TOPOGRAPHY OF ACCESSORY STRUCTURES OF CHEMO- AND MECHANORECEPTOR FORMATION OF THE ADULT RAT TONGUE STUDIED BY SCANNING MICROSCOPY

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The surface of the tongue of an adult rat was investigated with the scanning electron microscope. On the basis of the results the structural organization of chemo- and mechanoreceptor formations of the tongue was described, an attempt was made to explain their functional role, and a topographic map of them was drawn.

KEY WORDS: mechanoreceptors; chemoreceptors; oral cavity; tongue.

The use of the scanning electron microscope to study a sensory surface not only enables the ultrastructural details of the various formations present to be investigated, but also makes the detailed examination of their spatial relations and topography possible. An interesting object for investigations of this type is the tongue. Attempts have already been made previously to examine individual parts of the tongue by methods of light [1, 2, 3, 5], and scanning [4, 6] microscopy. However, the receptor formations of the whole surface of the tongue have not yet been investigated. Nevertheless, knowledge of the structural organization of the accessory apparatus of the sensory formations of the tongue would help to shed light on their role and mechanisms of function.

The object of this investigation was to study this problem with reference to the rat tongue. By scanning electron microscopy, not only were the morphological and functional characteristics of the various receptor formations on the dorsal surface of the tongue ascertained, but an attempt also was made to map them, and the results could be of considerable interest to experimenters studying the sensory apparatus of the tongue.

EXPERIMENTAL METHOD

The tongue was removed from the oral cavity in the region near the root, and thoroughly washed for 10-15 min, at first in running tap water and later in distilled water. The preparations were then kept for 12 h in 10% formalin solution, gently dried, and quickly frozen. The frozen tongue was dried slowly above a hydrophilic substance (anhydrous $CaCl_2$) for 4-5 days at −12°C. The preparations thus obtained were studied in the "Stereoscan" scanning microscope with the stage tilted to different angles. The whole dorsal surface of the adult rat tongue, cut into six parts, was examined consecutively.

EXPERIMENTAL RESULTS

The anterior free part of the tongue (Fig. 2A, I) has two types of papillae on its dorsal surface (Fig. 1a): a smaller number of fungiform and a larger number of filiform papillae, performing mechanoreceptor functions. The fungiform papillae are distributed almost uniformly over the whole surface of the tip of the tongue. No definite order of their arrangement could be discovered. All the fungiform papillae of the adult rat have pores **(Fig. 1b)**. The number of fungiform papillae varies and may reach 150 [3].

The filiform papillae as a rule are wide at their base (Fig. 1c); in the adult rat they appeared to rise above the fungiform papillae (Fig. 1a), and in preparations that are not deformed their regular structure, due to their hexagonal arrangement, is clearly visible (Fig. 1d).

The dorsal surface of the body of the tongue (Fig. 2, II) has no taste papillae and contains two other types of papillae which evidently perform mechanoreceptor and mechanical functions.

