The morphological development of lingual papillae at prenatal, postnatal, young and adult stages of white albino mouse

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Abstract

Purpose: The purpose of this paper is to describe the morphological structure of white albino mice lingual mucosa at the ultra structural level by scanning electron microscopy. Specimens taken from tongue of mice in different developmental stages (prenatal, postnatal, young and adult) and examined after technical procedures.

Results: Our results show that the tongue of these mice has a number of unique morphological features that are different from the tongue of other rodents consequently to allow identifying their species-specific features. In fetuses (prenatal stage), the tongue surface showed thickening of epithelium appear as undifferentiated papillae. In newborn (postnatal stage), rudiments of more differentiated papillae begin to appear. In young stage, further differentiation of the epithelium rudiments into developed papillae and this continued to mature in adult stage in which taste buds were observed.

Conclusion: Our findings have shown the features of the tongue structure of white albino mice at the ultra structural level in different developmental stages. The data analysis revealed that mucous membrane of the tongue contains large number of papillae that appear in different stages. Gustatory papillae (fungiform, foliate and vallate) appear in early stages while mechanical ones (filiform and multifilamentary) appear later, each of these papillae has a different shape, size and location. With the advancement of growth, three types of filiform papillae appeared as small-finger like projections with rounded tips associated with much more keratinization of their free ends, well developed foliate and multifilamentary papillae that appear in adult stage. As well as one large and similar smaller circumvallate papillae. The gustatory fungiform papillae appear at early stages of development and were more differentiated gradually till adult stage.

However, we have received data for a complete picture of structure of this organ that will be useful in further experimental and morphological studies of white albino mice.

Keywords: Albino mice, lingual mucosa, papillae, scanning electron microscopy, tongue

Introduction

The morphology of the tongue and papillae widely vary in different species of mammals through the influence of the environment, functional activities and way of capture and manipulation of the food, swallowing, animal care and vocal modulations of animals [1-3].

During embryogenesis of the mouse, the developing tongue divided by terminal sulcus into an oral part anteriorly and pharyngeal part posteriorly, its dorsal surface has four types of lingual papillae: fungiform, circumvallate, foliate and filiform that distributed in a specific pattern [4].

Fungiform, foliate and circumvallate ones which known as gustatory papillae and contain taste buds act as sensory organs, these papillae distributed over the tongue surface in a distinct spatial pattern [5]. In central and lateral regions, circumvallate and foliate papillae found respectively but the fungiform ones

distributed among the filiform papillae that appear larger and more abundant in a stereotyped array in longitudinal rows on the anterior tongue with the medial rows forming prior to more lateral ones and the more anterior papillae developing first within each row [6].

Tongue mucosa differed markedly from that of the oral cavity in covering by functionally masticatory mucosa lined with different types of lingual papillae [7]. In mammals, taste buds are organized by taste receptor cells that located within specialized papillae [8,9] stated that taste papillae develop prenatal while taste buds appear subsequently within these papillae at the time of parturition in rodents. Thus; the first step in the gustatory system development of mammals is the papillae formation. Taste buds are discrete collections of nearly 40 to 60 cells within epithelial layer of papilla appear as organ with oval sensory end involved in perception of chemical stimuli and taste transduction [10-12].

Vallate papillae are found that were round-flat or long-flat, surrounded by a prominent circular groove and a thin annular pad, one circumvallate papilla is located in the middle part of the terminal sulcus in rodents, about 7 to 9 circumvallate papillae are located along the terminal sulcus in humans. Foliate papillae found posteriorly on the sides of one-third of the human tongue which were well developed at birth but revert to a rudimentary structure in adults; keratinisation of the covering stratified squamous epithelium was relatively weak, taste buds were observed in the epithelium of fungiform, vallate and foliate papillae [6].

Taste buds not found in filiform papillae that cover the entire anterior part of the tongue and consist of cone-shaped structures, each of them with a core of connective tissue covered by an epithelium appearing hair-related keratins [13], it also consist of larger main papillae with smaller secondary papillae on their anterolateral portions, these secondary papillae are well distributed over the anterior two-thirds of the tongue but very rare or absent in the posterior third [6].

