SCANNING ELECTRON MICROSCOPIC STUDY OF THE HUMAN FUNGIFORM PAPILLAE

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ABSTRACT

Human lingual mucosa reveals a highly differentiated papillary organization. The fungiform papillae are grouped as gustatory papillae as they contain taste buds and function as sensory end organs. Taste pores, the surface openings of the taste buds, play important roles both in preneural and neural phases of taste perception by receiving external chemical stimuli and its transduction. Scanning electron microscopy [SEM] of the dorsal lingual surface was used to study the morphology and ultrastructure of the fungiform papillae in human. The lingual samples were prepared from 20 unfixed cadavers at Burdwan Medical College and after proper processing they were examined under SEM at the University of Burdwan. The results demonstrated that these gustatory structures were dome shaped with round base and their diameters were approximately 300 - 800 μm. They were surrounded by shallow circular furrow with small mucosal pad encircling the furrow. The study verified that the covering epithelium of the fungiform papillae is stratified squamous type and frequent desquamation of lining cells was also noticed. Elevated cell margin with distinct intercellular borders were evident in the lining epithelium. Single or multiple circular taste bud pores opened on the upper surface of some of these papillae while in others taste pores were absent. Taste bud pores had diameter of about 3-6 μm. On higher magnification SEM images established the presence of lattice patterned microridges over the epithelial cell surfaces. Within these microridges microgrooves or mucous pits were observed. These observations were related with specific mechanical and gustatory roles.

KEY WORDS :- Fungiform papillae, Human tongue, Taste buds, Ultrastructure

INTRODUCTION

The Papillae of the tongue are projections of the corium. The different morphologies of the tongue in vertebrates are generally the result of different strategies for capturing and manipulating food, grooming or vocal modulation. The lingual papillae contribute to some of these functions and in addition they obtain the taste sensation. So, it is possible to speak of two types of papillae, mechanical and gustatory. The former performs the functions of trapping and creating a frictional surface for food and are important components for grooming functions. The latter are those, which contain the sensory end organs of taste, the taste buds. Fungiform papillae represent this group. Via small openings in the tongue epithelium, called taste pores, parts of food dissolved in saliva come into contact with taste receptors. These receptors are located on top of the taste bud cells that constitute the taste buds. The taste receptor cells send information detected by them to the gustatory areas of the brain via different cranial nerves.

Galen (Claudius Galenus, 129 217 A.D.) hypothesized about role of lingual nerve in gustatory sensations, a concept yet resonant in contemporary anatomy. In 1665 Lorenzo Bellini portrayed about papillae on human tongues as innumerable mushrooms emerging between fine, densely standing blades of grass. Early studies on the morphology of the surface of the tongue described the shape, situation and types of lingual papillae in different groups of mammals. Taste buds were identified initially on the barbels by Leydig in 1851 and described as Becherförmige Organe (goblet-shaped organs). In 1863 Schulze subsequently suggested they were chemosensory structures. Similar organs in mammals were described as Schmeckbecher [taste goblets] by Lovén in 1868 and Geschmacksknospen [taste buds] or Geschmackszwiebeln [taste onions] by Schwalbe in 1868.[1] Their location within lingual papillae, which had been already correlated as the loci of taste perception, lent credence to their identity as taste sensor organs. In later years, various authors studied

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the morphology of the lingual surface of tongue with the scanning electron microscope (SEM).[2-4]

The fundamental question of how tastants are perceived has been addressed for more than two millennia. The concepts, theories, and experimental proofs proposed in the past have been discarded, so that our present day concepts can be incorporated. A better knowledge of the tongue and peripheral gustatory anatomy may help us to improve our understanding of one of the most peculiar models of dietary adaptation known. The purpose of the present study is to know ultrastructural features of the fungiform papillae in human, paying particular attention to the lining epithelium and gustatory pores. And also to evaluate those data in light of the current literature and comparing them with those found in other primates to provide comparative anatomical information to fill in the gaps in understanding and establishing basic principles.

