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Scanning Electron Microscopy of Human Endometrium

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ABSTRACT

Scanning electron microscopy of endometrial biopsies demonstrated cyclical changes in the surface structures of the secretory cells. Towards the time of implantation, the slender microvilli of the follicular stage grew irregular and often were replaced by ridge-like structures. Further, apical protrusions of some microns height appeared. It is suggested that these structural changes are of importance for the process of implantation and that scanning electron microscopy of ordinary endometrial biopsies with advantage can be used when examining the working mechanism of various contraceptive agents.

INTRODUCTION

The luminal surface of the endometrium undergoes changes during the menstrual cycle as observed by transmission electron microscopy (1–3, 7–9). A better view of surface structures, however, is given by scanning electron microscopy. But since uterine material for microscopy mostly is obtained by biopsies with ensuing risks of surface contamination, it has been questioned to what extent biopsies can be used for scanning electron microscopy.

This paper reports the results of successful attempts to use routine biopsies of the endometrium for scanning electron microscopy.

MATERIAL AND METHODS

The biopsies were obtained with a Genell curette from normally menstruating women without any patho-morphological findings of the endometrium during the subsequent examinations. Material from 3 women in the follicular phase on day 9–11 and 3 in the luteal phase on day 21–23 were used.

The biopsies were fixed immediately after removal by immersion in 2.5% glutar aldehyde in Soerensen's phosphate buffer, pH 7.4. Specimens with an endometrial surface area of about 1×1 mm were cut, carefully rinsed in destilled water, and taken to 10% ethanol in water for freeze-drying. The specimens were frozen in iso-pentane cooled by liquid nitrogen and dried in 10^{-4} Torr for 3 days at $-96°C$ (solid carbon dioxide). The dry specimens were mounted for scanning electron microscopy and coated with carbon followed by gold. A Jeol JSM-U3 scanning microscope was used.

RESULTS

The luminal surface demonstrated openings of the uterine glands and was covered by secretory and ciliated cells (Fig. 1). The secretory cells were the most frequent ones, and the ciliated cells were irregularily scattered among them (Fig. 2). The form and the area of the luminal surface of the cells varied.

Follicular phase

The secretory cells were slightly bulging and possessed microvilli (Fig. 3). These were more numerous in the central parts of the cell than along the cell borders. The microvilli of the follicular phase were slightly longer and more slender than those of the luteal phase.

The ciliated cells were easily distinguished due to their kinocilia (Fig. 3). These appeared as a tuft of projections which were longer and thicker than the microvilli. The cilia were localized centrally on the cell surface. In addition to the kinocilia, the cell surface possessed small microvilli, which appeared among the kinocilia. The number of kinocilia on each cell varied, but most often it amounted to about 60. The length of the cilia was about 8 μm. Their direction varied, and no indication of their beating characteristics could be obtained.

Luteal phase

The secretory cells now had a more bulging, irregular surface which often demonstrated apical

Fig. 1. Endometrial surface during the luteal phase. The mucosa is slightly bulging, and the openings of the uterine glands are seen. Ciliated cells appear like small white spots due to the presence of the kinocilia. × 700.

protrusions. The microvilli were few and short, and irregular ridges had appeared on the surface (Fig. 4). Dilated parts of the ridges were frequent. The dilations varied in size, the largest ones having the appearance of apical protrusions.

The apical protrusions were morel-like, commonly having a width of about 4 μm and a height of about 2 μm (Fig. 5). They were irregularily distributed, absent in some regions of the luminal surface and occurring on each cell in others. However, on a surface area of 1 × 1 mm, regions with protrusions could always be found. The surface of the protrusions was wrinkled, often with an indentation in the middle of the protrusion. The cell surface under the bulge was smooth. At places where detached protrusions seemed to have been situated smooth depressions were noted.

DISCUSSION

The reliability of the pictures, as obtained with the scanning electron microscope, seemed to be