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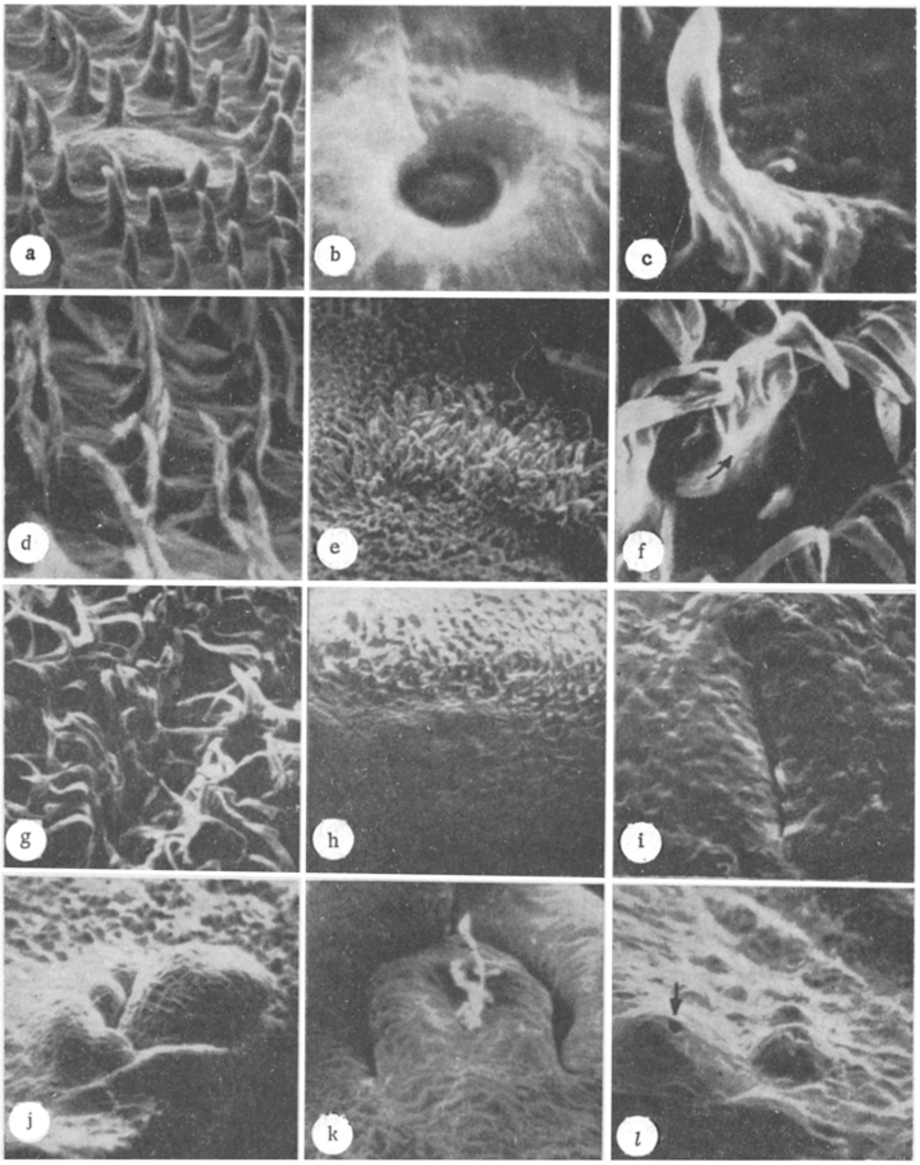

Fig. 1. Papillae of tongue under scanning microscope. a) Fungiform papilla surrounded by filiform papillae, 200 ×; b) pore of fungiform papilla, 11,000 ×; c) filiform papilla, 1100 ×; d) order of arrangement of filiform papillae on dorsal surface of tip of tongue, 220 ×; e) conical papillae on base of tongue (arrow), 50 ×; f) digitate papillae. Arrow points to body of papilla, 500 ×; g) order of arrangement of digitate papillae on dorsal surface of tongue, 200 ×; h) arrangement of foliate papillae on dorsolateral part of body of tongue, 50 ×; i) cleft of foliate papilla, 250 ×; j) circumvallate papilla, 100 ×; k) horseshoe-shaped furrow of circumvallate papilla, 200 ×; *l*) lymphoglandular papillae on root of tongue. Arrow indicates pore of one papilla, 200 ×.

Large conical papillae (Fig. 1d) are found on the frontal surface of the elevated part of the base (Fig. 2, 5) and in their external appearance very closely resemble filiform papillae, except that they are three or four times larger. In the medial part of the base the conical papillae are twice as large as those found in its lateral part.

The remainder of the surface of the body of the tongue (Fig. 2, 6) is covered by papillae, which many workers also call filiform. However, a closer examination showed that these papillae differ from the filiform in having a larger body which gives off digitate processes (Fig. 1f, g). The number of these processes is smaller in papillae located in the lateral part of the tongue. The largest number of processes which could be observed in the papillae of the medial part of the tongue is 4 or 5. Lengthening of the digitate processes of papillae lying nearer to the root of the tongue must also be noted. These digitate papillae usually commence

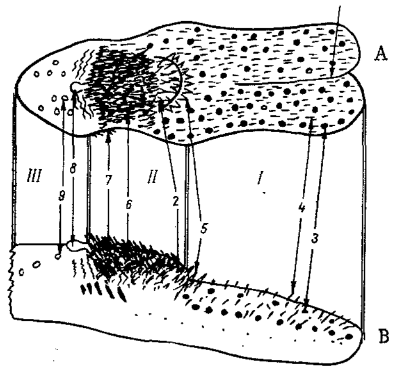

Fig. 2. Topography of papillae on surface of tongue. A) Dorsal surface of tongue; B) dorsolateral surface of tongue. I) Tip of tongue, II) body of tongue, III) root of tongue. 1) Longitudinal groove; 2) base of tongue; 3) fungiform papillae; 4) filiform papillae; 5) conical papillae; 6) digitate papillae; 7) foliate papillae; 8) circumvallate papilla; 9) lymphoglandular papillae.

at the base and extend as far as the root of the tongue. These papillae also are arranged in fairly clear rows on the surface of the body of the tongue in the lateral-medial direction (Fig. 1g). On the dorsolateral surface (Fig. 2, 7), at the boundary between the body and root of the tongue, there are between 4 and 6 foliate papillae (Fig. 1h, i). Some of them may be reduced in adult animals.