MATERIAL AND METHODS

Cadavers numbering twenty (20), aged between 63-78 yrs, donated to the Department of Anatomy, Burdwan Medical College were subjects of this study. Only those brought shortly after their death and without any evident substantial abnormalities were selected for this study. Relevant history was taken from relatives, whenever feasible. Before fixation of all these cadavers in 10% formalin for long term preservation, tongues were dissected out after disarticulation of mandible by using standard techniques. The specimens looked fresh without any gross irregularity. Small blocks of tissue were collected from anterior two thirds of the dorsum of the tongue.

Primary fixation was done in phosphate buffered glutaraldehyde-formalin mixture at pH 7.2-7.4 for 4 hours. The materials were then thoroughly rinsed in phosphate buffer and post fixed in 1% osmium tetroxide for 90 minutes. Then, tissues were rinsed again in phosphate buffer and dehydrated through a series of ascending concentration of ethanol to 100% amyl acetate. After that, the samples were dried in critical point dryer, using liquid carbon dioxide by Hitachi HCP-2 Apparatus. Finally dried samples were cut into small parts and mounted on an aluminium stab by using a double-sided adhesive tape. Then it was placed in an ion coater unit and coated with a thin layer of gold [IB2 ion coater Sputter Device]. After gold coating, the samples were observed by S530-Hitachi SEM instrument at 15kv

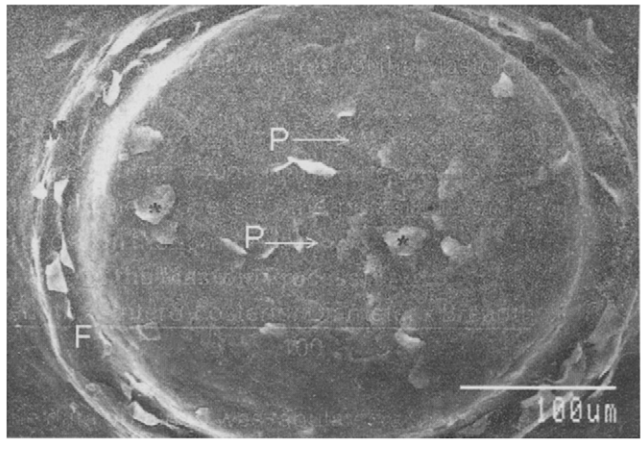

FIGURE 1 : HUMAN FUNGIFORM PAPILLA (VIEWED FROM ABOVE) [MAGNIFICATION 300X]
P→ TASTE BUD PORE; * DESQUAMATED CELL ; F : circular furrow; M: annular Mucosal pad

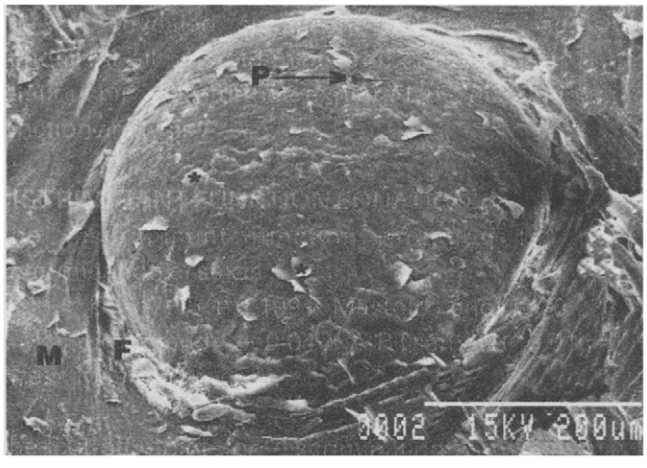

FIGURE 2 : HUMAN FUNGIFORM PAPILLA (VIEWED FROM SIDE) [MAGNIFICATION 200X]
P→ TASTE BUD PORE; * DESQUAMATED CELL ; F : circular furrow; M: annular Mucosal pad

