fig. 3. The apical surface is covered with numerous microvilli and one or two central cilia exist. ×3,000

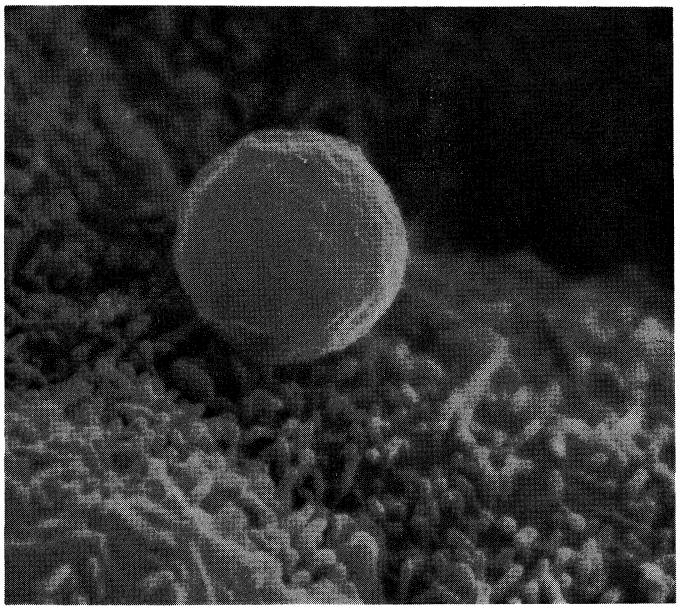

Fig. 4. Pseudopod is protruding into the lumen. It does not have microvilli. Basically the shape is globular. ×15,000