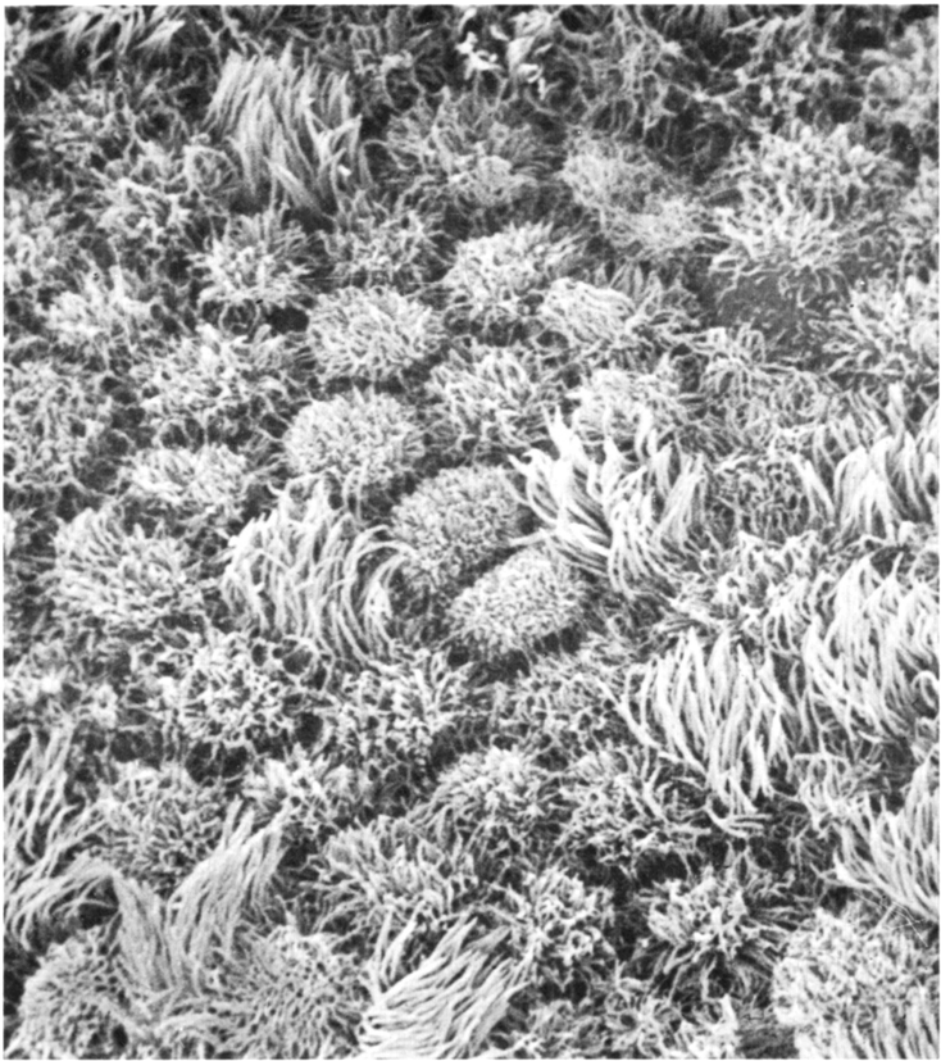

Fig. 2. Endometrial surface during the luteal phase. The ciliated cells possess long kinocilia and are scattered among the secretory cells. The secretory cells have a bulging surface with microvilli and are well demarcated. × 6 000.

good since they had the appearance which one would expect when comparing them with micrographs of the transmission microscopy (1–3, 7–9). The surface was not covered by any great amount of blood or secretion which otherwise could have been an obstacle for the scanning microscopy. Thus from a technical point of view it is possible to use ordinary uterine biopsies for scanning electron microscopy.

Cyclical changes of the microvilli and the apical protrusions were observed. Thus, when comparing the follicular and luteal endometrium a decrease in length and a change in shape of the microvilli with a concomitant outgrowth of the apical protrusions were observed. These structural changes should be regarded as a preparation of the luminal epithelium for implantation.

The change in microvilli corresponds partly to what is observed in the rat (4). This change was assumed to imply that the cell membrane gets more flexible in order to form a close contact with the implanting blastocyst. In humans the structural relationship between an implanting blastocyst and the uterine epithelium is not yet