The objective of this paper is to describe the research results of the morphological structure of white laboratory albino mice' tongue at different stages of development at the ultra structural levels by scanning electron microscopy for obtaining more detailed and complete information about the structure and spatial organization of the tongue.

Material and methods

The study was conducted on 10 albino mice for each stage (prenatal, postnatal at birth, young at 15 day old and adult), adult and young mice were housed in independent cage units and subject to the full local protocols and scientific research ethics on animals as well as the application of biosafety security requirements and bio-security through the steps of experiments. Each mouse was euthanized followed by scanning electron microscope study: dorsal surface of the tongue that was fixed in 2.5% buffered glutaraldehyde in 0.1 M PBS pH 7.4 at 4C for 2h. Followed by washing three times with PBS (10 min. each)

and Post fixed in 1% Osmic acid for (30min).

The specimens were washed three times with PBS (10 min. each), then dehydrated with ascending series of ethyl alcohol (30, 50, 70, 90% and absolute alcohol) infiltrated with acetone, each concentration for 30 min.

Samples were dried in SPI supplies®, critical point drying machine using liquid CO₂, mounted on aluminum stubs, coated with gold in a SPI- Module™ Vac/ Sputter and photography using JEOL, JSM- 5200 LV scanning electron microscope, Japan.

Results

The tongue of white laboratory mice is a well developed muscular organ that has an elongated shape in the rostro-caudal direction with an expanded tip. The intermolar prominence is the widest and thick part of the tongue located between the root and body of the tongue found only in the tongue of adult mice. The median sulcus extends from the tip to the middle of the back of the tongue that appears in young and adult stages only. Presence of a large number of papillae which are different in size, shape and localization on the tongue dorsal surface was observed under scanning electron microscope at different stages.

The dorsal surface in tongue of prenatal mice: is covered by partially keratinized stratified squamous epithelium; different types of undifferentiated papillae are arranged on the dorsal surface of prenatal tongue. These papillae are covered with dense cornification of the epithelium giving polygonal and round shape.

The fungiform papillae are less developed "less differentiated" and resemble a dome-like structure on both lateral surfaces with out any taste buds.

In the middle tongue, small foliate papillae appear but larger ones are located near the root of the tongue. The circumvallate papillae are developed and located among foliate papillae, their form resemble the fungiform ones but smaller in size and have one or two taste bud at middle of it, against fungiform ones they form circumferential groove around themselves.

In the tongue of new born albino mice, its dorsal surface covered with different types of more developed papillae than that found in prenatal tongue, these papillae appear as small cornified conical papillae in anterior tongue but large cornified foliate papillae at middle and undifferentiated ones appear as keratinized epithelium at posterior tongue that have undeveloped groove with out taste buds.

The fungiform papillae appear to be more differentiated with taste buds "as vallate papillae" and arranged at both lateral sides and middle of the tongue.

In young albino mice, the whole tongue is covered with more organized filiform papillae and fungiform ones with distinguished taste buds.

Primitive intermolar prominence with primitive groove without taste buds begins to appear in this stage as widest and thick part of the tongue located between the root and body of the tongue. The median sulcus also begins to appear and extends from the tip to the middle of the back of the tongue.

The anterior tongue covered with small long conical and filiform papillae, these filiform papillae branched to give the biramous shape at middle tongue. Well developed vallate and fungiform papillae appear at posterior tongue.

The tongue of adult mice is the most developed and differentiated tongue that have fungiform papillae large and numerous at the tip of the tongue. Well developed small and long conical papillae at the anterior tongue, branched filiform papillae cover the middle tongue.

The well developed intermolar prominence with taste bud and deep groove localized between the root and body of the tongue and formed by foliate papillae which are densely arranged to each other and have sharp splintered apices that covered by keratinized stratified epithelium. The multifilamentary papillae are located behind the intermolar prominence. They have a common base from which one or two or three long and thin filaments depart (**Figures A-D**).

Discussion

The results of this study supplement the description of the ultramicroscopic structure of papillae and dorsal surface of the tongue of white laboratory albino mice at different developmental stages, tongue morphology of these mice is substantially similar to the tongue structure of previously studied mammals. However, these results showed that tongue of these mice has a number of unique morphological features different from that of other rodents allow in identifying their species-specific features.