The digitate papillae converge on a single circumvallate papilla (Fig. 2, 8), located in the midline of the tongue (Fig. 1j). The circumvallate papilla of the rat is rather different in structure from the corresponding papillae of other mammals: The ridge surrounding the middle part of the papilla is not closed anteriorly and the groove of this papilla is horseshoe-shaped (Fig. 1k).

Approaching the root of the tongue, posteriorly to the circumvallate papilla, lie the lymphoglandular papillae (Fig. 1*l*, Fig. 2, 9), most of which have pores.

On the whole dorsal surface of the adult tongue it is thus possible to distinguish three types of papillae carrying tase buds and the same number of types of papillae which evidently perform mechanoreceptor and mechanical functions.

Considering that the structure of the dorsal surface of the tongue is closely linked with the dietary habits of the animal and the methods of mechanical processing of the food, the functions of the different formations of the rat tongue may perhaps be examined from this point of view. A distinguishing feature of the diet of these animals, as of most other rodents, is that primary mechanical processing of the food consists of chewing and initial fragmentation of the food with the front teeth (incisors). The final grinding of the food is done by the molars, which have a special structure. The chemo- and mechanosensory system of the rat tongue is adapted to this type of food processing. For instance, it can tentatively be suggested that the filiform papillae of the tip of the tongue are mechanoreceptor formations which play a primary role in the sensory evaluation of the mechanical components of the food. Evidence in support of this is given by the spatial arrangement of these formations relative to the fungiform papillae. In the adult rats they are always located above the taste papillae and, consequently, they are the first structures of the tongue which come into contact with the food stimulus. Evidence that the filiform papillae perform a mechanoreceptor function is given by their distinct hexagonal arrangement on the dorsal surface of the tongue, which may be important in connection with spatial coding of information about the mechanical stimulus. The fungiform papillae, located at the edges and on the dorsum of the free part of the tongue, participate in evaluation of the taste of the food. That is why all the fungiform papillae of the adult tongue have pores. The next area, where the chemical component of the food must be evaluated, is the region of the molar teeth, where the food is ground and moistened. This evaluation is done by the chemoreceptor formations of the foliate papillae.

The dorsal surface of the body of the tongue has no taste papillae. The role of formation in this part of the tongue can evidently be reduced to a purely mechanical function and to evaluation of the mechanical properties of the food. The base of the tongue is evidently a natural barrier which prevents the masticated food from falling toward the root of the tongue. It ensures that the basic flow of the food passes around the base toward the molar teeth. The large conical papillae may also be mechanoreceptor formations. The long and delicate processes of the digitate papillae evidently help to direct the flow of already masticated food into the pharynx. This explanation is supported by the presence of numerous "grooves," formed by digitate papillae, running toward the circumvallate papilla. Evaluation of the taste of the food in the course of swallowing is a function of the chemoreceptors of the circumvallate papilla.

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ROLE OF CARBOHYDRATE – PROTEIN COMPLEXES IN THE ORGANIZATION OF THE MICROSTRUCTURE OF FIBROUS CONNECTIVE TISSUE

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Samples of tendon and fascia, treated with enzymes possessing amylolytic and proteolytic activity (protorysin, trypsin) were investigated by scanning electron microscopy. Destruction of carbohydrate–protein complexes leads to disappearance of the characteristic morphological features of the collagen fibers. Construction of the collagen fiber was shown to be based on a network of thin anastomosing fibrils, forming a carcass connected with the carbohydrate–protein matrix. It is argued that the reticular structure is a general principle in the structural organization of fibrous connective tissues.

KEY WORDS: Scanning electron microscopy; connective tissue; collagen fiber; protorysin; trypsin.

The use of modern methods of morphological analysis combined with enzymic action on complexes of biopolymers has provided fresh opportunities for the study of their role in the structural organization and functions of different tissues. A current direction of such research is the study of the role of carbohydrate–protein complexes in the structural organization of fibrous connective tissue. This is due to the participation of the substances mentioned above in pathological processes connected with lesions of the connective tissue, and also their influence on some important biomechanical properties of the fibrous carcass [7, 10, 12]. The presence of protein complexes of glycosaminoglycans and glycoproteins in the collagen fiber has been established and evidence has been obtained that these complexes participate in fibrillogenesis and are concerned in the orderly union of fibrils into bundles [8, 11, 13].

The object of the present investigation was to study the role of carbohydrate–protein complexes in the organization of the microstructure of fibrous connective tissue. For this purpose a morphological analysis was made of the connective tissue of fascia and tendon after treatment with enzymes decomposing carbohydrate–protein complexes.

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