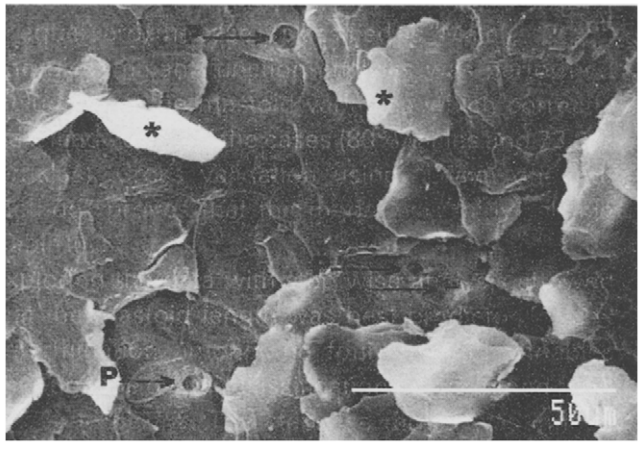

FIGURE 3 : HUMAN FUNGIFORM PAPILLA (LINING EPITHELIUM) [MAGNIFICATION 1000X]
P→ TASTE BUD PORE; * DESQUAMATED CELL ; J: INTERCELLULAR JUNCTION

FIGURE 4 : HUMAN FUNGIFORM PAPILLA (MICRORIDGE-MICROGROOVE PATTERN AND PROMINENT NTERCELLULAR JUNCTION) [MAGNIFICATION 3000X]
J: INTERCELLULAR JUNCTION

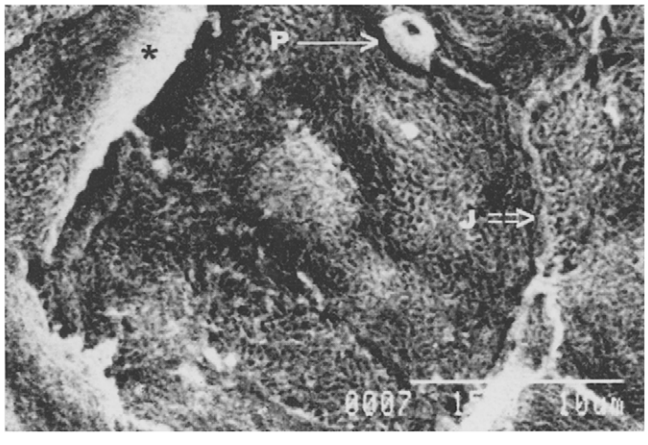

FIGURE 5 : HUMAN FUNGIFORM PAPILLA (MICRORIDGE-MICROGROOVE PATTERN AND TASTE BUD PORE)[MAGNIFICATION 4000X]
P→ TASTE BUD PORE; * DESQUAMATED CELL ;
J: INTERCELLULAR JUNCTION

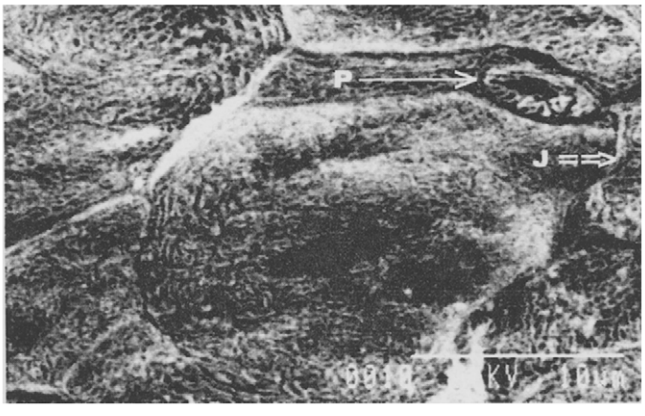

FIGURE 6 : HUMAN FUNGIFORM PAPILLA (TASTE BUD PORE) MAGNIFICATION 4000X]
P→ TASTE BUD PORE;
J: INTERCELLULAR JUNCTION

(Department of USIC, University of Burdwan).