In this study, tongue of white albino mice appear oblong in its shape in the rostro-caudal direction with an expanded tip, while tongue of white laboratory rats and blind mole rats described by [6,14] has an oblong shape and narrows toward the rounded tip at the same time, [15] described tongue of bank vole as oblong with an expanded tip and a narrow back.

Filiform papillae of young and adult albino mice are densely distributed on the dorsal surface of tongue while the distance between them is increased from tip to root of the tongue and become lower and wider, these results similar to that found in white laboratory rats [6].

[14-16] found that filiform papillae of blind mole rat, shrew and bank vole are also densely distributed on the dorsal surface of tongue, but at the same time they are gradually increased in size from the tip to the root of the tongue, these papillae don't appear yet in prenatal and postnatal mice.

On the other hand, fungiform papillae with taste buds in the middle of each one located among filiform ones on the tip of the tongue of all stages of white albino mice either well or less developed but well developed in white laboratory rats, it have a rounded shape and resemble a mushroom cap or dome. In guinea pig, bank vole and flying squirrel, these papillae are located on tip between filiform papillae and lateral surfaces of tongue body while near the edges of the tongue are smaller than in the central part and found only on arch of the tongue in the shrew [15,17,18].

Conical filiform papillae of white laboratory rats, young

Figure A. The structure of the prenatal tongue of white albino mice.

Fig. 1A: Scanning electron micrograph of the dorsal surface of the whole prenatal tongue of albino mice showing distribution of different types of undifferentiated papillae (UP).

Note: less differentiated (developed) fungiform papillae (UFu) arranged laterally at both sides of the tongue.

Fig. 2A: Scanning electron micrograph of the anterior prenatal tongue of albino mice showing dense cornification of the epithelium giving polygonal (PUP) and round undifferentiated papillae (RUP).

Fig. 3A: Scanning electron micrograph of the middle upper and lower prenatal tongue of albino mice showing small foliate papillae (FP). Note: keratinization of epithelium at lower border of middle tongue (KE).

Fig. 4A: Scanning electron micrograph of the posterior prenatal tongue of albino mice showing foliate papillae (FP).

Fig. 5A: Scanning electron micrograph of the posterior prenatal tongue of albino mice showing the difference between vallate (VP) and (FuP) fungiform papillae.

and adult white albino mice have the smaller length and are located on the back near the root on the long distance from each other than the previous filiform papillae. [15] observed that these papillae are the highest and numerous as well and they have the widest basis among all filiform papillae of the tongue of bank vole, while [14] observed these papillae in blind mole rat are long, thin, have irregular shape, pointed and represented by large quantity.

Number of circumvallate papillae among the rodents varied widely, it is large papilla surrounded by roll and located on the posterior part on the medial line of tongue not only in prenatal, young and adult white albino mice but also in white laboratory rat, mouse and bank vole [19,20].

Figure B. The structure of the postnatal tongue of white albino mice.

Fig. 1B: Scanning electron micrograph of the dorsal surface of the whole newborn tongue of albino mice showing distribution of different types of developed cornified papillae (DP). Note: more differentiated (developed) fungiform papillae (FuP) with taste buds arranged laterally at the middle and both lateral sides of the tongue.

Figs. 2,3B: Scanning electron micrographs of the anterior newborn tongue of albino mice showing small cornified conical papillae (CCP).

Fig. 4B: Scanning electron micrograph of the middle newborn tongue of albino mice showing large cornified foliate papillae (CFP).

Fig. 5B: Scanning electron micrograph of the posterior newborn tongue of albino mice showing undifferentiated papillae (UP). Note: undeveloped groove without taste buds.

Fig. 6B: Scanning electron micrograph of the posterior newborn tongue of albino mice showing vallate papillae (VP) with taste buds (TB).

Figure C. The structure of the young tongue of white albino mice.

Fig. 1C: Scanning electron micrograph of the dorsal surface of anterior and middle young tongue of albino mice showing distribution of more organized fungiform papillae (FuP) with distinguished taste buds among different categories of papillae. Note: less differentiated (developed) median sulcus (MS) appear at the half of the tongue.

Figs. 2, 3C: Scanning electron micrographs of the anterior young tongue of albino mice showing small, long conical (LCP) and filiform papillae (FP).