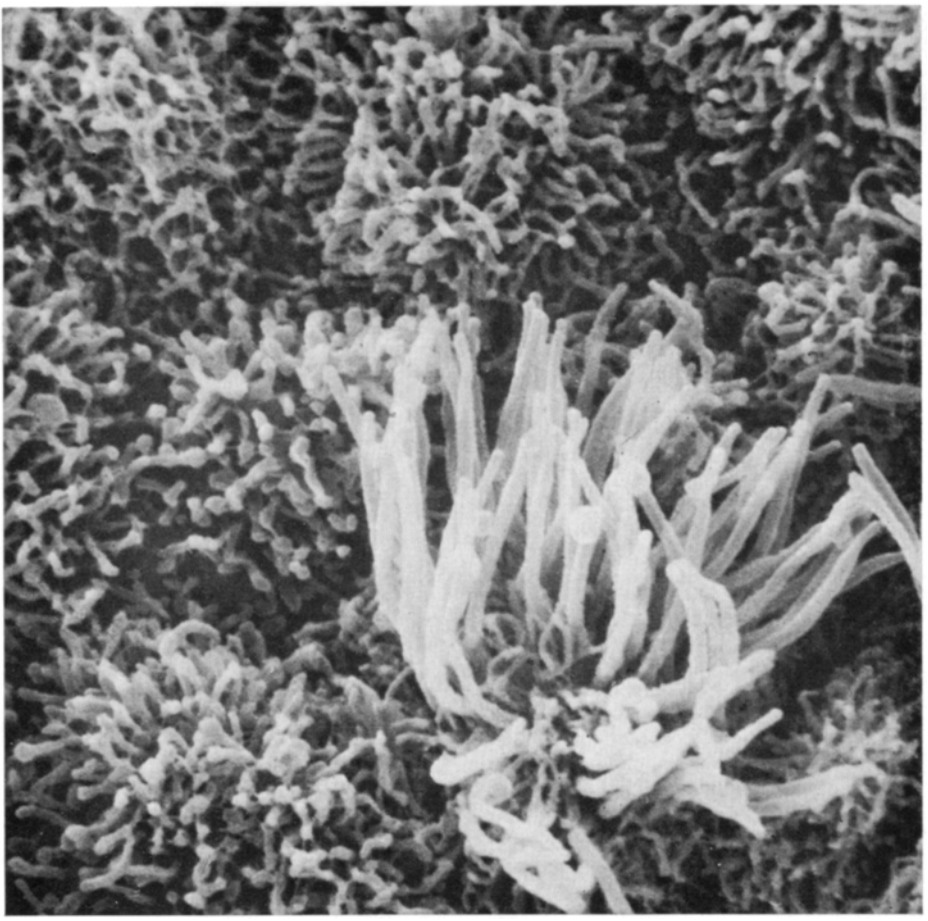

Fig. 3. Endometrial surface during the follicular phase. A ciliated cell is situated among the secretory cells. Its kinocilia are tall, and at their bases minor projections are seen. The secretory cells possess several microvilli. × 17 000.

known. However, the change in property of the maternal cell surface observed in some rodents is probably a sufficiently important and basic process of implantation to be assumed to be valid also in humans. If so, scanning electron microscopy can, in a simpler way than transmission electron microscopy, reveal the surface change necessary for implantation.

The appearance of a great number of apical protrusions during the time of implantation also corresponds to what occurs in some other species. Thus, in both the monkey and in the rat and mouse similar structures have been observed (5). It has been suggested that in the mouse the protrusions, besides furnishing the blastocyst with nutrients, also form a site of early communication to the blastocyst by having a tight contact with the trophoblast membrane (6). Considering the frequent occurrence of apical protrusions in the human endometrium, similar mechanisms might well be working also at implantation of the human blastocyst.

The present experiments have demonstrated that scanning electron microscopy reveals in an instructive way two surface specializations which the human endometrium has in common with some other species and which seem to be of importance at implantation. Therefore, scanning electron microscopy can be used with advantage to examine the surface epithelium when looking for the working mechanism of various contraceptive agents in humans.

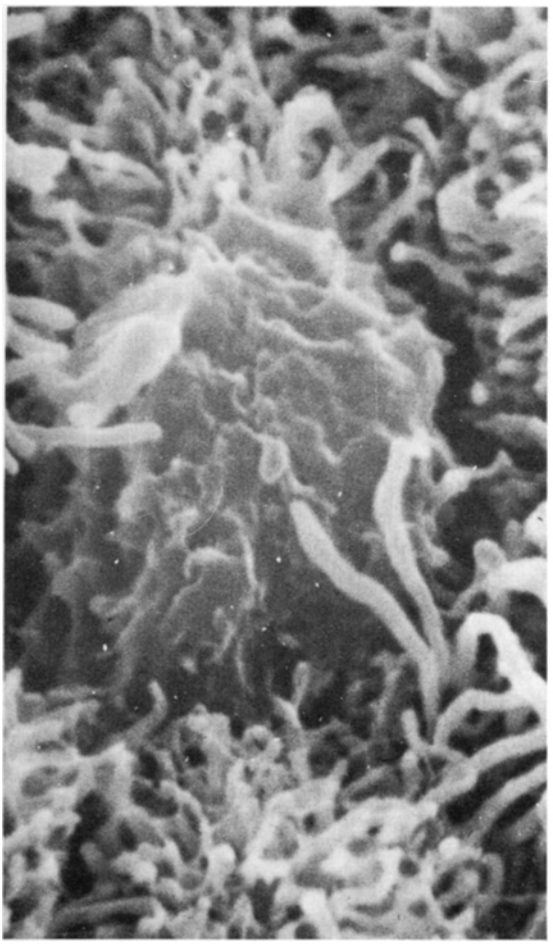

Fig. 4. Endometrial surface during the luteal phase. The microvillous surface of several secretory cells has been changed into bulging areas with irregular ridges. × 24 000.

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Fig. 5. Endometrial surface during the luteal phase. Many apical protrusions are observed on the surface of the secretory cells. Some ciliated cells are scattered among the secretory ones. Mag. × 5 500.