SCANNING ELECTRON MICROSCOPIC STUDY ON THREE POSTNATAL DEVELOPMENTS OF RAT TONGUE WITH SPECIAL REFERENCE TO THEIR LINGUAL PAPILLES

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Abstract

The present study was aimed to describe the anatomy of the tongue of three postnatal developments in new born and adult rat with compare between the development of lingual papillae in these different ages of development. The tongues taken from six new born and adult rats, each tongue was fixed in the appropriate fixtive for scanning electron microscopic investigation. Scanning electron microscopic observation revealed that the tongue of rat possessed a variety of gustatory papillae including; filiform, fungiform, and circumvallate in new born rats while, there were four types of lingual papillae on the tongue of adult rat. Finally, it is concluded that lingual structure varied between different postnatal developments in the same species.

Key words: Rat, tongue, gustatory papillae

I. INTRODUCTION

The tongue is a complex, musculature organ that shows variable morphological and histological pattern. The tongue is often considered a key innovation in evolution of a terrestrial life style as it allows animals to transport food particles through the oral cavity (Iwasaki, 2002). Moreover, there are fairly strong correlations between tongue anatomy and its functional roles (eg. food, transport and manipulation), and environmental conditions in which animals use their tongues or hypobranchial system (i.e. water vs . air) (Mc clung & Goldberg, 2000; Schwenk, 2000; Iwasaki, 2002; Darwish, 2012). The mammalian tongue plays an important role in ingestion, as in licking, lapping, and browsing; and it moves food distally through the oral cavity. The dorsal surface of mammalian tongue is covered by specialized structures called lingual papillae. Furthermore, Yoshimura et al. (2008) stated that the morphology of the tongue, the mucosa of the lingual papillae on its dorsal surface and the distribution of these papillae reflect dietary habits and living environment of the vertebrate animals. In mammals, four types of tongue papillae (filiform, fungiform, circumvallate and foliate) can be recognized on the dorsal surface of the tongue (Emura et al., 2006). Three types of lingual papillae were identified in rat including filiform, fungiform and circumvallate papillae. The fungiform and circumvallate papillae were large, and their outlines were somewhat irregular, meanwhile filiform papillae were long and slender (Iwasaki et al., 1997). The lingual taste papillae are in stertypic locations: fungiform papillae are in the anterior tongue; the circumvalate are at the posterior border between oral and pharyngeal tongue; and the foliate are on lateral edges of posterior tongue. Covering the rest of the tongue dorsum are the nongustatory, filiform papillae. The development of fungiform papillae on the rodent tongue, rat and mouse. Rat and mouse are emphasized because most of the data on papillae development is from these animals. The fungiform papillae are of particular interest because they present on the tongue dorsum in a pattern of diagonal rows. In rat and mouse fungiform, there is only a single taste bud in the central,
apical epithelium of the papilla (Mistretta and Xian Liu 2006). Hastologically defined, the early taste bud development within the gustatory papillae is essentially a postnatal process (Mistretta, 1972; Hill, 2001; Mistretta and Hill, 2003). Because development of oral facial structure begins so early in the embryo and extremely sensitive to genetic and epigenetic factors, mutant mouse models are not always amenable to study of tongue and papillae development. For example, in Shh null mutant mice, tongue formation is essentially obliterated (Dahmane et al., 2001). Concerning keratinization of lingual mucosa, the lingual epithelium showed varying degrees of keratinization, especially in the anterior, posterior and interpapillar cell columns (Iwasaki & Miyata, 1990). In most mammals, keratohyalin granules were recognized only in the anterior region of the filiform papillae (Iwasaki, 1992; Iwasaki et al., 1992). Iwasaki et al., (1996, 1997) demonstrated fungiform and circumvallate papillae in rats and mice.

The morphological and histological features of the tongues of rodents, such as rats and mice, have significant hard keratinization of the epithelium over the entire dorsal area, which includes filiform papillae (Baratz and Farbman, 1975). A plausible explanation for this phenomenon might be that rodents eat hard foods. With some exceptions (Baratz and Farbman, 1975), the histological structure of filiform papillae is similar in almost all mammals. These papillae are commonly inclined towards the lingual radix, and their keratinization is harder than that in the interpapillar area, being similar to that of hair (Boshell et al., 1982). Moreover, the anterior regions of papillae are softer than their posterior regions (Iwasaki & Miyata, 1989; Iwasaki, 1992; Agungpriyono et al., 1995). Therefore, the papillae are easily bent in the direction of the radix but not in the opposite direction. This property facilitates retention of food on the dorsal surface of the tongue. The structure of the specialized filiform papillae that are also used for grooming is different from that mentioned above. Also, this study aimed to clarify and compare the anatomy and the structure of the tongue on the rats in three different postnatal developments and also to complement the previous studies on other mammalian species.

II. MATERIAL AND METHODS

The experimental animals

In the present work, specimens of three postnatal developments of rat; 3 days, 12 days (new born) and adult rat were used.