RESULTS

The fungiform papillae were scattered among the filiform papillae over the anterior two third of the dorsum of the tongue, especially on the lateral sides and at the tip. The fungiform (mushroom like) papillae were large dome shaped eminences on the lingual mucosa with an almost spherical body with a round base and a flattened upper surface(fig.1). Though, there was no morphological uniformity among these papillae and some of them had convex upper surface (fig.2). Diameters of fungiform papillae were ranged between 300 - 800 μm at their free surface which is larger than the diameter at their base. Each fungiform papilla was surrounded by a shallow papillary circular furrow and a tiny annular mucosal pad encircling that furrow (fig.1, 2).

Under greater magnification (1,000 X) it was evident that the lining epithelium was stratified squamous type on the surface of the papilla, which were polygonal in shape. Shedding of cells from the outer layer of the stratified squamous epithelium, exposing the next layer squamous cells were also discernible (fig.3). Further magnification (3,000 X) revealed a network of clear microridges on the cell surface which maintained specific orientation, though that orientation differed from cell to cell. In between lattice of microridges there were well defined microgrooves or mucous pits. The elevated margins of the epithelial cells ending in distinct intercellular borders were also noticed (fig.4,5).

Circular taste pores or gustatory pores were observed as sharp dips in the epithelium of the fungiform papillae. They were mostly present on the upper free surface of the papillae and not in the walls. In fairly large number of papillae pores were not detectable, while in others there were up to three pores in a papilla. Only a few papillae demonstrated four or more taste pore openings(fig.3). Most taste pores opened in the form of a rounded crater with a diameter of about 3-6 μm and were elevated slightly above the surface of the papilla. These taste pores are the surface apertures of the taste buds and are enclosed by tightly connected taste bud cells(fig.6).

DISCUSSION

Due to their morphological heterogeneity, fungiform papillae have been variously described as papillae clavatae, capitatae, lenticulares, obtusae, majores, mediae.[5] Following the surface in a posterior

direction from the midline of the tip toward the back of the tongue, fungiform papillae become progressively larger in size.[6] Each hemispherical papilla is fenced by mucosal annular pad which regulates the access and retention of the saliva in the groove by means of their smooth muscular fibers.[7]

The fungiform papillae in human are lined by stratified squamous epithelium. These superficial cells are polygonal in shape with prominent intercellular margins and microridge-microgroove patterns. These microridges protect the superficial cells keeping more quantity of mucous within microgrooves as mucous pits.

Authors have reported in other primates about microplicae in the surface epithelium, where a microridge pattern, a supposedly system of microchannels and a central round pit may be detected.[8] Such microridges have generated discussion in the literature regarding to their functionality. Some authors believe that the microridges could be linked to mucous retention, thus, making the papillae more efficient in regard to resistance to friction.[2] However, in this study we observed specifically oriented microridges in these papillae along with gustatory pores on papillary surface. This observation points towards facilitatory role of microridge-microgroove patterns in reaching tastants into the taśte pores. So, this indicates additional gustatory function of these pattern instead of solely the mechanical function.

Sensory taste pores in taste buds play an important role in the reception of external chemical stimuli with receptor microvilli. In the literature, the diameter of taste bud pore has been reported as ranging from 1 to 7 μm in mammals. The cells in the surface of the taste buds are connected tightly with each other and with the surface epithelium.[9] Above tight junctions taste bud receptor cells form microvilli providing considerable larger surface area.[10] That microridge-microgroove pattern may play a part in conduction of particles diluted in saliva, allowing a better access to the pore, thus providing, greater tasting efficiency. However, further functional studies are required to evaluate such hypothesis.

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