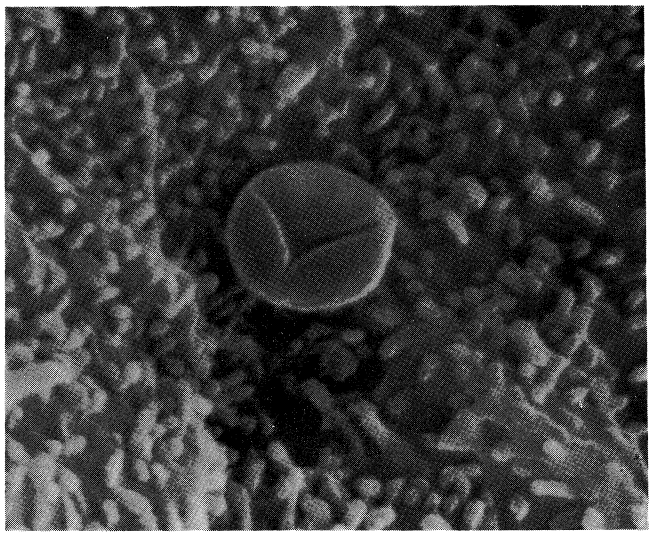

Fig. 5. The vertex of pseudopod is depressed triangularly. ×20,000

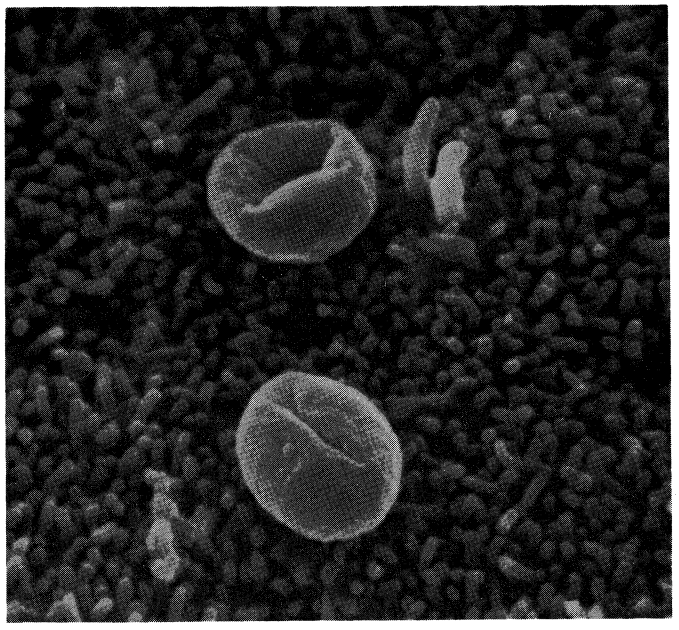

Fig. 6. A large dent is seen at the vertex of the pseudopod. ×15,000

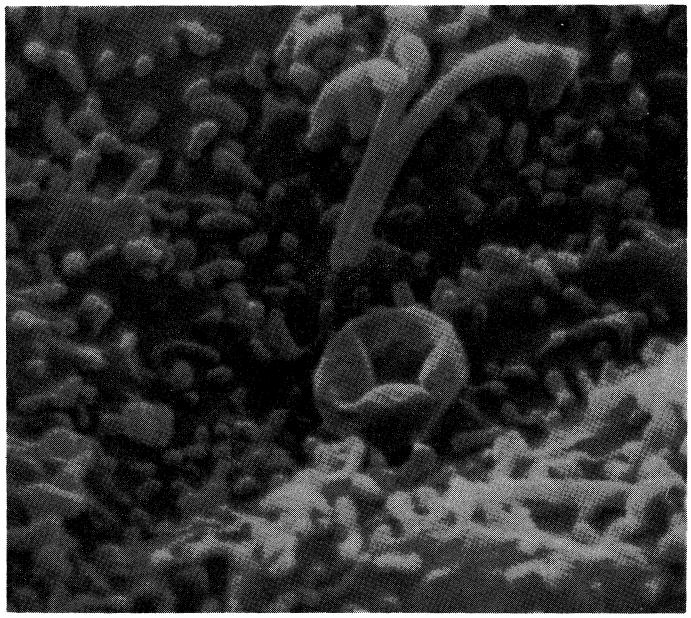

Fig. 7. The vertex of the pseudopod is so depressed that it appears like a bowl or flower-like appearance. ×20,000

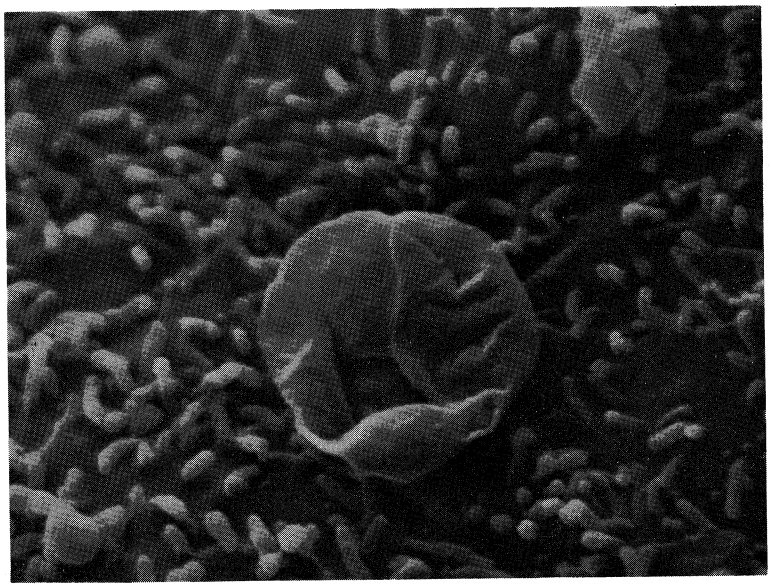

Fig. 8. The vertex of the pseudopod is so depressed that it appears like a bowl or flower-like appearance. ×15,000

DISCUSSION

There are a few literatures dealing with observation of thyroid tissues by SEM. Hansen and Skaaring[1] reported a study of the surface morphology of the follicles and the perifollicular structures of the normal rat thyroid. Kobayashi[2] studied the thyroid in the dog, swine, rat, and also Basedow's disease and cystic goiter in man. Ketelbant-Balasse et al.[3] observed apical surface of the dog thyroid follicle cells with administration of TSH *in vivo* and *in vitro*. Lupulescu and Boyd[4] reported cell structural changes in patients of the thyroid tumors. However, the fundamental studies of human normal thyroid follicles by SEM have not yet been reported in detail.