SEM preparations

For SEM examination, the tongues of three postnatal developments of rat were placed into 3% glutaraldehyde with phosphate buffer (pH 7.3). Then, the tongues were dehydrated in a graded series of ethanol (70-100%), and subsequently dried with critical-point-dryer (Russell & Daghlian, 1985). The dried material was coated by gold sputter coater (SPLModule) and samples examined by JEOL-JSM-5500 LV reflection scanning electron microscopy in the central laboratory of Schistosoma Biological Supply Program (SBSP) Theodor Bilharz Research Institute, Cairo, Egypt.

III. RESULTS

At SEM level, the tongue of new born rat (3 days) revealed the different anatomical regions; the apex appears rounded flat and possesses a shallow sulcus, the body and the root (Fig. 1). In this postnatal development the dorsum tongue appears with small numerous lingual papillae (Fig. 2). The filiform papillae were the most numerous, extending over the whole dorsal surface of the tongue up to the root. The filiform papillae are bent slightly backwards and each short cone in shape (Fig. 3). The fungiform papillae were rounded or dome-shaped and distributed irregularly among the filiform papillae (Fig. 3).

Examination of the tongue and the lingual papillae of the new born rat, 12 days, showed also the different anatomical regions; the apex appears rounded flat and possesses a shallow sulcus, the body and
that the filiform papillae were distributed all over the dorsal surface of the tongue (Figs. 5&6) they cone in shape with pointed tips which were directed posteriorly.

**Fig.(1):** Scanning electron micrograph of the dorsal surface of the tongue of new born rat (3 days) showing the different anatomical regions; The apex (A) with shallow sulcus(hollow arrow), The body (B) and the root (R).

**Fig.(2):** Scanning electron micrograph of the dorsal surface of the tongue of new born rat (3 days) showing the beginning papillae development on the dorsal surface of the tongue.

**Fig.(3):** Scanning electron micrograph of the dorsal surface of the tongue of new born rat (3 days) showing the early development of filiform papillae (hollow arrow) and fungiform papilla (solid arrow).

**Fig.(4):** Scanning electron micrograph of the dorsal surface of the tongue of new born rat (12 days) showing the different anatomical regions; The apex (A) with shallow sulcus(hollow arrow), The body (B) and the root (R).

**Fig.(5):** Scanning electron micrograph of the dorsal surface of the tongue of new born rat (12 days) showing the moderate development of different types of papillae which covered the surface of the tongue.

**Fig.(6):** Scanning electron micrograph of the dorsal surface of the tongue of new born rat (12 days) showing numerous filiform papillae scattered on the dorsal surface of the tongue.
Fungiform papillae are few in number and located in the anterior part of the tongue compressed between the filiform papillae. They are dome-like in shape (Figs. 6&7). SEM examination of the tongue in adult rat illustrates that the tongue is relatively short with a round tip, the sulcus appears well developed and dividing the tongue into two symmetric parts may be seen on the dorsal surface of the apex and the body of the tongue (Fig. 8). The sulcus (groove) disappears at the distal third, near tongue root which become slightly wide base (Fig. 8). At SEM level, three different types of papillae were observed: filiform, fungiform and circumvallate. Filiform papillae were the most numerous extending over the whole dorsal surface of the tongue up to the root. They were leaf-like in shape with pointed tips which were directed posteriorly. Filiform papillae consisted of larger main papillae and smaller secondary papillae. In general, each main papilla was accompanied by 2 or, in same instances, 3 secondary papillae on the anterolateral side of its base as illustrated in figures 9&10. Secondary papillae were rare or absent in the posterior third of the tongue. Fungiform papillae were rounded and distributed irregularly among the filiform papillae, being more numerous in the anterior than in the posterior part of the tongue (Figs. 11&12). A pair of long-flat circumvallate papillae were also observed (Fig. 13). Each papilla was surrounded by a prominent circular primary groove and a thin annular pad and possesses a minute pore (Fig. 13).

Fig.(7): Scanning electron micrograph of the dorsal surface of the tongue of new born rat (12 days) showing the moderate development of fungiform papilla (hollow arrow) and cone-shaped filiform papilla (solid arrow).
Fig.(8): Scanning electron micrograph of the dorsal surface of the tongue of adult rat showing the different anatomical regions; The apex (A) with shallow sulcus(hollow arrow), The body (B) and the root (R).

Fig.(9): Scanning electron micrograph of the dorsal surface of the tongue of adult rat showing the simple filiform papillae.

Fig.(10): Scanning electron micrograph of the dorsal surface of the tongue of adult rat showing the different shapes of filiform papillae; conical-shaped process (solid arrow head), forked-shaped (hollow arrow head), hand-shaped process (solid arrow) and flagellum-shaped(hollow arrow).

Fig.(11): Scanning electron micrograph of the dorsal surface of the tongue of adult rat showing, flagellum like filliform papilla (solid arrow) and fungiform papillae (hollow arrow).