Figs. 4, 5C: Scanning electron micrographs of the middle young tongue of albino mice showing uni (UFP) and biramous (BFP) filiform papillae.

Figs. 6, 7C: Scanning electron micrographs of the posterior young tongue of albino mice showing filiform (FP), vallate (VP) and fungiform papillae (FuP).

Flying squirrel, shrew, and American beavers have three circumvallate papillae [3,18,21-23]. Two circumvallate papillae on both sides of posterior part of the tongue are located in blind mole rat and guinea pig [14,17,22].

The roll around papilla formed by thick fold of mucous membrane of the tongue caused by deep circumferential groove formation between bodies of papilla and roll that described in this study, this observation is similar to the studies of [20,21].

In this study, the back of the adult tongue has circumvallate papillae which are similar to the large circumvallate papillae that appear in other stages have been found between the conical filiform papillae, these papillae form the circumferential groove

around themselves and have one or two taste buds. However not all rodents have these papillae [20,24,25].

[15,26] studied the medial sulcus of the tongue of many rodents and noticed that is of different size and is a typical specific feature, this study showed that the sulcus begin to appear and extends from the tip to the middle of the back of the tongue in young albino mice, but in adult stage, it is well developed. [17] found that these sulcus is absent in guinea pig, but it has structural features in mouse, bank vole and American beavers [15,19,21,23].

Primitive intermolar prominence with primitive groove without taste buds begin to appear in young stage as widest

Figure D. The structure of the adult tongue of white albino mice.

Fig. 1D: Scanning electron micrograph of anterior dorsal surface of adult tongue of albino mice showing fungiform papillae (FuP) large and numerous at the tip of the tongue. Note: well developed median sulcus (MS) at the half of the tongue.

Fig. 2D: Scanning electron micrograph of the anterior adult tongue of albino mice showing small (SCF) and long conical papillae (LCF). Note: well developed fungiform papillae with taste buds.

Fig. 3D: Scanning electron micrograph of the middle adult tongue of albino mice showing branched filiform papillae (BrF) on the border and conical papillae (CP) near the median sulcus.

Fig. 4D: Scanning electron micrograph of the posterior adult tongue of albino mice showing intermolar prominence (IP) near the root of the tongue surrounded by multifilamentary papillae (MP).

Fig. 5D: Scanning electron micrograph of the posterior adult tongue of albino mice showing biramous (BFP) and branched filiform papillae.

Fig. 6D: Scanning electron micrograph of the posterior adult tongue of albino mice showing uniramous (UFP) and biramous filiform (BFP) papillae.

Fig. 7D: Scanning electron micrograph of the posterior adult tongue of albino mice showing taste bud (TB) and deep groove (DG).

Fig. 8D: Scanning electron micrograph of the posterior adult tongue of albino mice showing enlarged biramous filiform papillae.

and thick part of the tongue located between the root and body of the tongue, but in adult mice, the prominence is formed by massive and wide foliate and branched papillae, this prominence was described by many authors as a lingual prominence formed by the longer filiform and perpendicularly directed papillae [14], but in rats, it formed by the large conical papillae as reported [21].

In addition, we found that the large numbers of special papillae are located behind the intermolar prominence in the caudal regions, it was similar with [21,25] in having a common base from which two in young or three, four and sometimes five long filaments depart in adult, so they were named as multifilamentary papillae and located between foliate and circumvallate papillae.

[21] have noted that the filiform papillae are located behind the intermolar prominence, the apices of which are branched to form several slender twigs.

It has been found that one or several taste buds have a lot of nerve fibers (nerve endings) located in each fungiform papilla and circumvallate papilla, this finding highlights the importance of mice in having developed taste and sensory organs including tongue due to the food habits, their behavior and nocturnal nature.

Conclusions

Our findings have shown the features of the tongue structure of white albino mice in different stages at ultrascopic levels. The data analysis revealed that mucous membrane of the tongue contains a large number of papillae, such as fungiform, three types of filiform, well developed foliate and multifilamentary papillae, as well as one large and similar smaller circumvallate papillae. Each of them has a different shape, size, and location. However, we have received data for a complete picture of structure of tongue that will be useful in further experimental and morphological studies of the white albino mice.

Competing interests

The author declares that he has no competing interests.

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