As described by Clinck et al.[5] in ultrastructural studies, our observation using SEM indicated that the apical surface of the human thyroid follicles is essentially similar to that of the animals. At survey magnification the follicles appear as empty half-spheres although their diameter and depth are variable depending upon their initial size and level of section. They are not connected with each other, but solitary. However, Hansen and Skaaring[1] observed ostia of follicular side branches in the bottom of several follicles of normal rat thyroid, which was previously reported as "Drüsenbäumchen" by Loeschke[6]. They also showed hemispherical, protruding apical surface of hexagonal follicular cells, but in our observation, the apical surface was flat or nearly convex which was similar to the observation of the swine by Kobayashi.

The role of the microvilli is generally considered to enlarge the cell surface and to increase the absorption and secretion of the cell. Accordingly the microvilli of the thyroid epithelium may participate in the storage and release of thyroid hormone. In our observation, the length and the number of microvilli in individual cell were not always constant even in a follicle. The microvilli tend to be more numerous when they are longer; the shorter the more sparse. These variations may suggest differences in the function of the individual cells.

Concerning the central cilia, Kobayashi[2] described that the frequency of follicular cells having the cilia differs by species; 45 % in the dogs, 30 % in the rats and very few in the swine, and the frequency and the shape of the cilia are not affected by the state of the function of the cells. Hansen and Skaaring[1] did not mention the central cilia in their rat thyroid studies. Our observation revealed that usually only one cilium, occasionally two cilia are present at the central portion of the cell surface. Their shape and length are almost constant in the indivi-

dual cells, in contrast with various microvilli which differ in length and shape.

Burnes[7] reviewed the structure of motile cilia and non-motile ones which are modified as sensory receptor and stated that the mortile cilia all appear to have a 9-plus-2 pattern, that is, nine peripheral sets of fibrils and a central pair within the shaft, whereas the non-mortile forms have a 9-plus-0 pattern without the central pair of fibrils which are generally thought to be essential for motility. According to ultrastructural study by Klinck et al. and the authors[3], the cilia of the thyroid epithelium appeared to fall into the latter group. However, there function has not been speculated through SEM studies.

An interesting observation in the present study is the globular projections from the apical surface to the lumen; so-called the pseudopods. This designation may be derived from the structural similarity to the pseudopods of amoeba ultrastructurally. However, according to our SEM observation, their structure appears to be essentially different from those of amoeba. By TEM observation they are so conspicuous that their structure and function have been studied and debated by many investigators. The discussion has mainly concerned their function whether they release the colloid into the lumen[9,10], or they reabsorb it into the follicular cells[11,12]. Most of the current concept obtained mainly from microradiographic studies tend to support the latter. Kelelbant-Balasse[3] reported SEM studies of the dog thyroid follicle *in vivo* and *in vitro* after TSH stimulation and described that their shape is variable. Some are sheet-like, which are spread out. Some appear rolled up with a clear-cut aperture at the apex; others only seen *in vivo* are club-shaped, and seem to engulf colloid content. They speculated that newly formed pseudopods would first appear as sheet-like structures, and later their lips would join for engulfment of luminal colloid. Although there is a possibility that artifact produced by the process of fixation or dehydration may influence their shape. Our observations revealed that the newly formed pseudopods are not sheet-like, but basically spherical in shape, which may undergo structural changes from small dent to bowl-like shape in a later period.

Therefore, as far as our observation is concerned, it amply suggests that pseudopods engulf the colloid whose reabsorption to the follicular cells does not occur. From the morphological point of view, the role of pseudopods is presumed to be the secretion of the celluar content, i.e. a merocrine type of secretion.

Acknowledgements

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(The details of this study will be published by Akihiko MATSUDO.)

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