Fig.(12): Scanning electron micrograph of the dorsal surface of the tongue of adult rat showing, cone-shaped filiform papillae (solid arrow) and circumvallate papillae with central pore (hollow arrow).

Fig.(13): Scanning electron micrograph of the dorsal surface of the tongue of adult rat showing, the weakly developed foliate papillae (solid arrow).

IV. DISCUSSION

From the present study the general morphological features of the tongue show a considerable similarity to the structure of the tongue in the three postnatal development ages. The median sulcus on the apex of the tongue is characteristic feature found in many rodents, although its length and width are species-specific (Grandi et al., 1994; Iwasaki et al., 1996 &1997). The present findings illustrated that the median sulcus is more prominent in adult rat, this result agrees with the findings which obtained by (Iwasaki et al., 1996; Kilinc et al., 2010; Parchmi et al., 2010). In mouth, blinded mole rat and common quail, respectively.

From the SEM images, the present study revealed that present of three dimensional structure of the filiform papillae, and different types of filiform papillae were recognized depending on their location on the tongue regions. In rat, filiform papillae appeared numerous, covering the whole dorsal surface of the tongue up to the root. Two different forms filiform papillae were recognized either leaf-like or large conical-shaped structure. Each filiform papilla had two or three secondary papillae subtypes emerged from its broad base. These secondary subtypes of filiform papilla were rare or absent in the posterior third of the tongue. Filiform papillae, which are considered to have a mechanical function (Nickel, 1979) have been reported to vary considerably in shape and structural organization from one species to another (Kullaa-Mikkonen et al., 1985). The arrangement of the filiform papillae provides the tongue with a rough surface suited for the movement and grinding of food (Svejda&Skach, 1975; Yamada et al., 1982).

The size and number of fungiform papillae also vary according to animal species (Yoshimura et al., 2008; Takemura et al., 2009). Their gustatory function is clear in view of the multiple taste pores on their surfaces. As mentioned by Delheusy et al., (1994), the role of these taste buds on the anterior papillae might be tasting the palatability of the prey when contacts with the tongue occure during capture. Roper (2009) mentioed that taste buds are the peripheral sensory organs of gestation, these structures have the task of monitoring the chemical environment of the oral cavity and particularly of sensing ingested foods. The distribution of the filiform papillae surrounding the fungiform ones, suggests a protective role (Jackowiak 2006). The present results showed that in the tongue dorsum of rat, the fungiform papillae are localized in the anterior part. They are elliptical or circular in shape embedded between the filiform papillae. These findings agree with the results obtained by Ojima et al., 1997; Silva et al., 2002 in rabbits and Nasr et al., 2012 in rats.

The characteristics of the fungiform papillae in the investigated three postnatal developments, being larger and scattered sporadically and irregularly among filiform papillae. Their numbers appear more numerous in the anterior than in the posterior part of the tongue. Similar findings of distributed
fungiform papillae are detected among filiform papillae in the distal region, however foliate papilla is rudimentary (Jabbar, 2014). However Nasr et al. (2008) investigated the tongue of Cape hyrax procavia capensis and identified filiform, fungiform and foliate papillae on the dorsal surface of the tongue; however, fungiform papillae were quite diminished on the lingual prominence. The present findings agree with the results which obtained by (Hofer et al. 1993) they stated that the tip of the tongue can therefore be considered as a special sense organ, transmitting several kinds of sensory information and the round-flat circumvallate papillae represent the main second type of gustatory papillae. The vallate papillae are two in number as previously mentioned by Estecondo et al., 2004 and Ciuccio et al., 2010. The number and morphology of vallate papillae varied between species, from absent, as in Capehyrx, too abundant, as in ruminants (Yoshimura et al., 2008). These variations depend on the types of food consumed.

Numerous taste buds were detected in the epithelium of the dorsal and lateral parts in the vallate papillae. Circumvallate, is commonly found in other mammalian species such as rat and mouse (Kobayashi et al. 1989), guinea pig (Kobayashi,1990).

The present results confirmed the characteristics of the foliate papillae reported by Watanabe et al. (1988) which presented some parallel projections (ridges) separated by grooves and three laminar sheets of connective tissue called groove folds and septal fold.

A pair of foliate papillae are located on the posterolateral margins of the adult rat tongue. This finding agrees with Jackowiak and Godynicki, 2005; Burity et al., 2009.

Foliate papillae were less numerous and located on the posterolateral margin of the tongue in adult rat. Each foliate papilla possessed numerous taste buds. The structure of these papillae was similar to those in the gerbilus, and rat (Grandi et al.,1994). The taste buds are relatively abundant in both foliate and circumvallate papillae, more than in fungiform papillae (Levin and Pfeiffer, 2002).

In conclusion, the comparison of the morphology of the tongues of three postnatal developmental ages which feed different diets; particularly the structure and distribution of their lingual papillae using scanning electron microscopy revealed marked differences between them. Such variations are probably due to the environmental conditions in which animals use their tongues, and reflect adaptations respond to their feeding pattern.

BIBLIOGRAPHY